DEPARTMENT OF TRANSPORTATION

National Highway Traffic Safety Administration

49 CFR Parts 523, 531, 533, 534, 536 and 537

[Docket No. NHTSA-2008-0177]

RIN 2127-AK29

Average Fuel Economy Standards

Passenger Cars and Light Trucks

Model Years 2011-2015

AGENCY: National Highway Traffic Safety Administration (NHTSA), Department of Transportation (DOT).

ACTION: Final rule; record of decision.

SUMMARY: Since the late 1970s, NHTSA has been issuing and implementing Corporate Average Fuel Economy (CAFE) standards that have saved consumers money by reducing fuel needs, strengthened energy security by reducing dependence on foreign oil, conserved petroleum, a non-renewable resource, and helped to protect the environment by reducing the emissions of carbon dioxide (CO_2), the most important of the man-made greenhouse gases (GHGs).[1] The reform of the CAFE standards (beginning in model year (MY) 2008 for light trucks and in MY 2011 for passenger cars) has opened the way to making substantial steady annual increases in the standards for both types of automobiles. The reform, which was accomplished by switching to attribute-based standards, makes possible greater fuel savings, avoids creating undue risks of adverse

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[1] Although the global warming potential of CO_2 is less than that of other GHGs, the sheer volume of volume of its production makes it the most important GHG.

impacts on safety, is mindful of potential impacts on jobs and the economy, and more equitably distributes compliance responsibilities among the vehicle manufacturers.

This final rule adopts standards for MY 2011-2015 passenger cars and light trucks that will raise the industry-wide combined average to 31.8 mpg by MY 2015. Achieving this average will save tens of billions of gallons of gasoline, adding dramatically to the many billions of gallons of fuel already saved.

Since the CO_2 emitted from the tailpipes of new motor vehicles is the natural by-product of the combustion of fuel, and since the only way for automobile manufacturers to reduce those emissions substantially is to increase fuel economy, achieving the combined average of 31.8 mpg will also reduce tailpipe emissions of CO_2 by hundreds of millions of metric tons relative to what they otherwise would have been and thereby address climate change. Those CO_2 emissions represent approximately 95 percent of the total greenhouse gas emissions from motor vehicles.

This rule also addresses two other important issues. It establishes programs for the transferring and trading of credits, thus increasing manufacturer compliance flexibility. Finally, in recognition that CAFE standards whose stated purpose is reducing fuel consumption and State standards whose stated purpose is reducing tailpipe emissions of GHGs, especially CO_2, both have the essentially same compliance measuring procedures, produce the same types of benefits and other impacts, and depend on the same technologies for achieving compliance, and in the interest of promoting an efficient, unified national policy, this rule addresses the effect of the statutory express preemption provision on those State standards.

DATES: This final rule is effective January 19, 2008.

Petitions for reconsideration must be received by **[Please insert the date 45 days after date of publication of this document in the Federal Register]**.

ADDRESSES: Petitions for reconsideration must be submitted to: Administrator, National Highway Traffic Safety Administration, 1200 New Jersey Avenue, SE, Washington, DC 20590.

FOR FURTHER INFORMATION CONTACT:

For policy and technical issues: Ms. Julie Abraham or Mr. Peter Feather, Office of Rulemaking, National Highway Traffic Safety Administration, 1200 New Jersey Avenue, SE, Washington, DC 20590. Telephone: Ms. Abraham (202) 366-1455; Mr. Feather (202) 366-0846.

For legal issues: Mr. Stephen Wood or Ms. Rebecca Yoon, Office of the Chief Counsel, National Highway Traffic Safety Administration, 1200 New Jersey Avenue, SE, Washington, DC 20590. Telephone: (202) 366-2992.

SUPPLEMENTAL INFORMATION:

Table of Contents

I. Executive overview
- **A. Summary**
- **B. Energy Independence and Security Act of 2007**
- **C. Notice of proposed rulemaking and request for new product plans**
  - **1. Key economic values for benefits computations and standard setting**
  - **2. Standards**
    - **(a) Classification of vehicles**
    - **(b) Stringency**
    - **(c) Benefits and costs**
      - **(i) Benefits**
      - **(ii) Costs**
    - **(d) Effect of flexibilities on benefits and costs**
  - **3. Credits**
  - **4. Preemption**
- **D. Brief summary of public comments on the NPRM**

E. New information received or developed by NHTSA between the NPRM and final rule
  - **1. New manufacturer product plans**
  - **2. Revised assessment of technology effectiveness and costs**
  - **3. Final environmental impact statement (FEIS)**

F. Final rule
  - **1. Introduction**
  - **2. Key economic values for benefits computations**
  - **3. Standards**
    - **(a) Classification**
    - **(b) Stringency**
    - **(c) Benefits and costs**
      - **(i) Benefits**
      - **(ii) Costs**
    - **(d) Flexibilities**
  - **4. Credits**
  - **5. Preemption**

II. Background

A. Contribution of fuel economy improvements to addressing energy independence, energy security, and climate change
  - **1. Relationship between fuel economy and CO_2 tailpipe emissions**
  - **2. Fuel economy improvements/CO_2 tailpipe emission reductions since 1975**

B. Chronology of events since the National Academy of Sciences called for reforming and increasing CAFE standards
  - **1. National Academy of Sciences issues report on future of CAFE program (February 2002)**
    - **(a) Significantly increasing CAFE standards without reforming them would adversely affect safety**
    - **(b) Climate change and other externalities justify increasing the CAFE standards**
  - **2. NHTSA issues final rule establishing reformed (attribute-based) CAFE standards for MY 2008-2011 light trucks (March 2006)**
  - **3. President announces Twenty-in-Ten Initiative (January 2007)**
  - **4. Supreme Court issues decision in Massachusetts v. EPA (April 2007)**
  - **5. NHTSA and EPA coordinate on development of rulemaking proposals (Summer-Fall 2007)**
  - **6. Ninth Circuit issues decision re final rule for MY 2008-2011 light trucks (November 2007)**
  - **7. Congress enacts Energy Security and Independence Act of 2007 (December 2007)**
  - **8. President announces goal of stopping growth of U.S. greenhouse gas emissions by 2025 (April 2008)**

9. NHTSA proposes CAFE standards for MYs 2011-2015 and requests new product plans for those years (April 2008)[2]
10. NHTSA contracts with ICF International to conduct climate modeling and other analyses in support of draft and final environmental impact statements (May 2008)
11. Manufacturers submit new product plans (June 2008)
12. NHTSA contracts with Ricardo to aid in assessing public comments on cost and effectiveness of fuel saving technologies (June 2008)
13. Ninth Circuit revises its decision re final rule for MY 2008-2011 light trucks (August 2008)
14. EPA publishes notice announcing availability of NHTSA's final environmental impact statement (October 2008)

C. Energy Policy and Conservation Act, as amended
1. Vehicles subject to standards for automobiles
2. Mandate to set standards for automobiles
3. Structure of standards
4. Factors governing or considered in the setting of standards
5. Consultation in setting standards
6. Compliance flexibility and enforcement

III. The anticipated vehicles in the MY 2011-2015 fleets and NHTSA's baseline market forecast
A. Why does NHTSA establish a baseline market forecast?
B. How does NHTSA develop the baseline market forecast?
1. NHTSA first asks manufacturers for updated product plan data
(a) Why does NHTSA use manufacturer product plans to develop the baseline?
(b) What product plan data did NHTSA use in the NPRM?
(c) What product plan data did NHTSA receive for the final rule?
(d) How is the product plan data received for the final rule different from what the agency used in the NPRM analysis, and how does it impact the baseline?
2. Once NHTSA has the product plans, how does it develop the baseline?
3. How does NHTSA's market forecast reflect current market conditions?

IV. Fuel economy-improving technologies
A. NHTSA analyzes what technologies can be applied beyond those in the manufacturers' product plans
B How NHTSA decides which technologies to include
1. How NHTSA did this historically, and how for the NPRM
2. NHTSA's contract with Ricardo for the final rule
C. What technology assumptions has NHTSA used for the final rule?

[2] A description of the NPRM appears earlier in this preamble.

1. How do NHTSA's technology assumptions in the final rule differ from those used in the NPRM?
2. How are the technologies applied in the model?
3. Technology application decision trees
4. Division of vehicles into subclasses based on technology applicability, cost and effectiveness
5. How did NHTSA develop technology cost and effectiveness estimates for the final rule?
6. Learning curves
7. Technology synergies
8. How does NHTSA use full vehicle simulation?
9. Refresh and redesign schedule
10. Phase-in caps

D. Specific technologies considered for application and NHTSA's estimates of their incremental costs and effectiveness
1. What data sources did NHTSA evaluate?
2. Individual technology descriptions and cost/effectiveness estimates
(a) Gasoline Engine Technologies
(i) Overview
(ii) Low Friction Lubricants (LUB)
(iii) Engine Friction Reduction (EFR)
(iv) Variable Valve Timing (VVT)
***1.* Intake Cam Phasing (ICP)**
***2.* Coupled Cam Phasing (CCPS and CCPO)**
***3.* Dual Cam Phasing (DCP)**
(v) Discrete Variable Valve Lift (DVVLS, DVVLD, DVVLO)
(vi) Continuously Variable Valve Lift (CVVL)
(vii) Cylinder Deactivation (DEACS, DEACD, DEACO)
(viii) Conversion to Double Overhead Camshaft Engine with Dual Cam Phasing (CDOHC)
(ix) Stoichiometric Gasoline Direct Injection (SGDI)
(x) Combustion Restart (CBRST)
(xi) Turbocharging and Downsizing (TRBDS)
(xii) Cooled Exhaust Gas Recirculation Boost (EGRB)
(b) Diesel Engine Technologies
(i) Diesel Engine with Lean NO_x Trap (LNT) Catalyst After-Treatment
(ii) Diesel Engine with Selective Catalytic Reduction (SCR) After-Treatment
(c) Transmission Technologies

(i) Improved Transmission Controls and Externals (IATC)
(ii) Automatic 6-, 7- and 8-Speed Transmissions (NAUTO)
(iii) Dual Clutch Transmissions / Automated Manual Transmissions (DCTAM)
(iv) Continuously Variable Transmission (CVT)
(v) 6-Speed Manual Transmissions (6MAN)
(d) Hybrid and Electrification/Accessory Technologies
(i) Overview
(ii) Hybrid System Sizing and Cost Estimating Methodology
(iii) Electrical Power Steering (EPS)
(iv) Improved Accessories (IACC)
(v) 12V Micro Hybrid (MHEV)
(vi) High Voltage / Improved Alternator (HVIA)
(vii) Integrated Starter Generator (ISG)
(viii) Power Split Hybrid
(ix) 2-Mode Hybrid
(x) Plug-In Hybrid
(e) Vehicle Technologies
(i) Material Substitution (MS1, MS2, MS5)
(ii) Low Drag Brakes (LDB)
(iii) Low Rolling Resistance Tires (ROLL)
(iv) Front or Secondary Axle Disconnect for Four-Wheel Drive Systems (SAX)
(v) Aerodynamic Drag Reduction (AERO)
(f) Technologies considered but not included in the final rule analysis
(i) Camless Valve Actuation
(ii) Lean-Burn Gasoline Direct Injection Technology
(iii) Homogeneous Charge Compression Ignition
(iv) Electric Assist Turbocharging
E. Cost and effectiveness tables
V. Economic assumptions used in NHTSA's analysis
A. Introduction: how NHTSA uses the economic assumptions in its analysis
B. What economic assumptions does NHTSA use in its analysis?
1. Costs of fuel economy technologies
2. Potential opportunity costs of improved fuel economy
3. The on-road fuel economy 'gap'
4. Fuel prices and the value of saving fuel
5. Consumer valuation of fuel economy and payback period
6. Vehicle survival and use assumptions
7. Growth in total vehicle use
8. Accounting for the rebound effect of higher fuel economy

9. **Benefits from increased vehicle use**
10. **Added costs from congestion, crashes, and noise**
11. **Petroleum consumption and import externalities**
12. **Air pollutant emissions**
    (a) **Impacts on criteria pollutant emissions**
    (b) **Reductions in CO_2 emissions**
    (c) **Economic value of reductions in CO_2 emissions**
13. **The value of increased driving range**
14. **Discounting future benefits and costs**
15. **Accounting for uncertainty in benefits and costs**

VI. How NHTSA sets the CAFE standards
- **A. Which attributes does NHTSA use to determine the standards?**
- **B. Which mathematical function does NHTSA use to set the standards?**
- **C. What other types of standards did commenters propose?**
- **D. How does NHTSA fit the curve and estimate the stringency that maximizes net benefits to society?**
- **E. Why has NHTSA used the Volpe model to support its analysis?**

VII. Determining the appropriate level of the standards
- **A. Analyzing the preferred alternative**
- **B. Alternative levels of stringency considered for establishment as the maximum feasible level of average fuel economy**
- **C. EPCA provisions relevant to the selection of the final standards**
  1. **35 in 2020**
  2. **Annual ratable increase**
  3. **Maximum feasibility and the four underlying EPCA considerations**
     (a) **Technological feasibility**
     (b) **Economic practicability**
     (c) **Effect of other motor vehicle standards of the Government on fuel economy**
     (d) **Need of the United States to conserve energy**
        (i) **Consumer cost**
        (ii) **National balance of payments**
        (iii) **Environmental implications**
        (iv) **Foreign policy considerations**
  4. **Comparison of alternatives**
  5. **Other considerations under EPCA**
     (a) **Safety**
     (b) **AMFA credits**
     (c) **Flexibility mechanisms: credits, fines**
- **D. Environmental consequences relevant to the selection of the final standards**
- **E. Picking the final standards**
  1. **Eliminating the alternatives facially inconsistent with EPCA**
     (a) **No-action alternative**
     (b) **Technology exhaustion alternative**

2. Choosing among the remaining alternatives
(a) Difficulty and importance of achieving a reasonable balancing of the factors
(b) The correct balancing of the factors for MYs 2011-15 is to maximize societal net benefits
VIII. Safety
A. Background
1. NHTSA's Early Studies
2. The 2002 National Academy of Sciences Study
3. NHTSA's Updated 2003 Study
4. Summary of Studies Prior to this Rulemaking
B. Response to Comments in this Rulemaking on Safety and Vehicle Weight
1. Views of Other Government Agencies
2. Comments from Other Parties
C. Comments on Other Issues Related to Safety
1. Vehicle compatibility design issues
2. Whether manufacturers downweight in response to increased CAFE stringency
3. Whether flat standards are more or less harmful to safety than footprint-based standards
4. Whether NHTSA should set identical targets for passenger cars and light trucks for safety reasons
5. Whether NHTSA should have considered the 2002 NAS Report dissent in deciding not to apply material substitution for vehicles under 5,000 pounds
D. NHTSA Has Rationally Considered Safety Issues in Setting Fuel Efficiency Standards
IX. The final fuel economy standards for MYs 2011-2015
A. Final passenger car standards
B. Final light truck standards
C. Energy and Environmental Backstop
D. Combined Fleet Performance
E. Estimated technology utilization under final standards
F. Costs and benefits of final standards
1. Benefits
2. Costs
G. Environmental impacts of final standards
X. Other fuel economy standards required by EISA
XI. Vehicle classification
A. Summary of Comments
B. Response to Comments
1. This rule substantially tightens NHTSA's vehicle classification definitions
(a) Under § 523.5(b), only vehicles that actually have 4WD will be classified as 4WD vehicles

(b) The final rule amends § 523.5(a)(4) to prevent gaming that might jeopardize fuel savings created by NHTSA's clarified position on 2WD vehicles

2. Especially as tightened by this rule, NHTSA's classification definitions are more difficult to game than commenters suggest

3. Additional changes in NHTSA's classification definitions would not result in greater fuel savings and lower CO_2 emissions

4. The vehicle classification definitions embodied in this final rule are consistent with NHTSA's statutory authority and respond to the Ninth Circuit's opinion

XII. Flexibility mechanisms and enforcement

A. NHTSA's request for comment regarding whether the agency should consider raising the civil penalty for CAFE non-compliance

B. CAFE credits

C. Extension and phasing out of flexible-fuel incentive program

XIII. Test procedure for measuring wheelbase and track width and calculating footprint

A. Test procedure execution

B. Measured value tolerances

C. Administrative and editorial issues

XIV. Sensitivity and Monte Carlo Analysis

XV. Regulatory notices and analyses

A. Executive Order 12866 and DOT Regulatory Policies and Procedures

B. National Environmental Policy Act

1. Clean Air Act (CAA)

2. National Historic Preservation Act (NHPA)

3. Executive Order 12898 (Environmental Justice)

4. Fish and Wildlife Conservation Act (FWCA)

5. Coastal Zone Management Act (CZMA)

6. Endangered Species Act (ESA)

7. Floodplain Management (Executive Order 11988 & DOT Order 5650.2)

8. Preservation of the Nation's Wetlands (Executive Order 11990 & DOT Order 5660.1a)

9. Migratory Bird Treaty Act (MBTA), Bald and Golden Eagle Protection Act (BGEPA), Executive Order 13186.

10. Department of Transportation Act (Section 4(f))

C. Regulatory Flexibility Act

D. Executive Order 13132 (Federalism)

E. Executive Order 12988 (Civil Justice Reform)

F. Unfunded Mandates Reform Act

G. Paperwork Reduction Act

H. Regulation Identifier Number (RIN)

J. Executive Order 13045

K. National Technology Transfer and Advancement Act

L. Executive Order 13211
M. Department of Energy Review
N. Privacy Act
Appendix -- Preemption of State Regulations Regulating Tailpipe Emissions of Carbon Dioxide from Passenger Cars and Light Trucks
XV. Regulatory Text

I. Executive overview

A. Summary

For the first time in the more than 30-year history of the CAFE program, NHTSA is issuing a rule that simultaneously raises standards for both passenger cars and light trucks. This final rule is being issued pursuant to the Energy Independence and Security Act of 2007 (EISA), which became law in December 2007. EISA mandates the setting of separate maximum feasible standards for passenger cars and for light trucks at levels that must be high enough to ensure that the average fuel economy of the combined fleet of all passenger cars and light trucks sold by all manufacturers in the U.S. in model year (MY) 2020 equals or exceeds 35 miles per gallon (mpg). If the average just meets 35 mpg, that would be a 40 percent increase above the average of approximately 25 miles per gallon for the estimated MY 2008 industry-wide combined fleet.

Congress enabled NHTSA to require these substantial increases in fuel economy by not only authorizing, but also requiring that passenger car standards be reformed through basing them on one or more vehicle attributes. The attribute-based approach was originally recommended by the National Academy of Sciences in 2002 and later adopted by NHTSA in 2006 for light trucks standards. The new approach is a substantial improvement over the old approach of specifying the same numerical standard for each manufacturer. The attribute-based approach makes possible greater fuel savings, avoids creating undue risks of adverse safety impacts, and distributes compliance responsibilities among the vehicle manufacturers more equitably.

This rule adopts standards for five model years, MYs 2011-2015, the maximum number of model years for which NHTSA is permitted by EISA to establish standards in a single rulemaking. Lead time is a significant consideration in determining the stringency of future standards, as major changes in vehicle design (*e.g.,* changing from a conventional internal combustion engine to diesel engine or hybrid drivetrain) require longer leadtime. Accordingly, the agency needs to establish the standards as far in advance as possible so that manufacturers are able to make the vehicle design changes necessary to achieve the fuel savings mandated by EISA.

In developing the standards, the agency carefully considered the four statutory factors underlying maximum feasibility (technological feasibility, economic practicability, the effect of other standards of the Government on fuel economy, and the need of the nation to conserve energy (which includes environmental considerations)) as well as safety and other relevant factors. After assessing what fuel saving technologies would be available, how effective they are, how much they cost, and how quickly the agency can require fuel economy to be increased through the introduction of those technologies, and then factoring that information into a computer model it uses for applying technologies to particular vehicle models, the agency balanced the factors relevant to standard setting. In its decision making, the agency used a marginal benefit-cost analysis that placed monetary values on relevant externalities (both energy security and environmental externalities, including the benefits of reductions in CO_2 emissions). In developing and selecting these standards over the last year and a half, the agency consulted with the Department of Energy and the Environmental Protection Agency on many issues.

This document also adds a new regulation designed to give manufacturers added flexibility in using credits earned by exceeding CAFE standards. The regulation authorizes the trading of credits between manufacturers. In addition, it permits a manufacturer to transfer its credits from one of its compliance categories to another of its categories.

B. Energy Independence and Security Act of 2007

The Energy Independence and Security Act of 2007 (EISA)[3] builds on the President's "Twenty in Ten" initiative, which was announced in January 2007. That initiative sought to reduce gasoline usage by 20 percent in the next 10 years. The enactment of EISA represents a major step forward in expanding the production of renewable fuels, reducing oil consumption, and reducing CO_2 emissions in order to combat global climate change.

EISA requires the first statutory increase in fuel economy standards for passenger automobiles (referred to below as "passenger cars") since those standards were originally mandated in 1975. It also includes an important reform urged by the President – switching to "attribute-based standards." This switch will ensure that increased fuel efficiency does not come at the expense of automotive safety.

More specifically, EISA made a number of important changes to the Energy Policy and Conservation Act, (EPCA)(Pub. L. 94-163), the 1975 statute that governs the CAFE program. EISA:

3 P. L. 110-140, 121 Stat. 1492 (Dec. 18, 2007).

● Substitutes a mandate to establish passenger car standards for each model year at the maximum feasible level for the old statutory default standard of 27.5 mpg for passenger cars and the provision giving us discretion whether to amend that standard. Thus, given that there will no longer be a default standard, the agency must act affirmatively to establish a new passenger car standard for each model year.

● Sets forth special requirements for the MY 2011-2020 standards. They must increase ratably each year and, as a minimum, be set sufficiently high to ensure that the average fuel economy of the combined industry-wide fleet of all new passenger cars and light trucks sold in the United States during MY 2020 is at least 35 mpg. [4]

● Mandates the reforming of CAFE standards for passenger cars by requiring that all CAFE standards be based on one or more vehicle attributes, thus ensuring that the improvements in fuel economy do not come at the expense of safety. NHTSA pioneered that approach in its last rulemaking on CAFE standards for light trucks.

● Requires that for each model year, beginning with MY 2011, each manufacturer's domestically-manufactured passenger car fleet must achieve a measured average fuel economy that is not less than 92 percent of the average fuel economy of the combined industry-wide fleet of domestic and non-domestic passenger cars sold in the United States in that model year.

● Limits to five the number of model years for which standards can be established in a single rulemaking. That requirement, in combination with the

[4] Although NHTSA established an attribute-based standard for MY 2011 light trucks in its 2006 final rule, EISA mandates a new rulemaking, reflecting new statutory considerations and a new, up-to-date administrative record, and consistent with EPCA as amended by EISA, to establish the standard for those light trucks.

requirement to start rulemaking with MY 2011, necessitates limiting this rulemaking to MYs 2011-2015.

● Provides greater flexibility for automobile manufacturers by (a) increasing from three to five the number of years that a manufacturer can carry forward the compliance credits it earns by exceeding CAFE standards, (b) allowing a manufacturer to transfer the credits it has earned from one of its compliance categories of automobiles to another class, and (c) authorizing the trading of credits between manufacturers.

C. Notice of proposed rulemaking and request for new product plans

1. Key economic values for benefits computations and standard setting

NHTSA's analysis of the proposed and alternative CAFE standards in the Notice of Proposed Rulemaking (NPRM)[5] relied on a range of information, economic estimates, and input parameters. These economic assumptions play a role in the determination of the level of the standards, with some having greater impacts than others. The cost of technologies, the price of gasoline, and discount rate used for discounting future benefits had the greatest influence over the level of the standards. In order of impact, the full list of the economic assumptions is as follows: (1) technology cost; (2) fuel prices; (3) discount rate; (4) oil import externalities; (5) rebound effect; (6) criteria air pollutant damage costs; (7) carbon costs. The table below shows the NPRM assumptions on which the agency received the most extensive public comment.

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[5] 73 FED. REG. 24352, May 2, 2008. In a separate notice published on the same day, the agency requested automobile manufacturers to submit new product plans for MYs 2011-15. 73 FED. REG. 24190.

Table I-1. NPRM Key Economic Values for Benefits Computations (2006$)[6]

Fuel Prices (average retail gasoline price per gallon, 2011-30)	$2.34
Discount Rate Applied to Future Benefits	7%
Economic Costs of Oil Imports ($/gallon)	
"Monopsony" Component	$0.182
Price Shock Component	$0.113
Military Security Component	
Total Economic Costs	$0.295
Emission Damage Costs	
Carbon Dioxide ($/metric ton)	$7.00
Annual Increase in CO2 Damage Cost	2.4%

6 Although Table V-3 Economic Values for Benefits Computations in the NPRM indicated that all of the values in that table were 2006$, several values were actually in 2005$. Thus, the monopsony component, which was shown in that table as $0.176, should have been shown as $0.182. Likewise, the price shock component should have been $0.113, instead of $0.109. The sum of those two values should have been $0.295, not $0.285.

2. Standards

(a) Classification of vehicles

In the NPRM, the agency classified the vehicles subject to the proposed standards as passenger cars or as light trucks in the same way that the vehicles had been traditionally classified under the CAFE program. In particular, sport utility vehicles (SUVs), mini-vans and pickup trucks were classified as light trucks. However, the agency raised the possibility of reclassifying many of the two-wheel drive SUVs as passenger cars for the purposes of the final rule.

(b) Stringency

We proposed setting separate attribute-based fuel economy standards for passenger cars and light trucks consistent with the size-based approach that NHTSA used in establishing the light truck standards for MY 2008-2011 light trucks.

Compared to the April 2006 final rule that established those standards, the NPRM much more fully captured the value of the costs and benefits of setting CAFE standards. This was important because assumptions regarding projected gasoline prices, along with assumptions about the value of reducing the negative externalities (economic and environmental) from producing and consuming fuel, were based on changed economic, environmental, and energy security conditions. These environmental externalities include, among other things, the value of reducing tailpipe emissions of CO_2.[7] In light of EISA and the need to balance the statutory considerations in a way that reflects the

[7] The externalities included in our analysis do not, however, include those associated with the reduction of the other GHG emitted by automobiles, *i.e.*, methane (CH_4), nitrous oxide (N_2O), and hydroflurocarbons (HFCs). Actual air conditioner operation is not included in the test procedures used to obtain both (1) emission rates for purposes of determining compliance with EPA criteria pollutant emission standards and (2) fuel economy values for purposes of determining compliance with NHTSA CAFE standards, although air conditioner operation is included in "supplemental" federal test procedures used to determine compliance with corresponding and separate EPA criteria pollutant emission standards.

current need of the nation to conserve energy, including the current assessment of the climate change problem, the agency revisited the various assumptions used to determine the level of the standards. Specifically, the agency used higher gasoline prices and higher estimates for energy security values ($0.29 per gallon instead of $0.09 per gallon). The agency also monetized carbon dioxide (at $7.00/ton), which it did not do in the previous rulemaking, and expanded its list of technologies. In addition, the agency used cost estimates that reflect economies of scale and estimated "learning"-driven reductions in the cost of technologies as well as quicker penetration rates for advanced technologies.

The agency could not set out the exact level of CAFE that each manufacturer would be required to meet for each model year under the passenger car or light truck standards since the levels would depend on information that would not be available until the end of each of the model years, *i.e.,* the final actual production figures for each of those years. The agency could, however, project what the industry-wide level of average fuel economy would be for passenger cars and for light trucks if each manufacturer produced its expected mix of automobiles and just met its obligations under the proposed "optimized" standards for each model year. Adjacent to each average fuel economy figure in the NPRM was the estimated associated level of tailpipe emissions of CO_2 that would be achieved.[8]

[8] Given the contributions made by CAFE standards to addressing not only energy independence and security, but also to reducing tailpipe emissions of CO_2, fleet performance was stated in the above discussion both in terms of fuel economy and the associated reductions in tailpipe emissions of CO_2 since the CAFE standards would have the practical effect of limiting those emissions approximately to the indicated levels during the official CAFE test procedures established by EPA. The relationship between fuel consumption and carbon dioxide emissions is discussed ubiquitously, such as at www.fueleconomy.gov, a fuel economy-related web site managed by DOE and EPA (see http://www.fueleconomy.gov/feg/contentIncludes/co2_inc.htm, which provides a rounded value of 20 pounds of CO_2 per gallon of gasoline). (Last accessed October 22, 2008.) The CO_2 emission rates shown were based on gasoline characteristics. Because diesel fuel contains more carbon (per gallon) than gasoline, the presence of diesel engines in the fleet—which NHTSA expects to increase in response to the

For passenger cars:

MY 2011: 31.2 mpg (285 g/mi of tailpipe emissions of CO_2)

MY 2012: 32.8 mpg (271 g/mi of tailpipe emissions of CO_2)

MY 2013: 34.0 mpg (261 g/mi of tailpipe emissions of CO_2)

MY 2014: 34.8 mpg (255 g/mi of tailpipe emissions of CO_2)

MY 2015: 35.7 mpg (249 g/mi of tailpipe emissions of CO_2)

For light trucks:

MY 2011: 25.0 mpg (355 g/mi of tailpipe emissions of CO_2)

MY 2012: 26.4 mpg (337 g/mi of tailpipe emissions of CO_2)

MY 2013: 27.8 mpg (320 g/mi of tailpipe emissions of CO_2)

MY 2014: 28.2 mpg (315 g/mi of tailpipe emissions of CO_2)

MY 2015: 28.6 mpg (310 g/mi of tailpipe emissions of CO_2)

The combined industry-wide average fuel economy (in miles per gallon, or mpg) levels (in grams per mile, or g/mi) for both cars and light trucks, if each manufacturer just met its obligations under the proposed "optimized" standards for each model year, would be as follows:

MY 2011: 27.8 mpg (2.5 mpg increase above MY 2010; 320 g/mi CO_2)

MY 2012: 29.2 mpg (1.4 mpg increase above MY 2011; 304 g/mi CO_2)

MY 2013: 30.5 mpg (1.3 mpg increase above MY 2012; 291 g/mi CO_2)

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proposed CAFE standards—will cause the actual CO_2 emission rate corresponding to any given CAFE level to be slightly higher than shown here. (The agency projected that 4 percent of the MY 2015 passenger car fleet and 10 percent of the MY 2015 light truck fleet would have diesel engines.) Conversely (and hypothetically), applying the same CO_2 emission standard to both gasoline and diesel vehicles would discourage manufacturers from improving diesel engines, which show considerable promise as a means to improve fuel economy.

MY 2014: 31.0 mpg (0.5 mpg increase above MY 2013; 287 g/mi CO_2)

MY 2015: 31.6 mpg (0.6 mpg increase above MY 2014; 281 g/mi CO_2)

The annual average increase during this five year period was approximately 4.5 percent. Due to the uneven distribution of new model introductions during this period and to the fact that significant technological changes could be most readily made in conjunction with those introductions, the annual percentage increases were greater in the early years in this period.

(c) Benefits and costs

(i) Benefits

We estimated that the proposed standards would save approximately 54.7 billion gallons of fuel (18.7 billion gallons for passenger cars and 36 billion gallons for light trucks) and reduce tailpipe CO_2 emissions by 521 million metric tons (178 million metric tons for passenger cars and 343 million metric tons for light trucks) over the lifetime of the vehicles sold during those model years, compared to the fuel use and emissions reductions that would occur if the standards remained at the adjusted baseline (*i.e.,* the higher of manufacturer's plans and the manufacturer's required level of average fuel economy for MY 2010).

We estimated that the value of the total benefits of the proposed standards would be approximately $88 billion ($31 billion for passenger cars and $57 billion for light trucks) over the lifetime of the vehicles sold during those model years.

(ii) Costs

The total costs for manufacturers to comply with the standards would be approximately $47 billion ($16 billion for passenger cars and $31 for light trucks) compared to the costs they would incur if the standards remained at the adjusted baseline.

(d) Effect of flexibilities on benefits and costs

The above benefit and cost estimates did not reflect the availability and use of flexibility mechanisms, such as compliance credits and credit trading, because EPCA prohibits NHTSA from considering the effects of those mechanisms in setting CAFE standards. However, the agency noted that, in reality, manufacturers were likely to rely to some extent on flexibility mechanisms provided by EPCA and would thereby reduce the cost of complying with the proposed standards to a meaningful extent.

3. Credits

NHTSA also proposed a new Part 536 on trading and transferring "credits" earned for exceeding applicable CAFE standards.[9] Under the proposed Part 536, credit holders (including, but not limited to, manufacturers) would have credit accounts with NHTSA, and would be able to hold credits, apply them to compliance with CAFE standards, transfer them to another "compliance category" for application to compliance there, or trade them. Traded credits would be subject to an "adjustment factor" to ensure total oil savings are preserved, as required by EISA. EISA also prohibits credits earned before MY 2011 from being transferred, so NHTSA developed several regulatory restrictions on trading and transferring to facilitate Congress' intent in this regard.

4. Preemption

[9] Congress required that DOT establish a credit "transferring" regulation, to allow individual manufacturers to move credits from one of their fleets to another (*e.g.*, using a credit earned for exceeding the light truck standard for compliance in the domestic passenger car standard). Congress allowed DOT to establish a credit "trading" regulation, so that credits may be bought and sold between manufacturers and other parties.

In the proposal, the agency continued its discussion, conducted in a series of rulemaking proposals and final rules spanning a six-year period, of its views regarding the preemption of state regulations regulating tailpipe emissions of GHGs, especially carbon dioxide.

D. Brief summary of public comments on the NPRM

Standard stringency: Automobile manufacturers argued that the standards, especially those for light trucks in the early years, should be lower. Environmental and consumer groups and states wanted higher standards.

Footprint attribute: Commenters generally supported the agency's choice of footprint as an attribute, although several urged consideration of additional attributes and a few argued for different attributes.

Setting standards at levels at which net benefits are maximized (optimized standards) vs. using other decision-making formulae: A consumer group urged setting standards at the optimized + 50% alternative level, while some environmental groups favored setting them at levels at which total benefits equal total costs. Manufacturers contended that the optimized approach does not assure economic practicability, especially for manufacturers needing to borrow at high interest rates to finance design changes. A manufacturer association and other commenters said agency did not assess the ability of the manufacturers to raise the capital necessary to develop and implement sufficient technologies.

Front-loading/ratable increase: Some commenters, especially the manufacturers, argued that the statutory requirement for "ratable" increases in standards means that the increases must be proportional or at least must not be disproportionately large or small in relation to one another. They did not discuss how that requirement is to be read together with either the statutory requirement to set standards for each model year at the level that is the maximum feasible level for that model year, or the separate statutory requirement for the overall fleet to achieve at least 35 mpg.

Key economic and other assumptions affecting stringency--

- Technology costs and effectiveness – The manufacturers said that NHTSA underestimated the costs. A manufacturer association submitted a study by Sierra Research challenging the cost and effectiveness estimates developed by NHTSA and EPA for the NPRM.
- Fuel prices – A manufacturer association and dealer associations said that Energy Information Administration's reference case should be used. Environmental and consumer groups, states and some members of Congress said NHTSA should use at least the EIA high price case. The EIA Administrator stated at a congressional hearing that the then current prices were at or above EIA's high case and that he would use that case in the CAFE rulemaking.
- Discount rate – The manufacturers said the rate should be at least 7%, while environmental and consumer groups and states said it should not be greater than 3 percent.
- Military costs -- Many commenters argued that NHTSA should place a value other than zero on military security externalities.
- Social cost of carbon -- Some commenters said the domestic value of reducing CO_2 emissions should be lower than the NPRM value of $7; environmental

and consumer groups and states said it should be much higher. The former tended to favor a value reflecting damage to the U.S. only, while the latter favored a global value.

- Weight reduction -- States and environmental and consumer groups said that NHTSA should consider downweighting for vehicles under 5,000 lbs; an insurance safety research group supported the proposal not to consider that.

Rate of application of advanced technologies (diesels and hybrids): Manufacturers argued that NHTSA was overly optimistic; environmental/consumer groups and states argued that NHTSA relied too much on manufacturer product plans and should require manufacturers to improve fuel economy more quickly.

Fitting of standard curve to data: A manufacturer association and two manufacturers questioned the empirical and technical basis for the shape of the curves.

Steepness of car standard curve: The two manufacturer associations and several environmental groups said that the proposed car curves were too steep: manufacturers did so because of impracticability; environmental groups, because of what they see as an incentive to increase vehicle size.

Backstop standard: Environmental and consumer groups argued that NHTSA must establish absolute backstop standards for all vehicles. Manufacturers argued that anti-backsliding features of the attribute-based standards function as a backstop.

"SUV loophole": In general, manufacturers agreed with the agency's decision to reclassify 2 WD SUVs from the light truck fleet to the passenger car fleet, as long as this change would take effect after MY 2010. Environmental and consumer groups argued that the classification system should be further revised to address “gaming” and did not address the agency’s justification for the proposed revisions.

Credits: Manufacturers argued that earned carry forward/back credits, as long as they were not acquired by transfer or trade, should be available to meet the minimum standard for domestic cars. Manufacturers also requested flexibility to manage their own credit shortfalls instead of having the agency automatically decide upon and implement plans for them. One manufacturer wanted the new statutory provision giving credits a 5 year life to be applied to all existing credits, instead of only those credits earned in model year 2009 or thereafter.

Impact on small/limited-line manufacturers: Small/limited-line manufacturers argued that the proposed standards impact them more than full-line manufacturers, and requested either that the car standards be set based on the plans of all car manufacturers, instead of just the seven largest, or that some alternative form of standard be set for them.

Preemption: Manufacturers agreed with NHTSA statements that EPCA preempts state regulation of CO_2 emissions; environmental and consumer groups and states disagreed.

E. New information received or developed by NHTSA between the NPRM and final rule

There were a number of changes after the NPRM that made possible analytical improvements for the final rule. These changes also caused the CAFE levels, fuel savings, and CO_2 emissions that are attributable to each alternative and scenario examined for this final rule to differ from those presented in the NPRM

1. New manufacturer product plans

As discussed in the NPRM, the agency requested new product plans from manufacturers to aid in determining appropriate standards for the final rule. The product plans submitted in May 2007 naturally did not take into consideration the later passage of EISA and its minimum 35 mpg combined fleet requirement by 2020. In addition, during that time, the fuel prices rose substantially. The new product plans submitted in response to the NPRM reflect those new realities in a couple of ways. First, companies provided product plans that implemented some of the cost-effective technologies that the agency had projected in the NPRM. This increased the baseline against which the fuel saving from the standards are calculated. As a result, some of the savings and CO_2 emission reductions that were attributed in the NPRM to the rulemaking action are now attributed to the improved product plans. Second, the size of the overall fleet has declined from the time of the NPRM to the final rule, resulting in fewer vehicle miles traveled.

2. Revised assessment of technology effectiveness and costs

NHTSA revised the technology assumptions in the NPRM based on comments and new information received during the comment period and used those revised assumptions for analyzing alternatives and scenarios for the Final Environmental Impact Assessment (FEIS) and final rule. In several cases, the costs in the NPRM and Draft EIS were underestimated and benefits overestimated, and in most cases, these estimates were not well differentiated by vehicle class. The agency also revised its phase-in schedule of the technologies to account more fully for needed lead time.

3. Final environmental impact statement (FEIS)

The agency recently completed a final environmental impact statement that comprehensively examines the climate change and other environmental effects of the changes in emissions of greenhouse gases and criteria air pollutants resulting from a wide variety of alternative standards. For this purpose, the agency relied extensively on the 2007 reports of the Intergovernmental Panel on Climate Change and contracted with ICF International to perform climate modeling. That impact statement also carefully assesses the cumulative impacts of past, present and future CAFE rulemakings.

F. Final rule

1. Introduction

As discussed above, and at length later in this rule, NHTSA's review and analysis of comments on its proposal have led the agency to make many changes to its methods for analyzing potential CAFE standards, as well as to the data and other information to which the agency has applied these methods. The following are some of the more prominent changes:

- After receiving, reviewing, and integrating updated product plans from vehicle manufacturers, NHTSA has revised its forecast of the future light vehicle market.
- NHTSA has changed the methods and inputs it uses to represent the applicability, availability, cost, and effectiveness of future fuel-saving technologies.
- NHTSA has based its fuel price forecast on the AEO 2008 high price scenario rather than the AEO 2008 reference case.
- NHTSA has reduced mileage accumulation estimates (*i.e.,* vehicle miles traveled) to levels consistent with this increased fuel price forecast.
- NHTSA has applied increased estimates of oil import externalities.

- NHTSA has now included all manufacturers—not just the largest seven—in the process used to fit the curve and estimate the stringency at which societal net benefits are maximized.
- NHTSA has tightened its application of the definition of "nonpassenger automobiles," causing a reassigning of over one million vehicles from the light truck fleet to the passenger car fleet.
- NHTSA has now fitted the shape of the curve based on "exhaustion" of available technologies rather than on manufacturer-level optimization of CAFE levels.
- NHTSA has now fitted the shape of the curve once to the pooled data from all model years rather than separately to each model year (with subsequent inter-MY "smoothing" to prevent curves from crossing.

These changes affected both the shape and stringency of the attribute-based standards. Taken together, the last four of the above changes significantly reduced the steepness of the curves defining fuel economy targets for passenger cars, and also less significantly reduced the steepness of the light truck curves.

In terms of overall average required fuel economy levels (*i.e.*, averaging across all manufacturers and also across passenger cars and light trucks), the combined effect of all of these changes was a modest increase (0.2 mpg) in MY 2015, as well as a less "front loaded" schedule of increases during MY 2011-MY 2015. More detailed changes are revealed by comparing the final requirements shown above to the proposed requirements shown earlier in this Section.

NHTSA recognizes that, when considered in isolation, some of the above changes might, on an "intuitive" basis, be expected to result in higher average required fuel economy levels. For example, setting aside other changes, the increase in estimated fuel prices and oil import externalities might be expected to result in higher average fuel economy requirements in every model year, not just MY 2015. On the other hand, setting aside other changes, the updated characterization of fuel-saving technologies, the reassignment of over one million vehicles to the passenger car fleet, the reduction in mileage accumulation, and the inclusion of all manufacturers in the standard setting process might intuitively be expected to result in lower average fuel economy requirements in every model year.

However, there are theoretical reasons for which even such isolated expectations might not be met. For example, if a change in inputs caused societal net benefits to increase equally at all stringencies, the level of stringency that maximized societal net benefits would remain unchanged, although it would produce greater net benefits after the change in inputs. Further, some of the changes listed above are interdependent, making it difficult, if not impossible, to isolate the effect attributable to every change. For example, NHTSA applied the reduced mileage accumulation, which reduces the benefits of adding technology, in conjunction with applying increased fuel prices, which increase the benefits of adding technology.

There is no obvious way to determine the net effect of all these (and other) changes short of applying all of the revised values to the model and looking at the results. We devote a good deal of the preamble discussion to these changes and their net implications for the standards in this rule.

The final rule reflects the combined effect of all of these changes, as well as minor changes not listed above.

2. Key economic values for benefits computations

NHTSA's analysis of the final standards and alternative CAFE standards relied on an expanded range of information and revised economic estimates and input parameters. These economic assumptions played a role in the determination of the level of the standards, with some having greater impacts than others. The agency, working with other agencies of the U.S. government, updated its estimates of the domestic and global values of the social cost of carbon (i.e., the value of reducing CO_2 emissions) as well as estimates for other externalities based on comments and updated information received during the comment period. Specifically, the final standards are based the following revised economic assumptions:

Table I-2. Final Rule Key Economic Values for Benefits Computations (2007$)

Fuel Prices (average retail gasoline price per gallon, 2011-30)	$3.33
Discount Rates Applied to Future Benefits	
Reductions in CO_2 Emissions	3%
Other Benefits	7%
Economic Costs of Oil Imports ($/gallon)	
"Monopsony" Component	$0.27
Price Shock Component	$0.12
Military Security Component	
Total Economic Costs	$0.39
Emission Damage Costs	
Carbon Dioxide ($/metric ton)(U.S. domestic value)	$2.00[10]
Annual Increase in CO_2 Damage Cost	2.4%

[10] Derived from NHTSA's $33 per metric ton estimate of the global value of reducing CO_2 emissions.

3. Standards

(a) Classification

In the NPRM, the two-wheel drive sport-utility vehicles (2WD SUVs) were classified in the same way they were classified by their manufacturers in their May 2007 product plans. For the purposes of this final rule, however, they were reclassified in accordance with the discussion in the NPRM of the proper classification of those vehicles. This resulted in the shifting of over one million two-wheel drive vehicles from the truck fleet to the car fleet. This shift had the effect of lowering the average fuel economy for cars due to the inclusion of vehicles previously categorized as trucks, and lowered average fuel economy for trucks because the truck category now has a larger proportion of heavier trucks. Following our careful consideration of the public comments on that discussion, we reaffirm the reasoning and conclusions of that discussion.

(b) Stringency

This final rule establishes footprint-based fuel economy standards for MY 2011-2015 passenger cars and light trucks. As noted above, EISA limits to five the number of model years for which standards may be established in a single rulemaking. We are establishing standards for the full five years to maximize the amount of increased fuel economy we can require of the manufacturers. Setting standards as far ahead of time as possible maximizes lead time and makes it possible to require manufacturers to make the changes necessary to achieve the combined industry-wide level of average fuel economy required by MY 2020.

Each vehicle manufacturer's required level of CAFE is based on target levels of average fuel economy set for vehicles of different sizes and on the distribution of that manufacturer’s vehicles among those sizes. Size is defined by vehicle footprint. The curves defining the performance target at each footprint reflect the technological and economic capabilities of the industry. The target for each footprint is the same for all manufacturers, regardless of differences in their overall fleet mix. Compliance will be determined by comparing a manufacturer’s harmonically averaged fleet fuel economy levels in a model year with a required fuel economy level calculated using the manufacturer’s actual production levels and the targets for each footprint of the vehicles that it produces.

The standards were developed with the aid of a computer model (known as the “Volpe Model”). NHTSA uses the Volpe model as a tool to inform its consideration of potential CAFE standards. The Volpe model requires the following types of information as inputs: (1) a forecast of the future vehicle market, (2) estimates of the availability, applicability, and incremental effectiveness and cost of fuel-saving technologies, (3) estimates of vehicle survival and mileage accumulation patterns, the rebound effect, future fuel prices, the social cost of carbon, and many other economic factors, (4) fuel characteristics and vehicular emissions rates, and (5) coefficients defining the shape and level of CAFE curves to be examined. These inputs are selected by the agency based on best available information and data.

The agency analyzed seven regulatory alternatives, one of which maximizes net benefits and is known as the “optimized standards.” The optimized standards are set at levels, such that, considering all of the manufacturers together, no other alternative produces greater net benefits to society. Those net benefits reflect the difference between (1) the present value of all monetized benefits of the standards, and (2) the total costs of all technologies applied in response to the standards. Many of the other alternative standards exceed the point at which net benefits are maximized, including one alternative in which standards are set at a level at which total costs equal total benefits and another alternative set at a level of maximum technology application without regard to cost. For each alternative, the model estimates the costs associated with additional technology utilization, as well as accompanying changes in travel demand, fuel consumption, fuel outlays, emissions, and economic externalities related to petroleum consumption and other factors. These comprehensive analyses, which also included scenarios with different economic input assumptions as presented in the Final Environmental Impact Statement (FEIS) and the Final Regulatory Impact Analysis (FRIA), informed and contributed to the agency's consideration of the "need of the United States to conserve energy," as well as the other statutory factors in 49 U.S.C. § 32902(f), and safety impacts. In addition, they informed the agency's consideration of environmental impacts under NEPA. The agency identified the optimized standards as its preferred alternative in the FEIS.

NHTSA considered the results of analyses conducted on alternative standards by the Volpe model and analyses conducted outside of the Volpe model, including analysis of the impacts of carbon dioxide and criteria pollutant emissions, analysis of technologies that may be available in the long term and whether NHTSA could expedite their entry into the market through these standards, and analysis of the extent to which changes in vehicle prices and fuel economy might affect vehicle production and sales. Using all of this information, the agency considered the governing statutory factors, along with environmental issues and other relevant societal issues such as safety, and is promulgating the maximum feasible standards based on its best judgment on how to balance these factors.

Upon a considered analysis of all information available, including all information submitted to NHTSA in comments, the agency is adopting the "optimized standard" alternative as the final standards.[11] We note that we have used the Volpe Model in two prior CAFE rulemakings and that we adopted "optimized standards" in the last light truck rulemaking. We believe that this continues to be the most objective way to establish reformed standards under EPCA. Further, by limiting the standards to levels that can be achieved using technologies each of which provides benefits that at least equal its costs, the net benefit maximization approach provides a strong assurance of the marketability of the manufacturers' vehicles and thus economic practicability of the standards. This assurance assumes increased importance in view of current and anticipated conditions in the industry in particular and the economy in general. As has been widely reported in the public domain throughout this rulemaking, and as shown in public comments, the national and global economies are in crisis. Even before those recent developments, the automobile manufacturers were already facing substantial difficulties. Together, these problems have made NHTSA's economic practicability analysis particularly important and challenging in this rulemaking.

Automobile sales have dropped significantly. U.S. motor vehicle sales in 2007 were 6 percent below 2005 levels, and 2008 year-to-date sales declined a further 15 percent by comparison with the same period in 2007. October 2008 industry sales were

[11] The agency notes, for NEPA purposes, that the "optimized standard" alternative adopted as the final standards corresponds to the "Optimized Mid-2" scenario described in Section 2.2.2 of the FEIS.

34 percent lower than October 2007.[12] The sales of every major manufacturer declined in the first ten months of 2008.[13] Vehicle manufacturers have not been able to raise prices to offset declining unit sales.[14]

The financial state of the major U.S. automotive manufacturers is particularly difficult, at best. General Motors' year-to-date U.S. vehicle sales are down 21 percent GM last earned an accounting profit in 2004, and has lost a cumulative $72 billion between 2005 and the third quarter of 2008.[15] GM has a negative net worth of $60 billion, and consumed more than $3.5 billion in cash in the third quarter. GM is largely unable to borrow additional funds in capital markets, and must rely on a dwindling pool of cash to fund any further operating losses and capital investments.

Ford Motor Company's 2008 year-to-date U.S. vehicle sales have declined 19 percent. The firm has lost $24 billion since 2006. The firm has a negative net worth of $2 billion, and has consumed some $4.3 billion in cash in the third quarter of 2008.[16] Ford is also largely unable to borrow additional funds in capital markets, and must also rely on a dwindling pool of cash to fund any further operating losses and capital investments.

Chrysler is closely held, and consequently does not publish financial statements. However, Chrysler's 2008 year-to-date unit sales are 26 percent below last year's sales at this time. Chrysler's October sales were off 38 percent. It would be reasonable to

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[12] U.S. Department of Commerce, Bureau of Economic Analysis, Underlying Table Detail, Table 7.25S, "Auto and Truck Unit Sales, Production, Inventories, Expenditures, and Prices." *Available at* http://www.bea.gov.

[13] January-September 2008 vehicle sales based on industry data from Motorintelligence, Inc. *Available at* http://www.motorintelligence.com/m_frameset.html (last accessed Nov 12, 2008). Only Maserati and Subaru showed sales increases.

[14] Commerce Department data indicates no apparent change in nominal prices of new vehicle sales over the past few years. *See supra* note 11.

[15] General Motors Corp. annual reports for 2005-2007, quarterly earnings announcement for the second quarter of 2008. *Available at* http://www.gm.com/corporate/investor_information/earnings/index.jsp (last accessed Nov 12, 2008).

[16] Ford Motor Company, annual reports for 2005-2007, Form 10-Q for second quarter 2008.

assume that a reduction in sales of this magnitude has negatively affected the firm's finances.

The agency cannot set out the exact level of CAFE that each manufacturer will be required to meet for each model year under the passenger car or light truck standards since the levels will depend on information that will not be available until the end of each of the model years, *i.e.,* the final actual production figures for each of those years. The agency can, however, project what the industry-wide level of average fuel economy will be for passenger cars and for light trucks if each manufacturer produced its expected mix of automobiles and just met its obligations under the "optimized" standards for each model year. Adjacent to each average fuel economy figure is the estimated associated level of tailpipe emissions of CO_2 that will be achieved.[17]

For passenger cars:

MY 2011: 30.2 mpg (294 g/mi of tailpipe emissions of CO_2)

MY 2012: 32.1 mpg (277 g/mi of tailpipe emissions of CO_2)

MY 2013: 34.4 mpg (258 g/mi of tailpipe emissions of CO_2)

MY 2014: 35.4 mpg (251 g/mi of tailpipe emissions of CO_2)

MY 2015: 37.1 mpg (240 g/mi of tailpipe emissions of CO_2)

For light trucks:

MY 2011: 24.1 mpg (369 g/mi of tailpipe emissions of CO_2)

MY 2012: 25.1 mpg (354 g/mi of tailpipe emissions of CO_2)

MY 2013: 26.1 mpg (346 g/mi of tailpipe emissions of CO_2)

MY 2014: 26.7 mpg (333 g/mi of tailpipe emissions of CO_2)

MY 2015: 27.1 mpg (328 g/mi of tailpipe emissions of CO_2)

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[17] *See supra* note 6.

The combined industry-wide average fuel economy (in miles per gallon, or mpg) levels (in grams per mile, or g/mi) for both cars and light trucks, if each manufacturer just met its obligations under the “optimized” standards for each model year, will be as follows:

MY 2011: 27.3 mpg (2.0 mpg increase above MY 2010; 326 g/mi CO_2)

MY 2012: 28.7 mpg (1.4 mpg increase above MY 2011; 310 g/mi CO_2)

MY 2013: 30.3 mpg (1.6 mpg increase above MY 2012; 293 g/mi CO_2)

MY 2014: 31.0 mpg (0.7 mpg increase above MY 2013; 287 g/mi CO_2)

MY 2015: 31.8 mpg (0.8 mpg increase above MY 2014; 280 g/mi CO_2)

The annual average increase during this five year period is approximately 4.6 percent. Due to a variety of factors, including the uneven distribution of new model introductions during this period and the fact that significant technological changes can be most readily made in conjunction with those introductions, the annual percentage increases are greater in the early years in this period.

Given a starting point of 31.8 mpg in MY 2015, the average annual increase for MYs 2016-2020 will need to be approximately 1.9 percent in order for the projected combined industry-wide average to reach at least 35 mpg by MY 2020, as mandated by EISA.

In addition, per EISA, each manufacturer’s domestic passenger fleet is required in each model year to achieve 27.5 mpg or 92 percent of the CAFE of the industry-wide combined fleet of domestic and non-domestic passenger cars[18] for that model year, whichever is higher. This requirement results in the following alternative minimum standard (not attribute-based) for domestic passenger cars:

MY 2011: 27.8 mpg (320 g/mi of tailpipe emissions of CO2)

MY 2012: 29.5 mpg (300 g/mi of tailpipe emissions of CO2)

MY 2013: 31.6 mpg (280 g/mi of tailpipe emissions of CO2)

MY 2014: 32.6 mpg (273 g/mi of tailpipe emissions of CO2)

MY 2015: 34.1 mpg (260 g/mi of tailpipe emissions of CO2)

(c) Benefits and costs

(i) Benefits

We estimate that the standards will save approximately 24 billion gallons and reduce tailpipe emissions by 218 million metric tons of CO_2.

For passenger cars, the standards will save approximately 12.2 billion gallons of fuel and reduce tailpipe CO_2 emissions by 112 million metric tons over the lifetime of the passenger cars sold during those model years, compared to the fuel savings and emissions reductions that would occur if the standards remained at the adjusted baseline (*i.e.,* the higher of manufacturer's plans and the manufacturer's required level of average fuel economy for MY 2010). The value of the total benefits of the passenger car standards will be approximately $28 billion[19] over the lifetime of the 5 model years combined. This estimate of societal benefits includes direct impacts from lower fuel consumption as well as externalities and also reflects offsetting societal costs resulting from the rebound effect.

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[18] Those numbers set out several paragraphs above.
[19] The $28 billion estimate is based on a 7 percent discount rate for valuing future impacts.

We estimate that the standards for light trucks will save approximately 11 billion gallons of fuel and prevent the tailpipe emission of 106 million metric tons of CO_2 over the lifetime of the light trucks sold during those model years, compared to the fuel savings and emissions reductions that would occur if the standards remained at the adjusted baseline. The value of the total benefits of the light truck standards will be approximately $26 billion[20] over the lifetime of the 5 model years combined. This estimate of societal benefits includes direct impacts from lower fuel consumption as well as externalities and also reflects offsetting societal costs resulting from the rebound effect.

As in past rulemakings, NHTSA has estimated the amount of fuel savings achieved by new CAFE standards on an incremental basis, relative to the amount of fuel the agency estimates would be consumed if preexisting standards were to remain in place. In the NPRM, NHTSA estimated that, under its proposed standards, light vehicles sold during MY 2011-2015 would, during the course of their useful lives consume 54.7 billion gallons less fuel than would be the case (about 692 billion gallons) if standards in place in MY 2010 were instead applied to the model years.

As discussed earlier, many inputs to NHTSA's analysis have since changed, and the agency has also changed some of its analytical methods. As a result, the standards the agency is promulgating today are different from those proposed in the NPRM, and the agency's estimates of the incremental fuel savings are also different. The variety of factors that contributed to the revised fuel savings estimates for standards adopted today make it difficult to compare the fuel savings estimate reported in the final rule with the estimate reported in the NPRM. Still, NHTSA estimates that, accounting for some of

[20] The $26 billion estimate is based on a 7 percent discount rate for valuing future impacts.

these changes, fuel economy increases induced by the standards promulgated today will result in fuel savings similar to the estimate shown in the NPRM. A significant portion of these fuel savings are, however, attributable to fuel economy increases shown in manufacturers' updated product plans. However, because it is impossible for NHTSA to determine to what extent these increases are truly attributable to EISA, the agency does not "count" these fuel savings in its accounting for the final rule. This difference, and others, between the NPRM and final rule estimates are discussed in the RIA.

The combination of changes to manufacturers' product plans from the NPRM to the final rule together with the additional technologies applied by the Volpe Model to those product plans and other revisions to input assumptions, resulted in an overall CAFE level of 31.8 mpg in MY 2015. Raising the fleet wide fuel economy to 31.8 mpg will save 44.9 billion gallons of gasoline and will reduce tailpipe carbon dioxide emissions by 413 million metric tons over the lifetime of the vehicles manufactured. Approximately 21.3 of the 44.9 billion gallons saved and 196 of the 413 million metric tons of carbon dioxide emissions are attributable to the product plans.

(ii) Costs

NHTSA estimates that, as a result of the final standards for MY 2011-2015, manufacturers will incur costs of approximately $37 billion for additional fuel-saving technologies, compared to the costs they would incur if the standards remained at MY 2010 levels.

For passenger cars, manufacturers will incur costs of approximately $21 billion for additional fuel-saving technologies, compared to the costs they would incur if the standards remained at MY 2010 levels. The resulting vehicle price increases to buyers of

MY 2015 passenger cars will be recovered or paid back[21] in additional fuel savings in an average of 5.9 years (71 months), assuming fuel prices ranging from $3.14 per gallon in 2016 to $3.62 per gallon in 2030.[22]

The agency further estimates that, in response to the final standards for MY 2011-2015 light trucks, manufacturers will incur costs of approximately $16 billion for additional fuel-saving technologies, compared to the costs they would incur if the standards remained at MY 2010 levels. The resulting vehicle price increases to buyers of MY 2015 light trucks will be paid back in additional fuel savings in an average of 4.2 years (51 months), assuming the same fuel prices as mentioned above.

(d) Flexibilities

The above benefit and cost estimates do not reflect the availability and use of flexibility mechanisms, such as compliance credits and credit trading because EPCA prohibits NHTSA from considering the effects of those mechanisms in setting CAFE standards. EPCA has precluded consideration of the FFV adjustments ever since it was amended to provide for those adjustments. The prohibition against considering compliance credits was added by EISA.

The benefit and compliance cost estimates used by the agency in determining the maximum feasible level of the CAFE standards assume that manufacturers will rely solely on the installation of fuel economy technology to achieve compliance with the standards. In reality, however, manufacturers are likely to rely to some extent on

[21] See Section V.B.5 below for discussion of payback period.
[22] The fuel prices (shown here in 2007 dollars) used to calculate the length of the payback period are those projected (Annual Energy Outlook 2008) by the Energy Information Administration over the life of the MY 2011-2015 light trucks, not current fuel prices.

flexibility mechanisms provided by EPCA (as described in Section XII) and will thereby reduce the cost of complying with the standards to a meaningful extent.

4. Credits

NHTSA is also adopting a new Part 536 on use of "credits" earned for exceeding applicable CAFE standards. Part 536 will implement the provisions in EISA authorizing NHTSA to establish by regulation a credit trading program and directing it to establish by regulation a credit transfer program.[23] Since its enactment, EPCA has permitted manufacturers to earn credits for exceeding the standards and to apply those credits to compliance obligations in years other than the model year in which it was earned. EISA extended the "carry-forward" period to five model years, and left the "carry-back" period at three model years. Under Part 536, credit holders (including, but not limited to, manufacturers) will have credit accounts with NHTSA, and will be able to hold credits, apply them to compliance with CAFE standards, transfer them to another "compliance category" for application to compliance there, or trade them. A credit may also be cancelled before its expiry date, if the credit holder so chooses. Traded credits will be subject to an "adjustment factor" to ensure total oil savings are preserved, as required by EISA. EISA also prohibits credits earned before MY 2011 from being transferred, so NHTSA has developed several regulatory restrictions on trading and transferring to facilitate Congress' intent in this regard. Additional information on Part 536 is available in Section XII below.

5. Preemption

[23] Congress required that DOT establish a credit "transferring" regulation, to allow individual manufacturers to move credits from one of their fleets to another (*e.g.*, using a credit earned for exceeding the light truck standard for compliance with the domestic passenger car standard). Congress allowed DOT to establish a credit "trading" regulation, so that credits may be bought and sold between manufacturers and other parties.

The following statements about preemption apply to State regulations regulating greenhouse gas (GHG) tailpipe emissions, particularly to the extent that they regulate CO_2 tailpipe emissions.

To the extent that any state regulation regulates GHG tailpipe emissions from automobiles, such a regulation relates to average fuel economy standards within the meaning of 49 USC 32919. As a state regulation related to fuel economy standards, any state regulation regulating tailpipe GHG emissions from automobiles is expressly preempted under 49 U.S.C. 32919.

A state regulation regulating tailpipe GHG emissions from automobiles, particularly a regulation that is not attribute-based and does not separately regulate passenger cars and light trucks, conflicts with

1. The fuel economy standards established in 49 CFR Parts 531 and 533,
2. The judgments made by the agency in establishing those standards, and
3. The achievement of the objectives of EPCA, including objectives relating to reducing fuel consumption in a manner and to the extent consistent with manufacturer flexibility, consumer choice, and automobile safety.

Any state regulation regulating tailpipe GHG emissions from automobiles is impliedly preempted under 49 U.S.C. Chapter 329.

II. Background

A. Contribution of fuel economy improvements to addressing energy independence, energy security, and climate change

1. Relationship between fuel economy and CO_2 tailpipe emissions

Improving fuel economy reduces the amount of tailpipe emissions of CO_2. CO_2 emissions are directly linked to fuel consumption because CO_2 is the ultimate end product of burning gasoline. The more fuel a vehicle burns, the more CO_2 it emits. Since the amount of CO_2 emissions is essentially constant per gallon of fuel combusted, the amount of fuel consumption per mile is directly related to the amount of CO_2 emissions per mile. Thus, requiring improvements in fuel economy necessarily has the effect of requiring reductions in tailpipe emissions of CO_2 emissions. This can be seen in the table below. To take the first value of fuel economy from the table below as an example, a standard of 21.0 mpg would indirectly place substantially the same limit on tailpipe CO_2 emissions as a tailpipe CO_2 emission standard of 423.2 g/mi of CO_2, and vice versa.[24]

Indeed, in order to reduce the amount of tailpipe emissions of CO_2 per mile, you must reduce the amount of fuel consumed per mile. The technologies for reducing tailpipe emissions of CO_2 are the technologies that reduce fuel consumption and thereby reduce CO_2 emissions as well. While there are emission control technologies that can capture or destroy the pollutants (*e.g.*, carbon monoxide) that are produced by imperfect combustion of fuel, there is no such technology for CO_2.

[24] To the extent that manufacturers comply with a CAFE standard with diesel automobiles instead of gasoline ones, the level of CO_2 tailpipe emissions would be higher. As noted above, the agency projects that 4 percent of the MY 2015 passenger car fleet and 10 percent of the MY 2015 light truck fleet will have diesel engines. The CO_2 tailpipe emissions of a diesel powered passenger car are 15 percent per mile higher than those of a comparable gasoline powered-passenger car achieving the same mpg.

Table II-1

CAFE Standards (mpg) and the Limits They Indirectly Place on Tailpipe Emissions of CO_2 (g/mi)*											
CAFE Std	CO_2	CAFE Std	CO_2	CAFE Std	CO_2	CAFE Std	CO_2	CAFE Std	CO_2	CAFE Std	CO_2
21.0	423.2	**26.0**	341.8	**31.0**	286.7	**36.0**	246.9	**41.0**	216.8	**46.0**	193.2
22.0	404.0	**27.0**	329.1	**32.0**	277.7	**37.0**	240.2	**42.0**	211.6	**47.0**	189.1
23.0	386.4	**28.0**	317.4	**33.0**	269.3	**38.0**	233.9	**43.0**	206.7	**48.0**	185.1
24.0	370.3	**29.0**	306.4	**34.0**	261.4	**39.0**	227.9	**44.0**	202.0	**49.0**	181.4
25.0	355.5	**30.0**	296.2	**35.0**	253.9	**40.0**	222.2	**45.0**	197.5	**50.0**	177.7

***** This table is based on calculations that use the figure of 8,887 grams of CO_2 per gallon of gasoline consumed, based on characteristics of gasoline vehicle certification fuel. To convert a mpg value into CO_2 g/mi, divide 8,887 by the mpg value.

2. Fuel economy improvements/CO_2 tailpipe emission reductions since 1975

The need to take action to reduce GHG emissions, *e.g.,* motor vehicle tailpipe emissions of CO_2, in order to forestall and even mitigate climate change is well recognized.[25] Less well recognized are two related facts.

First, improving fuel economy is the only method available to motor vehicle manufacturers for making substantial reductions in the CO_2 tailpipe emissions of motor vehicles and thus must be the core element of any effort to achieve those reductions.

Second, the significant improvements in fuel economy since 1975, due to the CAFE standards and other market conditions as well, have directly caused reductions in the rate of CO_2 tailpipe emissions per vehicle.

In 1975, passenger cars manufactured for sale in the U.S. averaged only 15.8 mpg (562.5 grams of CO_2 per mile or 562.5 g/mi of CO_2). By 2007, the average fuel economy of new passenger cars had increased to 31.3 mpg, causing g/mi of CO_2 to fall to 283.9. Similarly, in 1975, light trucks produced for sale in the U.S. averaged 13.7 mpg (648.7 g/mi of CO_2). By 2007, the average fuel economy of new light trucks had risen to 23.1 mpg, causing g/mi of CO_2 to fall to 384.7.

[25] IPCC (2007): *Climate Change 2007: Mitigation of Climate Change. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [B. Metz, O. Davidson, P. Bosch, R. Dave, and L. Meyer (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Table II-2

Improvements in MPG/Reductions in G/MI of CO_2 **Passenger Cars** 1975-2007		
	MPG	G/MI of CO_2
1975	15.8	562.5
2007	31.3	283.9

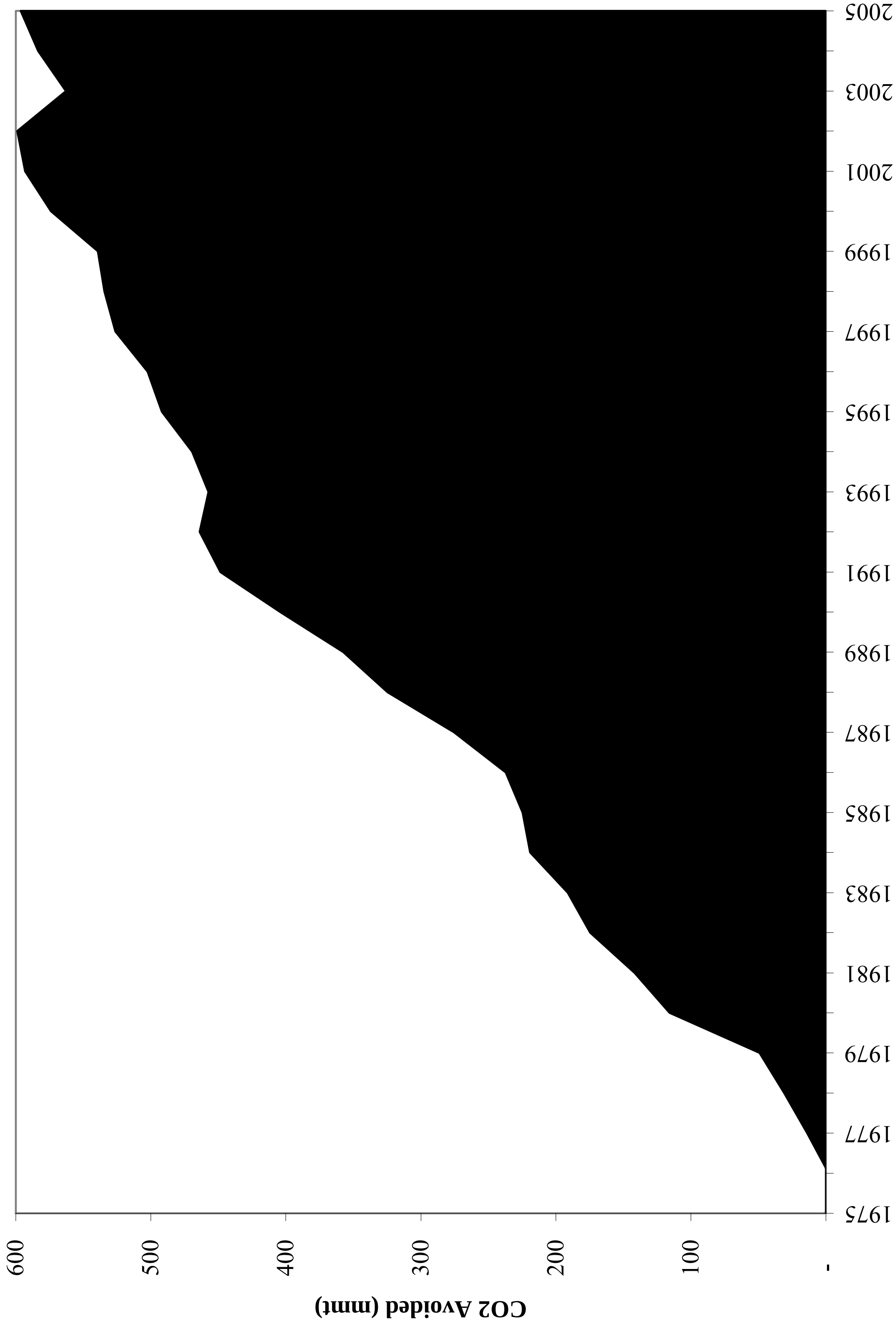
Table II-3

Improvements in MPG/Reductions in G/MI of CO_2 **Light Trucks** 1975-2007		
	MPG	G/MI of CO_2
1975	13.7	648.7
2007	23.1	384.7

If fuel economy had not increased above the 1975 level, cars and light trucks would have emitted an additional 11 billion metric tons of CO_2 into the atmosphere between 1975 and 2005. That is nearly the equivalent of emissions from all U.S. fossil fuel combustion for two years (2004 and 2005). The figure below shows the amount of CO_2 emissions avoided due to increases in fuel economy.

Figure II-1. CO_2 tailpipe emissions avoided due to increases in fuel economy

1975-2005



Some commenters on the NPRM argued that some of improvements in fuel economy and thus some of the reductions in CO_2 shown in that figure would have occurred in the absence of any CAFE standards. We agree, but note that no published research has isolated the contribution of CAFE standards themselves to historical increases in fuel economy from those of the many other factors that can affect fuel economy.

Similarly, and to the same extent, some of the improvements in fuel economy and accompanying reductions in CO_2 that would occur under a regulation directly regulating CO_2 would occur in the absence of any such regulation. This would be not merely likely, but certain, given the continuing mandate for CAFE standards.

A CAFE standard and its mathematically equivalent CO_2 tailpipe emission standard would each have the same effect on those emissions and thus on the risk of harm due to climate change, except to the extent, as noted in a footnote above, that diesel engines are used to comply with the CAFE standards. Thus, the marginal benefit of putting into effect and implementing a regulation directly regulating CO_2 emissions would be limited to those reductions over and above those resulting from the CAFE standards.

B. Chronology of events since the National Academy of Sciences called for reforming and increasing CAFE standards

1. National Academy of Sciences issues report on future of CAFE program (February 2002)

(a) Significantly increasing CAFE standards without reforming them would adversely affect safety

In the 2002 congressionally-mandated report entitled "Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards,"[26] a committee of the National Academy of Sciences (NAS) ("2002 NAS Report") concluded that the then-existing form of passenger car and light truck CAFE standards permitted vehicle manufacturers to comply in part by downweighting and even downsizing their vehicles and that these actions had led to additional fatalities. The committee explained that this safety problem arose because the CAFE standards subjected all passenger cars to the same fuel economy target and all light trucks to the same target, regardless of their weight, size, or load-carrying capacity.[27] The committee said that this experience suggests that consideration should be given to developing a new system of fuel economy targets that reflects differences in such vehicle attributes.

Looking to the future, the committee said that while it was technically feasible and potentially economically practicable to improve fuel economy without reducing vehicle weight or size and, therefore, without significantly affecting the safety of motor vehicle travel, the actual strategies chosen by manufacturers to improve fuel economy would depend on a variety of factors. In the committee's judgment, the extensive downweighting and downsizing that occurred after fuel economy requirements were established in the 1970s suggested that the likelihood of a similar response to further

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[26] National Research Council, "Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards," National Academy Press, Washington, DC (2002). *Available at* http://www.nap.edu/openbook.php?isbn=0309076013 (last accessed October 22, 2008). The conference committee report for the Department of Transportation and Related Agencies Appropriations Act for FY 2001 (Pub. L. 106-346) directed NHTSA to fund a study by NAS to evaluate the effectiveness and impacts of CAFE standards (H. Rep. No. 106-940, p. 117-118). In response to the direction from Congress, NAS published this lengthy report.

[27] NHTSA has used this approach for CAFE standards, but will cease doing so after Model Year 2010. California seeks to begin using this approach for its greenhouse gas standards for passenger cars and light trucks.

increases in fuel economy requirements must be considered seriously. Any reduction in vehicle size and weight would have safety implications.

The committee said, "to the extent that the size and weight of the fleet have been constrained by CAFE requirements … those requirements have caused more injuries and fatalities on the road than would otherwise have occurred."[28] Specifically, it noted: "the downweighting and downsizing that occurred in the late 1970s and early 1980s, some of which was due to CAFE standards, probably resulted in an additional 1300 to 2600 traffic fatalities in 1993."[29]

The committee cautioned that the safety effects of future downsizing and downweighting were likely to be hidden by the generally increasing safety of the light-duty vehicle fleet.[30] It said that some might argue that this improving safety picture means that there is room to improve fuel economy without adverse safety consequences; however, such an approach would not achieve the goal of avoiding the adverse safety consequences of fuel economy increases. Rather, the safety penalty imposed by increased fuel economy (if weight reduction were used as one of the fuel economy improving measures) would be more difficult to identify in light of the continuing improvement in vehicle safety. NAS said that although it anticipated that these safety innovations would improve the safety of vehicles of all sizes, that fact did not mean downsizing to achieve fuel economy improvements would not have any safety costs. If two vehicles of the same size were modified, one both by downsizing it and adding the safety innovations and the other solely by adding safety innovations, the latter vehicle would in all likelihood be safer.

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[28] NAS, p. 29.
[29] NAS, p. 3 (Finding 2).
[30] Two of the 12 members of the committee dissented from the majority's safety analysis and conclusions.

The committee concluded that if an increase in fuel economy were implemented pursuant to standards that were structured so as to encourage either downsizing or the increased production of smaller vehicles, some additional traffic fatalities would be expected. It said that the larger and faster the required increases, the more likely adverse impacts. Without a thoughtful restructuring of the program, there would be the trade-offs that must be made if CAFE standards were increased by any significant amount.[31]

In response to these conclusions, NHTSA began issuing attribute-based CAFE standards for light trucks and sought legislative authority to issue attribute-based CAFE standards for passenger cars before undertaking to raise the car standards. Congress went a step further in enacting EISA, not only authorizing the issuance of attribute-based standards, but also mandating them.

Fully realizing all of the safety and other[32] benefits of these reforms will depend in part on whether the unreformed, non-attribute based GHG standards adopted by California and other states are implemented. Apart from issues of relative stringency, the effects on vehicle manufacturers of implementing those state emission standards would

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[31] NAS, p. 9.

[32] Reformed CAFE has several advantages compared to Unreformed CAFE:

First, Reformed CAFE increases energy savings. The energy-saving potential of Unreformed CAFE is limited because only a few full-line manufacturers are required to make improvements. Under Reformed CAFE, which accounts for size differences in product mix, virtually all manufacturers will be required to use advanced fuel-saving technologies to achieve the requisite fuel economy for their automobiles.

Second, Reformed CAFE reduces the chances of adverse safety consequences. Downsizing of vehicles as a CAFE compliance strategy is discouraged under Reformed CAFE since as vehicles become smaller, the applicable fuel economy target becomes more stringent.

Third, Reformed CAFE provides a more equitable regulatory framework for different vehicle manufacturers. Under Unreformed CAFE, the cost burdens and compliance difficulties have been imposed nearly exclusively on the full-line manufacturers.

Fourth, Reformed CAFE is more market-oriented because it more fully respects economic conditions and consumer choice. Reformed CAFE does not force vehicle manufacturers to adjust fleet mix toward smaller vehicles although they can make adjustments if that is what consumers are demanding. Instead, it allows the manufacturers to adjust the mix of their product offerings in response to the market place.

be substantially similar to the effects of implementing non-attribute-based CAFE standards, given the nearly identical nature of most aspects of those emission standards and CAFE standards in terms of technological means of compliance and methods of measuring performance.

(b) Climate change and other externalities justify increasing the CAFE standards

The 2002 NAS report also concluded that the CAFE standards have increased fuel economy, which in turn has reduced dependence on imported oil, improved the nation's terms of trade, and reduced emissions of carbon dioxide, (a principal GHG), relative to what they otherwise would have been. If fuel economy had not improved, gasoline consumption (and crude oil imports) in 2002 would have been about 2.8 million barrels per day (mmbd) greater than it was then.[33] As noted above, reducing fuel consumption in vehicles also reduces carbon dioxide emissions. If the nation were using 2.8 mmbd more gasoline in 2002, carbon emissions would have been more than 100 million metric tons of carbon (mmtc) higher. Thus, improvements in light-duty vehicle (4 wheeled motor vehicles under 10,000 pounds gross vehicle weight rating) fuel economy reduced overall U.S. emissions by about 7 percent as of 2002.[34]

The report concluded that technologies exist that could significantly reduce fuel consumption by passenger cars and light trucks further within 15 years (*i.e.,* by about 2017), while maintaining vehicle size, weight, utility and performance.[35] Given their lower fuel economy, light duty trucks were said to offer the greatest potential for

[33] NAS, pp. 3 and 20.
[34] NAS, p. 20.
[35] NAS, p. 3 (Finding 5).

reducing fuel consumption.[36] The report also noted that vehicle development cycles – as well as future economic, regulatory, safety and consumer preferences – would influence the extent to which these technologies could lead to increased fuel economy in the U.S. market.

To assess the economic trade-offs associated with the introduction of existing and emerging technologies to improve fuel economy, the NAS conducted what it called a "cost-efficient analysis" based on the direct benefits (value of saved fuel) to the consumer -- "that is, the committee identified packages of existing and emerging technologies that could be introduced over the next 10 to 15 years that would improve fuel economy up to the point where further increases in fuel economy would not be reimbursed by fuel savings."[37]

The committee emphasized that it is critically important to be clear about the reasons for considering improved fuel economy. While it said that the dollar value of the saved fuel would be the largest portion of the potential benefits, the committee noted that there is theoretically insufficient reason for the government to issue higher standards just to obtain those direct benefits since consumers have a wide variety of opportunities to buy a fuel-efficient vehicle.[38]

The committee said that there are two compelling concerns that justify a government-mandated increase in fuel economy, both relating to externalities. The first and most important concern, it argued, is the accumulation in the atmosphere of greenhouse gases, principally carbon dioxide.[39]

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[36] NAS, p. 4 (Finding 5).
[37] NAS, pp. 4 (Finding 6) and 64).
[38] NAS, pp. 8-9.
[39] NAS, pp. 2, 13, and 83.

A second concern is that petroleum imports have been steadily rising because of the nation's increasing demand for gasoline without a corresponding increase in domestic supply. The high cost of oil imports poses two risks: downward pressure on the strength of the dollar (which drives up the cost of goods that Americans import) and an increase in U.S. vulnerability to macroeconomic shocks that cost the economy considerable real output.

To determine how much the fuel economy standards should be increased, the committee urged that all social benefits be considered. That is, it urged not only that the dollar value of the saved fuel be considered, but also that the dollar value to society of the resulting reductions in greenhouse gas emissions and in dependence on imported oil should be calculated and considered. The committee said that if it is possible to assign dollar values to these favorable effects, it becomes possible to make at least crude comparisons between the socially beneficial effects of measures to improve fuel economy on the one hand, and the costs (both out-of-pocket and more subtle) on the other. The committee chose a value of about $0.30/gal of gasoline for the externalities associated with the combined impacts of fuel consumption on greenhouse gas emissions and on world oil market conditions.[40]

The report expressed concerns about increasing the standards under the CAFE program as currently structured. While raising CAFE standards under the existing structure would reduce fuel consumption, doing so under alternative structures "could accomplish the same end at lower cost, provide more flexibility to manufacturers, or address inequities arising from the present" structure.[41]

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[40] NAS, pp. 4 and 85-86.
[41] NAS, pp. 4-5 (Finding 10).

To address those structural problems, the report suggested various possible reforms. The report found that the "CAFE program might be improved significantly by converting it to a system in which fuel targets depend on vehicle attributes."[42] The report noted further that under an attribute-based approach, the required CAFE levels could vary among the manufacturers based on the distribution of their product mix. NAS stated that targets could vary among passenger cars and among trucks, based on some attribute of these vehicles such as weight, size, or load-carrying capacity. The report explained that a particular manufacturer's average target for passenger cars or for trucks would depend upon the fractions of vehicles it sold with particular levels of these attributes.[43]

2. NHTSA issues final rule establishing reformed (attribute-based) CAFE standards for MY 2008-2011 light trucks (March 2006)

The 2006 final rule reformed the structure of the CAFE program for light trucks by introducing an attribute-based approach and using that approach to establish higher CAFE standards for MY 2008-2011 light trucks.[44] Reforming the CAFE program enables it to achieve larger fuel savings, while enhancing safety and preventing adverse economic consequences.

As noted above, under Reformed CAFE, fuel economy standards were restructured so that they are based on a vehicle attribute, a measure of vehicle size called "footprint." It is the product of multiplying a vehicle's wheelbase by its track width. A target level of fuel economy was established for each increment in footprint (0.1 ft^2). Trucks with smaller footprints have higher fuel economy targets; conversely, larger ones

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42 NAS, p. 5 (Finding 12).
43 NAS, p. 87.
44 71 FR 17566; April 6, 2006.

have lower targets. A particular manufacturer's compliance obligation for a model year is calculated as the harmonic average of the fuel economy targets for the manufacturer's vehicles, weighted by the distribution of the manufacturer's production volumes among the footprint increments. Thus, each manufacturer is required to comply with a single overall average fuel economy level for each model year of production.

The approach for determining the fuel economy targets was to set them just below the level where the increased cost of technologies that could be adopted by manufacturers to improve fuel economy would first outweigh the added benefits that would result from those technologies. These targets translate into required levels of average fuel economy that are technologically feasible because manufacturers can achieve them using technologies that are or will become available. Those levels also reflect the need of the nation to reduce energy consumption because they reflect the economic value of the savings in resources, as well as of the reductions in economic and environmental externalities that result from producing and using less fuel.

We carefully balanced the costs of the rule with the benefits of reducing energy consumption. Compared to Unreformed (non-attributed-based) CAFE, Reformed CAFE enhances overall fuel savings while providing vehicle manufacturers with the flexibility they need to respond to changing market conditions. Reformed CAFE also provides a more equitable regulatory framework by creating a level playing field for manufacturers, regardless of whether they are full-line or limited-line manufacturers. We were particularly encouraged that Reformed CAFE will confer no compliance advantage if vehicle makers choose to downsize some of their fleet as a CAFE compliance strategy, thereby reducing the adverse safety risks associated with the Unreformed CAFE program.

3. President announces Twenty-in-Ten Initiative (January 2007)

In his January 2007 State of the Union address, the President announced his Twenty-in-Ten initiative for increasing the supply of renewable and alternative fuels and reforming and increasing the CAFE standards. Consistent with the NAS report, he urged the authority be provided to reform CAFE for passenger cars by adopting an attribute-based system (for example, a size-based system) that reduces the risk that vehicle safety is compromised, helps preserve consumer choice, and helps spread the burden of compliance across all product lines and manufacturers. He also urged that authority be provided to set the CAFE standards, based on cost/benefit analysis, using sound science, and without impacting safety. He set specific fuel saving goals based in part on the assumption that passenger car and light truck CAFE standards would be increased 4 percent annually through at least 2017.

4. Supreme Court issues decision in Massachusetts v. EPA (April 2007)

On April 2, 2007, the U.S. Supreme Court issued its opinion in *Massachusetts v. EPA,*[45] a case involving a 2003 order of the Environmental Protection Agency (EPA) denying a petition for rulemaking to regulate greenhouse gas emissions from motor vehicles under the Clean Air Act.[46] The Court ruled that the state of Massachusetts had standing to sue EPA because it had already lost a small amount of land and stood to lose more due to global warming-induced increases in sea level; that some undefined, small portion of this harm was traceable to the absence of a regulation issued by EPA requiring reductions in

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[45] 127 S.Ct. 1438 (2007).
[46] 68 FED. REG 52922, September 8, 2003.

GHG emissions (CO_2 emissions, most notably) by motor vehicles; and that EPA's issuance of such a regulation would reduce the risk of further harm to Massachusetts.[47] On the merits, the Court ruled that greenhouse gases are "pollutants" under the Clean Air Act and that the Act therefore authorizes EPA to regulate greenhouse gas emissions from motor vehicles if that agency makes the necessary findings and determinations under section 202 of the Act.

The Court considered EPCA briefly, stating

> that DOT sets mileage standards in no way licenses EPA to shirk its environmental responsibilities. EPA has been charged with protecting the public's "health" and "welfare," 42 U.S.C. § 7521(a)(1), a statutory obligation wholly independent of DOT's mandate to promote energy efficiency. See Energy Policy and Conservation Act, § 2(5), 89 Stat. 874, 42 U.S.C. § 6201(5). The two obligations may overlap, but there is no reason to think the two agencies cannot both administer their obligations and yet avoid inconsistency.

127 S.Ct. at 1462.

The Supreme Court did not address or define the nature or extent of the overlap or explore either the underlying science of fuel economy improvement and CO_2 tailpipe emission reduction or the types of benefits considered in establishing the levels of the CAFE standards. Further, the Court did not address the express preemption provision in EPCA.

[47] As noted above, a CAFE standard and its mathematically equivalent CO_2 tailpipe emission standard would each have the same effect on those emissions and thus on the risk of further harm except to the extent, as noted in a footnote above, diesel engines are used to comply with the CAFE standards.

The context of the Court's statement about avoiding inconsistency[48] was the concern that EPA had expressed in its petition denial order that issuing standards regulating CO_2 tailpipe emissions could interfere with the CAFE standards:

> Given that the only practical way of reducing tailpipe CO2 emissions is by improving fuel economy, any EPA effort to set CO2 tailpipe standards under the CAA would either abrogate EPCA's regime (if the standards were effectively more stringent than the applicable CAFE standard) or be meaningless (if they were effectively less stringent).[49]

The Court did not define or discuss its concept of consistency.

5. NHTSA and EPA coordinate on development of rulemaking proposals (Summer-Fall 2007)

In the wake of the Supreme Court's decision and in the-then absence of the legislation he called for in his 2007 State of the Union message, the President called on NHTSA and EPA to take the first steps toward regulations that would cut gasoline consumption and greenhouse gas emissions from motor vehicles, using his Twenty-in-Ten initiative as a starting point. He also issued an executive order directing all of the departments and agencies to work together on the proposal.

Pursuant to the President's directive, NHTSA and EPA staff jointly assessed which technologies would be available and their effectiveness and cost. They also jointly assessed the key economic and other assumptions affecting the stringency of future standards. Finally, they worked together in updating and further improving the Volpe model that had been used to help determine the stringency of the MY 2008-2011 light truck CAFE standards. Much of the work between NHTSA and EPA staff was reflected

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48 In the same vein, the Supreme Court noted three paragraphs later: "EPA no doubt has significant latitude as to the manner, timing, content, and coordination of its regulations with those of other agencies." 127 S.Ct. at 1462.

49 68 FED. REG 52922, 52929.

in rulemaking proposals being developed by NHTSA prior to the enactment of EISA and was substantially retained when NHTSA revised its proposals to be consistent with that legislation. Ultimately, the NPRM published by the agency in May and today's final rule are based on NHTSA's assessments of how they meet EPCA, as amended by EISA.

6. Ninth Circuit issues decision re final rule for MY 2008-2011 light trucks (November 2007)

On November 15, 2007, the United States Court of Appeals for the Ninth Circuit issued its decision in *Center for Biological Diversity v. NHTSA*,[50] the challenge to the MY 2008-11 light truck CAFE rule. The Court rejected the petitioners' argument that EPCA precludes the use of a marginal cost-benefit analysis that attempted to weigh all of the social benefits (*i.e.*, externalities as well as direct benefits to consumers) of improved fuel savings in determining the stringency of the CAFE standards.

The Court found that NHTSA had been arbitrary and capricious in the following respects:

- NHTSA's decision that it could not monetize the benefit of reducing CO_2 emissions for the purpose of conducting its marginal benefit-cost analysis based on its view that the value of the benefit of CO_2 emission reductions resulting from fuel consumption reductions was too uncertain to permit the agency to determine a value for those emission reductions;[51]

[50] 508 F.3d 508.

[51] As noted above in the preamble, the agency has developed a value for those reductions and used it in the analyses underlying the standards adopted in this final rule. For further discussion, see Section V of this preamble.

- NHTSA's lack, in the Court's view, of a reasoned explanation for its decision not to establish a "backstop" (*i.e.*, a fixed minimum CAFE standard applicable to manufacturers);[52]

- NHTSA's lack, again in the Court's view, of a reasoned explanation for its decision not to revise the regulatory definitions for the passenger car and light truck categories of automobiles so that some vehicles currently classified as light trucks are instead classified as passenger cars;[53]

- NHTSA's decision not to subject most medium- and heavy-duty pickups and most medium- and heavy-duty cargo vans (*i.e.*, those between 8,500 and 10,000 pounds gross vehicle weight rating (GVWR,) to the CAFE standards;[54]

- NHTSA's decision to prepare and publish an Environmental Assessment (EA) and making a finding of no significant impact notwithstanding what the Court found to be an insufficiently broad range of alternatives, insufficient analysis of the climate change effects of the CO_2 emissions, and limited assessment of cumulative impacts in its EA under the National Environmental Policy Act (NEPA).[55]

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[52] EISA's requirement that standards be based on one or more vehicle attributes appears to preclude the specification of such a backstop standard for the latter two categories of automobiles. For further discussion, see Section VI of this preamble.

[53] In the final rule, NHTSA moved 1.4 million 2 wheel drive SUVs from the light truck class to the passenger car class. It also re-examined the legislative history of the statutory definitions of "automobile" and "passenger automobile" and the term "nonpassenger automobile" and analyzed the impact of that moving any vehicles out of the nonpassenger automobile (light truck) category into the passenger automobile (passenger car) category would have the level of standards for both groups of automobiles. For further discussion, see Section XI of this preamble.

[54] EISA removed these vehicles from the statutory definition of "automobile" and mandated the establishment of CAFE standards for them following the completion of reports by the National Academy of Sciences and NHTSA.

[55] On February 6, 2008, the Government petitioned for en banc rehearing by the 9th Circuit on the limited issue of whether it was appropriate for the panel, having held that the agency insufficiently explored the environmental implications of the MY 2008-11 rulemaking in its EA, to order the agency to prepare an EIS rather than simply remanding the matter to the agency for further analysis. The Court subsequently modified its order as described below.

The Court did not vacate the standards, but instead said it would remand the rule to NHTSA to promulgate new standards consistent with its opinion "as expeditiously as possible and for the earliest model year practicable.[56] Under the decision, the standards established by the April 2006 final rule would remain in effect unless and until amended by NHTSA. In addition, it directed the agency to prepare an Environmental Impact Statement.

As of the date of the issuance of this final rule, the Court has not yet issued its mandate in this case.

7. Congress enacts Energy Security and Independence Act of 2007 (December 2007)

As noted above in Section I.B., EISA significantly changed the provisions of EPCA governing the establishment of future CAFE standards. These changes made it necessary for NHTSA to pause in its efforts so that it could assess the implications of the amendments made by EISA and then, as required, revise some aspects of the proposals it had been developing (*e.g.,* the model years covered and credit issues).

8. President announces goal of stopping growth of U.S. greenhouse gas emissions by 2025 (April 2008)

On April 16, 2008, the President announced a goal of stopping the growth of U.S. greenhouse gas emissions by 2025. He cautioned against attempting to achieve this goal

[56] The deadline in EPCA for issuing a final rule establishing, for the first time, a CAFE standard for a model year is 18 months before the beginning of that model year. 49 U.S.C. 32902(g)(2). The same deadline applies to issuing a final rule amending an existing CAFE standard so as to increase its stringency. Given that the agency has long regarded October 1 as the beginning of a model year, the statutory deadline for increasing the MY 2009 standard was March 30, 2007, and the deadline for increasing the MY 2010 standard is March 30, 2008. Thus, the only model year for which there was sufficient time at the time of the Court's decision to gather all of the necessary information, conduct the necessary analyses and complete a rulemaking was MY 2011. As noted earlier in this notice, however, EISA requires that a new standard be established for that model year. This rulemaking was conducted pursuant to that requirement.

by unilaterally imposing regulatory costs that put American businesses at a disadvantage with their competitors abroad -- which would simply drive American jobs overseas and increase emissions there. He urged instead that all major economies be bound to act together and to that end said that the U.S. should work cooperatively with its partners for a fair and effective international climate agreement.

9. NHTSA proposes CAFE standards for MYs 2011-2015 and requests new product plans for those years (April 2008)[57]

10. NHTSA contracts with ICF International to conduct climate modeling and other analyses in support of draft and final environmental impact statements (May 2008)

NHTSA contracted with ICF International (ICF) to support it in conducting its environmental analyses and preparing the draft and final environmental impact statements. ICF provides consulting services and technology solutions in energy, climate change, environment, transportation, social programs, health, defense, and emergency management.

11. Manufacturers submit new product plans (June 2008)

These product plans identify which vehicle models manufacturers intend to build and which technologies the manufacturers intend to apply and when to their vehicles. NHTSA begins its analysis of future CAFE standards with the product plans and uses them to establish a baseline, which is then used to evaluate different potential levels of future CAFE stringency.

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[57] A description of the NPRM appears earlier in this preamble.

12. NHTSA contracts with Ricardo to aid in assessing public comments on cost and effectiveness of fuel saving technologies (June 2008)

NHTSA received numerous public comments on the types of potential fuel saving technologies that we discussed in the NPRM, their costs and effectiveness in improving fuel economy, and in which model year and to which vehicles they may be applied. To aid the agency in analyzing and responding to these comments, and to ensure that the analysis for the final rule is thorough and robust, NHTSA contracted with Ricardo, a highly reputable and neutral source of outside expertise in the areas of powertrain and vehicle technologies. NHTSA chose Ricardo because of its extensive experience and expertise in working with both government and industry on fuel economy-improving technology issues.

13. Ninth Circuit revises its decision re final rule for MY 2008-2011 light trucks (August 2008)

In response to the Government petition for rehearing, the Ninth Circuit modified its decision by replacing its direction to prepare an EIS with a direction to prepare either a new EA or, if necessary, an EIS.[58]

14. EPA publishes notice announcing availability of NHTSA's final environmental impact statement (October 2008)

On October 17, 2008, EPA published a notice announcing the availability of NHTSA's final environmental impact statement (FEIS) for this rulemaking.[59] Throughout the FEIS, NHTSA relied extensively on findings of the United Nations

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[58] *See* CBD v. NHTSA, 538 F.3d 1172 (9th Cir. 2008).
[59] 73 FED. REG. 61859.

Intergovernmental Panel on Climate Change (IPCC) and the U.S. Climate Change Science Program (USCCSP). In particular, the agency relied heavily on the most recent, thoroughly peer-reviewed, and credible assessments of global climate change and its impact on the United States: the IPCC Fourth Assessment Report Working Group I4 and II5 Reports, and reports by the USCCSP that include *Scientific Assessments of the Effects of Global Climate Change on the United States* and Synthesis and Assessment Products.

In the FEIS, NHTSA compared the environmental impacts of its preferred alternative and those of reasonable alternatives. It considered direct, indirect, and cumulative impacts and describes these impacts to inform the decisionmaker and the public of the environmental impacts of the various alternatives.

Among other potential impacts, NHTSA analyzed the direct and indirect impacts related to fuel and energy use, emissions, including carbon dioxide and its effects on temperature and climate change, air quality, natural resources, and the human environment. Specifically, the FEIS used a climate model to estimate and report on four direct and indirect effects of climate change, driven by alternative scenarios of GHG emissions, including:

1. Changes in CO_2 concentrations;
2. Changes in global mean surface temperature;
3. Changes in regional temperature and precipitation; and
4. Changes in sea level.

NHTSA also considered the cumulative impacts of the proposed standards for MY 2011-2015 passenger cars and light trucks, together with estimated impacts of

NHTSA's implementation of the CAFE program through MY 2010 and NHTSA's future CAFE rulemaking for MYs 2016-2020.

C. Energy Policy and Conservation Act, as amended

EPCA, which was enacted in 1975, mandates a motor vehicle fuel economy regulatory program to meet the various facets of the need to conserve energy, including ones having environmental and foreign policy implications. EPCA allocates the responsibility for implementing the program between NHTSA and EPA as follows: NHTSA sets CAFE standards for passenger cars and light trucks; EPA calculates the average fuel economy of each manufacturer's passenger cars and light trucks; and NHTSA enforces the standards based on EPA's calculations.

We have summarized below EPCA, as amended by EISA.

1. Vehicles subject to standards for automobiles

With two exceptions specified in EPCA, all four-wheeled motor vehicles with a gross vehicle weight rating of 10,000 pounds or less will be subject to the CAFE standards, beginning with MY 2011. The exceptions will be work trucks[60] and multi-stage vehicles. Work trucks are defined as vehicles that are:

-rated at between 8,500 and 10,000 pounds gross vehicle weight; and

-are not a medium-duty passenger vehicle (as defined in section 86.1803-01 of title 40, Code of Federal Regulations, as in effect on the date of the enactment of the Ten-in-Ten Fuel Economy Act).[61]

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[60] While EISA excluded work trucks from "automobiles," it did not exclude them from regulation under EPCA. EISA requires that work trucks be subjected to CAFE standards, but only first after the National Academy of Sciences completes a study and then after NHTSA completes a follow-on study. Congress thus recognized and made allowances for the practical difficulties that led NHTSA to decline to include work trucks in its final rule for MY 2008-11 light trucks.

[61] 49 U.S.C. 32902(a)(19).

Medium-duty passenger vehicles (MDPV) include 8,500 to 10,000 lb. GVWR sport utility vehicles (SUVs), short bed pick-up trucks, and passenger vans, but exclude pickup trucks with longer beds and cargo vans rated at between 8,500 and 10,000 lb. GVWR. It is those excluded pickup trucks and cargo vans that are work trucks. "Multi-stage vehicle" includes any vehicle manufactured in different stages by 2 or more manufacturers, if no intermediate or final-stage manufacturer of that vehicle manufactures more than 10,000 multi-stage vehicles per year.[62]

Under EPCA, as it existed before EISA, the agency had discretion whether to regulate vehicles with a GVWR between 6,000 lb and 10,000, GVWR. It could regulate the fuel economy of vehicles with a GVWR within that range under CAFE if it determined that (1) standards were feasible for these vehicles, and (2) either (a) that these vehicles were used for the same purpose as vehicles rated at not more than 6,000 lbs. GVWR, or (b) that their regulation would result in significant energy conservation.

EISA eliminated the need for administrative determinations in order to subject vehicles between 6,000 and 10,000 lb. GVWR to the CAFE standards for automobiles. Congress did so by making the determination itself that all vehicles within that GVWR range should be included, with the exceptions noted above.

2. Mandate to set standards for automobiles

For each future model year, EPCA, as amended by EISA, requires that the agency establish standards for all new automobiles at the maximum feasible levels for that model year. A manufacturer's individual passenger cars and light trucks are not required to meet a particular fuel economy level. Instead, the harmonically averaged fuel economy

[62] 49 U.S.C. 32902(a)(3).

of a manufacturer's production of passenger cars (or light trucks) in a particular model year must meet the standard for those automobiles for that model year.

For MYs 2011-2020 and for MYs 2021-2030, EPCA specifies additional requirements regarding standard setting. Each of those requirements and the maximum feasible requirement must be interpreted in the context of the other requirements. For MYs 2011-2020, separate standards for passenger cars and for light trucks must be set at high enough levels to ensure that the CAFE of the industry-wide combined fleet of new passenger cars and light trucks for MY 2020 is not less than 35 mpg.

In light of the confusion of some commenters about the 35 mpg requirement, we want to emphasize that that figure is not the CAFE level that any individual manufacturer's combined CAFE will be required to meet. The 35 mpg requirement applies solely to the agency's standard setting and concerns the required combined effect that the separate MY 2020 standards for passenger cars and light trucks must achieve with respect to the single fleet containing the MY 2020 passenger cars and light trucks of all manufacturers. That single industry-wide fleet must have a CAFE of at least 35 mpg. If that requirement were exactly met, we anticipate that manufacturers with relatively larger proportions of smaller automobiles would be required to achieve combined CAFEs greater than 35 mpg, while manufacturers with relatively largely proportions of larger automobiles would be required to achieve combined CAFEs that might be somewhat below 35 mpg.

EISA does not specify precisely how compliance with this minimum requirement is to be ensured or how or when the CAFE of the industry-wide combined fleet for MY 2020 is to be calculated for purposes of determining the agency's compliance. Given the gap between passenger car CAFE and light truck CAFE, in order for the CAFE of the combined industry-wide fleet to reach or exceed 35 mpg, the standard for MY 2020 passenger cars will, as a practical matter, need to be set high enough to ensure that the industry-wide level of average fuel economy for passenger cars is not less than 40 mpg. The standard for MY 2020 light trucks would need to be set high enough to raise the industry-wide level of average fuel economy for MY 2020 light trucks, although it could be somewhat below 35 mpg. Again, these are the levels of stringency necessary to meet the minimum requirement of an industry-wide combined average of at least 35 mpg. We cannot at this point assess whether the separate requirement to set the MY 2020 standards at the maximum feasible level might make it necessary to set even higher standards. In addition, the CAFE of each manufacturer's fleet of domestic passenger cars must meet a sliding, absolute minimum level in each model year: 27.5 mpg or 92 percent of the projected CAFE of the industry-wide fleet of new domestic and non-domestic passenger cars for that model year.

The standards for passenger cars and those for light trucks must increase ratably each year. We interpret this requirement, in combination with the requirement to set the standards for each model year at the level determined to be that maximum feasible level for that model year, to mean that the annual increases should not be disproportionately large or small in relation to each other.

EPCA, as it existed before EISA, required that light truck standards be set at the maximum feasible level for each model year, but simply specified a default standard of 27.5 mpg for passenger cars for MY 1985 and thereafter. It permitted, but did not require that NHTSA establish a higher or lower standard for passenger cars if the agency found that the maximum feasible level of fuel economy is higher or lower than 27.5 mpg. Henceforth, the agency must establish a standard for each model year at the maximum feasible level.

3. Structure of standards

The standards for passenger cars and light trucks must be based on one or more vehicle attributes and expressed in terms of a mathematical function. This makes it possible to increase the CAFE standards for both passenger cars and light trucks significantly without creating incentives to improve fuel economy in ways that reduce safety. Formerly, EPCA provided authority for this approach for light trucks, but not passenger cars.

4. Factors governing or considered in the setting of standards

In determining the maximum feasible level of average fuel economy for a model year, EPCA requires that the agency consider four factors: technological feasibility, economic practicability, the effect of other standards of the Government on fuel economy, and the need of the nation to conserve energy. EPCA does not define these terms or specify what weight to give each concern in balancing them; thus, NHTSA defines them and determines the appropriate weighting based on the circumstances in each CAFE standard rulemaking.

"Technological feasibility" refers to whether a particular method of improving fuel economy can be available for commercial application in the model year for which a standard is being established.

"Economic practicability" refers to whether a standard is one "within the financial capability of the industry, but not so stringent as to" lead to "adverse economic consequences, such as a significant loss of jobs or the unreasonable elimination of consumer choice."[63] In an attempt to ensure the economic practicability of attribute based standards, the agency considers a variety of factors, including the annual rate at which manufacturers can increase the percentage of its fleet that has a particular type of fuel saving technology, and cost to consumers. Since consumer acceptability is an element of economic practicability, the agency has limited its consideration of fuel saving technologies to be added to vehicles to those that provide benefits that match their costs. Disproportionately expensively technologies are not likely to be accepted by consumers.

At the same time, the law does not preclude a CAFE standard that poses considerable challenges to any individual manufacturer. The Conference Report for EPCA, as enacted in 1975, makes clear, and the case law affirms, "(A) determination of maximum feasible average fuel economy should not be keyed to the single manufacturer which might have the most difficulty achieving a given level of average fuel economy."[64] Instead, the agency is compelled "to weigh the benefits to the nation of a higher fuel economy standard against the difficulties of individual automobile manufacturers." *Id.* The law permits CAFE standards exceeding the projected capability of any particular manufacturer as long as the standard is economically practicable for the industry as a whole. Thus, while a particular CAFE standard may pose difficulties for one manufacturer, it may also present opportunities for another. The CAFE program is not necessarily intended to maintain the competitive positioning of each particular company. Rather, it is intended to enhance fuel economy of the vehicle fleet on

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[63] 67 FR 77015, 77021; December 16, 2002.
[64] *CEI-I*, 793 F.2d 1322, 1352 (D.C. Cir. 1986).

American roads, while protecting motor vehicle safety and being mindful of the risk of harm to the overall United States economy.

"The effect of other motor vehicle standards of the Government on fuel economy" means "the unavoidable adverse effects on fuel economy of compliance with emission, safety, noise, or damageability standards." In the case of emission standards, this includes standards adopted by the Federal government and can include standards adopted by the States as well, since in certain circumstances the Clean Air Act permits States to adopt and enforce State standards in lieu of the Federal ones. It does not, however, include State standards expressly preempted by EPCA.[65]

"The need of the United States to conserve energy" means "the consumer cost, national balance of payments, environmental, and foreign policy implications of our need for large quantities of petroleum, especially imported petroleum." Environmental implications principally include reductions in emissions of criteria pollutants and carbon dioxide. A prime example of foreign policy implications are energy independence and security concerns.

The agency has considered environmental issues in making decisions about the setting of standards from the earliest days of the CAFE program. As the three courts of appeal have noted in decisions stretching over the last 20 years,[66] the agency defined the "need of the Nation to conserve energy" in the late 1970s as including "the consumer cost, national balance of payments, environmental, and foreign policy implications of our

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[65] 49 U.S.C. 32919 and 71 FR 17566, 17654-70; April 6, 2006.

[66] *Center for Auto Safety v. NHTSA*, 793 F.2d 1322, 1325 n. 12 (D.C.Cir.1986); *Public Citizen v. NHTSA*, 848 F.2d 256, 262-3 n. 27 (D.C. Cir. 1988)(noting that "NHTSA itself has interpreted the factors it must consider in setting CAFE standards as including environmental effects"); and *Center for Biological Diversity v. NHTSA*, 508 F.3d 508, 529 (9th Cir. 2007).

need for large quantities of petroleum, especially imported petroleum."[67] Pursuant to that view, the agency declined to include diesel engines in determining the maximum feasible level of average fuel economy for passenger cars and for light trucks because particulate emissions from diesels were then both a source of concern and unregulated.[68] In the late 1980s, NHTSA cited concerns about climate change as one of its reasons for limiting the extent of its reduction of the CAFE standard for MY 1989 passenger cars[69] and for declining to reduce the standard for MY 1990 passenger cars.[70] Since then, DOT has considered the indirect benefits of reducing tailpipe carbon dioxide emissions in its fuel economy rulemakings pursuant to the statutory requirement to consider the nation's need to conserve energy by reducing consumption. In this rulemaking, consistent with the Ninth Circuit's decision and its observations about the potential effect of changing information about climate change on the balancing of the EPCA factors and aided by the 2007 reports of the United Nations Intergovernmental Panel on Climate Change[71] and other information, NHTSA has monetized the reductions in tailpipe emissions of CO_2 that will result from the CAFE standards and is adopting CAFE standards for MYs 2011-15 at levels that reflect the value of those reductions in CO_2 as well as the value of other benefits of those standards. In setting these CAFE standards, NHTSA also considered environmental impacts under NEPA, 42 U.S.C. §§ 4321-4347.

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[67] 42 FR 63,184, 63,188 (Dec. 15, 1977) (emphasis added)
[68] For example, the final rules establishing CAFE standards for MY 1981-84 passenger cars, 42 FR 33,533, 33,540-1 and 33,551; June 30, 1977, and for MY 1983-85 light trucks, 45 FR 81,593, 81,597; December 11, 1980
[69] 53 FR 39,275, 39,302; October 6, 1988.
[70] 54 FR 21985,
[71] The IPCC 2007 reports can be found at http://www.ipcc.ch/. (Last accessed October 22, 2008.)

In addition, the agency historically has considered the potential for adverse safety consequences when deciding upon a maximum feasible level. This practice is sanctioned in case law.[72]

EPCA requires that the MY 2011-2020 CAFE standards for passenger cars and for light trucks must increase annually and ratably. As noted above, NHTSA interprets this to mean that the annual increases should not be disproportionately large or small in relation to each other.

Finally, EPCA provides that in determining the level at which it should set CAFE standards for a particular model year, NHTSA may not consider the ability of manufacturers to take advantage of several EPCA provisions that facilitate compliance with the CAFE standards and thereby reduce the costs of compliance. As noted below in Section XII, manufacturers can earn compliance credits by exceeding the CAFE standards and then use those credits to achieve compliance in years in which their measured average fuel economy falls below the standards. Manufacturers can also increase their CAFE levels through MY 2019 by producing alternative fuel vehicles. EPCA provides an incentive for producing these vehicles by specifying that their fuel economy is to be determined using a special calculation procedure that results in those vehicles being assigned a high fuel economy level.

5. Consultation in setting standards

[72] See, *e.g., Center for Auto Safety v. NHTSA* (CAS), 793 F. 2d 1322 (D.C. Cir. 1986) (Administrator's consideration of market demand as component of economic practicability found to be reasonable); Public Citizen 848 F.2d 256 (Congress established broad guidelines in the fuel economy statute; agency's decision to set lower standard was a reasonable accommodation of conflicting policies). As the United States Court of Appeals pointed out in upholding NHTSA's exercise of judgment in setting the 1987-1989 passenger car standards, "NHTSA has always examined the safety consequences of the CAFE standards in its overall consideration of relevant factors since its earliest rulemaking under the CAFE program." *Competitive Enterprise Institute v. NHTSA* (CEI I), 901 F.2d 107, 120 at n.11 (D.C. Cir. 1990).

EPCA provides that NHTSA is to consult with the Department of Energy (DOE) and Environmental Protection Agency prior to prescribing CAFE standards. It specifies further that NHTSA is to provide DOE with an opportunity to provide written comments on draft proposed and final CAFE standards.[73]

6. Compliance flexibility and enforcement

EPCA specifies a precise formula for determining the amount of civil penalties for failure to comply with a standard. The penalty, as adjusted for inflation by law, is $5.50 for each tenth of a mpg that a manufacturer's average fuel economy falls short of the standard for a given model year multiplied by the total volume of those vehicles in the affected fleet (*i.e.,* import or domestic passenger car, or light truck), manufactured for that model year. The amount of the penalty may not be reduced except under the unusual or extreme circumstances specified in the statute.

Likewise, EPCA provides that manufacturers earn credits for exceeding a standard. The amount of credit earned is determined by multiplying the number of tenths of a mpg by which a manufacturer exceeds a standard for a particular category of automobiles by the total volume of automobiles of that category manufactured by the manufacturer for a given model year.

EPA is responsible for measuring automobile manufacturers' CAFE so that NHTSA can determine compliance with the CAFE standards. In making these measurements for passenger cars, EPA is required by EPCA[74] to use the EPA test procedures in place as of 1975 (or procedures that give comparable results), which are the

[73] In addition, Executive Order No. 13432 provides that a Federal agency undertaking a regulatory action that can reasonably be expected to directly regulate emissions, or to substantially and predictably affect emissions, of greenhouse gases from motor vehicles, shall act jointly and consistently with other agencies to the extent possible and to consider the views of other agencies regarding such action.
[74] 49 U.S.C. § 32904(c).

city and highway tests of today, with adjustments for procedural changes that have occurred since 1975.

EPA's fuel economy test procedures specify equations for calculating fuel economy. These equations are based on the carbon balance technique which allows fuel economy to be determined from measurement of exhaust emissions. This technique relies upon the premise that the quantity of carbon in a vehicle's exhaust gas is equal to the quantity of carbon consumed by the engine as fuel.

When NHTSA finds that a manufacturer is not in compliance, it notifies the manufacturer. Surplus credits generated from the five previous years can be used to make up the deficit. If there are no (or not enough) credits available, then the manufacturer can either pay the fine, or submit a carry back plan to the agency. A carry back plan describes what the manufacturer plans to do in the following three model years to earn enough credits to make up for the deficit. NHTSA must examine and determine whether to approve the plan.

III. The anticipated vehicles in the MY 2011-2015 fleets and NHTSA's baseline market forecast

NHTSA has a long-standing practice of analyzing regulatory options based on the best available information, including information regarding the future vehicle market and future fuel economy technologies. The passenger cars and light trucks currently sold in the United States, and which are anticipated to be sold in the MY 2011-2015 timeframe, are highly varied and satisfy a wide range of consumer needs. From the two-seater Mercedes Benz smart (produced by Daimler) to the Ford F-150 pickup truck, from the Honda CR-V to the Chrysler Town and Country to the GMC Savana, American consumers have a great number of vehicle options to accommodate their needs and preferences. To meet expected future consumer demand, and in light of the fact that automotive parts supply contracts are made years in advance and that factories need time to retool as consumer demand shifts, manufacturers develop product plans reflecting their expectations of the future vehicle fleets, including the salability and marketability of these future vehicles. These product plans contain not only the specific vehicle models which manufacturers intend to build and their planned annual production, but also information about specific design features and configurations as well as the fuel efficient technologies they are planning to incorporate in these vehicles. Manufacturers provide these product plans to the agency during rulemaking. NHTSA begins its analysis with the product plans and uses them to establish a baseline, which is used to analyze varying levels of future CAFE standards.

In anticipation of the analysis to support today's final rule, NHTSA issued a request that manufacturers provide the agency with updated product plans, as well as estimates of the availability, effectiveness, and cost of fuel-saving technologies.[75] Considering its past experiences integrating manufacturers' product plans, reviewing the content of those plans, and seeking clarification and appropriate correction of those plans, the agency provided manufacturers with updated tools to facilitate manufacturers' quality control efforts. NHTSA also tripled the number of agency engineers assigned to reviewing manufacturers' plans.

A. Why does NHTSA establish a baseline market forecast?

[75] *See* 73 FR 24910 (May 2, 2008) for NHTSA's most recent request for comments, which accompanied the NPRM.

NHTSA begins its analysis by establishing the baseline market forecast. This forecast represents the fleet that the agency believes would exist in the absence of fuel economy standards for MYs 2011-2015. A forecast is necessary because the standards will apply to a future fleet, which does not yet exist and must be predicted in order to estimate the costs and benefits of CAFE standards as well as regulatory alternatives as required by OMB and DOT.

B. How does NHTSA develop the baseline market forecast?

1. NHTSA first asks manufacturers for updated product plan data

NHTSA relies on product plans from manufacturers to help the agency determine the composition of the future fleets. The product plans are provided in response to NHTSA's request for information from the manufacturers, and respond to very detailed questions about vehicle model characteristics that influence fuel economy.[76] The baseline market forecast that NHTSA uses in its analysis is based significantly on the confidential product plan information manufacturers submit to the agency. Individual manufacturers are better able than any other entity to anticipate what mix of products they are likely to sell in the future. In this rulemaking as in prior rulemakings, some commenters requested that NHTSA make product plan information public to allow members of the public to comment more fully on the baseline developed by the agency. For example, the Attorneys General commented that "the agency should provide sufficient summaries or aggregations of this information or make special arrangements so that interested parties such as the state Attorneys General can view this confidential information under a confidentiality agreement."

[76] *Id.*

The submitted product plans contain confidential business information, which the agency is prohibited by federal law from disclosing;[77] making this information publicly available would cause competitive harm to manufacturers. *See* 5 U.S.C. § 552(b)(4); 18 U.S.C. § 1905; 49 U.S.C. § 30167(a); 49 CFR Part 512; *Critical Mass Energy Project v. Nuclear Regulatory Comm'n*, 975 F.2d 871 (D.C. Cir. 1992). Notwithstanding this restriction, in its publicly available rulemaking documents, the agency provides aggregated information (compiled from individual manufacturer submissions) regarding its forecasts of the future vehicle market. This aggregated information, which includes vehicle fleet size and composition (passenger cars versus light trucks), overall fuel economy baseline and major technology applications and design trends.

(a) Why does NHTSA use manufacturer product plans to develop the baseline?

As discussed above, NHTSA believes that individual manufacturers are better able than any other entity to anticipate what mix of products they are likely to sell in the future. The vehicle market is defined on a model-by-model, engine-by-engine, and transmission-by-transmission basis, such that each defined vehicle model refers to a separately-defined engine and a separately-defined transmission. For the model years covered by the final rule, the light vehicle (passenger car and light truck) market forecast included more than 5,500 vehicle models, more than 700 specific engines, and nearly 600 specific transmissions. This level of detail in the representation of the vehicle market is

[77] NHTSA grants confidentiality to manufacturers' future specific product plans under 49 CFR Part 512. Once NHTSA has granted a manufacturer's claim of confidentiality, NHTSA may not release the covered information except in certain circumstances listed in § 512.23, none of which include increasing the ability of the public to comment on rulemakings employing the confidential information, unless the manufacturers consent to the disclosure. Commenters are free, however, to request product plan information directly from the manufacturers.

vital to an accurate analysis of manufacturer-specific costs and the analysis of attribute-based CAFE standards, and is much greater than the level of detail used by many other models and analyses relevant to light vehicle fuel economy. Because CAFE standards apply to the average performance of each manufacturer's fleets of cars and light trucks, the impact of potential standards on individual manufacturers cannot be credibly estimated without analysis of manufacturers' planned fleets. NHTSA has used this level of detail in CAFE analysis throughout the history of the program. Furthermore, because required CAFE levels under an attribute-based CAFE standard depend on manufacturers' fleet composition, the stringency of an attribute-based standard cannot be predicted without performing analysis at this level of detail.

Manufacturers generally support NHTSA's use of product plan data in developing the baseline. Other commenters such as CFA and Public Citizen, in contrast, stated that the product plans relied upon in the NPRM are outdated because they were developed before EISA was enacted, and that the agency should develop its own projections of the MY 2011-2015 vehicle fleets, which could be made public instead of relying on confidential industry plans, which could bias the standards in favor of the industry. CFA suggested that NHTSA's analysis was based on only "a very thin body of knowledge about the veracity, relevance and predictive value of auto manufacturer product plans, recent changes in fuel economy and the practices of automakers in adopting fuel economy technologies." Public Citizen stated that because the product plans are confidential, "This significantly biases the standards in favor of industry by shutting the public out of the process," and that "Consumers must essentially trust that NHTSA has set standards in their interest using information provided by industry." Public Citizen argued that "In the past, …NHTSA has done its own research and evaluation of these factors which was more transparent."

NHTSA's analysis of product plan data is much more rigorous than commenters suggest. NHTSA engineers carefully examine the information submitted by manufacturers, and upon discovering what appear to be errors or inconsistencies, request and receive manufacturers' explanations and, as appropriate, corrections. For example, the agency's analysis in preparation for the final rule revealed systematic errors in plans submitted by two major manufacturers, both of which resubmitted their plans with corrections.[78] In addition, the agency found that two manufacturers inappropriately planned to have some 2-wheel drive sport-utility vehicles (2WD SUVs) classified as light trucks, even though the agency explained in the NPRM that, for enforcement purposes, it planned to classify such vehicles as passenger cars, and other manufacturers submitted product plans consistent with the agency's intentions. As discussed below and in Section IX, NHTSA performed its analysis with all of these vehicles reassigned to the passenger car fleet.

NHTSA also disagrees that the agency's use of product plans inhibits public participation in the rulemaking process. As discussed, analysis of confidential product plans has long been a core feature of developing the CAFE standards, and the agency is fully transparent in providing aggregated information about the plans as well as detailed information about the agency's technology and economic assumptions and the process the agency undertakes to evaluate and set the standards.

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[78] One manufacturer had submitted data with a structure that had inadvertently been misaligned, such that many vehicle models were incorrectly identified as using engines applicable to other vehicle models (*e.g.*, a vehicle known to use an inline 4-cylinder engine might have been identified as using a V-8 engines). Another manufacturer had submitted vehicle dimensional estimates based on an incorrect SAE measurement procedure.

NHTSA could conceivably do research as Public Citizen suggests using exclusively public information, but the agency believes that such an analysis would be considerably less accurate than an analysis based on product plan data. Most publicly available information about vehicles and vehicle technologies concerns the current fleet, not the MY 2011-2015 fleet. Manufacturers' public statements about future vehicles have been very optimistic recently with regard to fuel economy-enhancing technologies, and NHTSA takes these statements into account when evaluating the submitted product plans. When manufacturer statements about future vehicles differ substantially from the submitted product plans, NHTSA generally contacts the manufacturer to determine the reason for the discrepancy. However, manufacturers frequently make announcements regarding vehicles or technologies they hope to produce in the future. Often, they are conditional statements and plans, and whether they reach the point of commercialization depends greatly on how circumstances evolve. Thus, for purposes of analyzing MY 2011-2015 CAFE standards, the agency concludes that information manufacturers provide confidentially to NHTSA is more reliable than information appearing in public sources such as press reports and speeches by manufacturers' employees.

(b) What product plan data did NHTSA use in the NPRM?

For the NPRM, NHTSA received product plan information from Chrysler, Ford, GM, Honda, Nissan, Mitsubishi, Porsche and Toyota covering multiple model years. The agency did not receive any product plan information from BMW, Ferrari, Hyundai, Mercedes (Daimler) or VW. However, only Chrysler and Mitsubishi provided us with product plans that showed differing production quantities, vehicle introductions, vehicle redesign/refresh changes, without any carryover production quantities through MY 2015.

For the other companies that provided data, the agency carried over production quantities for their vehicles, allowing for growth, starting with the year after their product plan data showed changes in production quantities or showed the introduction or redesign/refresh of vehicles.

Product plan information was provided until MY 2013 for Ford and Toyota, thus the first year that the agency carried over production quantities for those companies was MY 2014. Product plan information was provided until MY 2012 for GM and Nissan, thus the first year that the agency carried over production quantities for those companies was MY 2013. Product plan information was provided by Honda until MY 2008. Honda asked the agency to carry over those plans and also provided data for the last redesign of a vehicle and asked the agency to carry them forward. Product plan information was provided until MY 2008 for Porsche, thus the first year that the agency carried over production quantities for Porsche was MY 2009.

Because Hyundai was one of the 7 largest vehicle manufacturers, and factored into the optimization process, for accuracy purposes NHTSA used Hyundai's mid-year 2007 data contained in the agency's CAFE database to establish the baseline models and production quantities for their vehicles.[79] For the other manufacturers, NHTSA used the 2005 information from the database, which was the latest complete data set that NHTSA had available for use.

As mentioned above, NHTSA received comments that the product plans it relied upon in the NPRM were out of date and not reflective of recent announcements from manufacturers regarding new products. CFA referred to NHTSA's discussion in the

[79] Manufacturers must submit pre- and mid-model year CAFE reports to the agency as part of the CAFE compliance process under 49 CFR Part 537.

NPRM of the relative completion of various manufacturers' product plans to argue that the product plans were incomplete and inaccurate. Public Citizen argued that the product plans were out of date. The Attorneys General and NRDC argued that NHTSA should update the product plans, the baseline, and the technology inputs to the Volpe model in light of recent manufacturer statements about their intent to introduce advanced technologies like plug-in hybrid vehicles within the MY 2011-2015 timeframe.

In response, as noted above, NHTSA published a request for comments seeking updated information from manufacturers regarding their future product plans in a companion notice to the NPRM. In examining the updated product plans received in response to the request for information, and as discussed more fully below, NHTSA has determined that they incorporate these announcements and reflect changes to the planned product introduction by manufacturers in response to the recent market shift towards more fuel-efficient vehicles, particularly the shift towards increased production of smaller cars.

(c) What product plan data did NHTSA receive for the final rule?

For the final rule, NHTSA received product plan information from Chrysler, Ford (Ford's product plans included separate plans for Jaguar and Land Rover vehicles, both of which are now owned by Tata Motors and are thus attributed to that company in the final rule), GM, Honda, Hyundai, Mitsubishi, Nissan, Porsche, Subaru and Toyota covering multiple model years. The agency did not receive product plan information from BMW, Daimler (Mercedes), Ferrari, Suzuki or VW. Chrysler, Ford, Hyundai and Mitsubishi provided us with product plans that showed changes in production quantities, vehicle introductions, and vehicle redesigns/refreshes changes, without any carryover production quantities through MY 2015. For the other companies that provided data, the agency carried over production quantities for their vehicles, allowing for growth, starting with the year after their product plan data showed changes in production quantities or showed the introduction or redesign/refresh of vehicles.

Product plan information was provided up to and including MY 2013 for GM, Nissan and Toyota, thus the first year that the agency began to carry over production quantities for those companies was MY 2014. Product plan information was provided up to and including MY 2012 for Subaru, thus the first year that the agency began to carry over production quantities for those companies was MY 2013. Product plan information was provided up to and including MY 2011 for Porsche, thus the first year that the agency began to carry over production quantities for those companies was MY 2012. Product plan information was provided by Honda up to and including MY 2010. Honda asked the agency to carry over those plans forward through MY 2015, but provided some information regarding planned redesigns and technology applications for years beyond 2008.

For the other manufacturers, NHTSA used the pre-model year 2008 CAFE reports as the basis for the future product plans and filled in gaps in the data (*e.g.*, engine specifications, wheelbase, track width, etc.) for those manufacturers with information gathered from the web sites of the individual manufacturers and from general automotive web sites such as Edmunds.com, Cars.com, and Wards.com.

(d) How is the product plan data received for the final rule different from what the agency used in the NPRM analysis, and how does it impact the baseline?

Coupled with the overall fleet size and market share estimates applied by the agency (and discussed below), manufacturers' plans for MYs 2011-2015 changed considerably between 2007 and 2008. NHTSA's forecast, based on the Energy Information Administration's (EIA's) Annual Energy Outlook (AEO), of the total number of light vehicles likely to be sold during these model years dropped from 85 to 83 million vehicles. Also, due in part to the reclassification of roughly 7 million (1.4 million annually) 2WD SUVs during these model years, discussed below in Section IX, the share of vehicles expected to be classified as light trucks fell from 49-53 percent in NHTSA's 2007 market forecast to 42-45 percent in the agency's current forecast.

The latter of the above changes is reflected in the baseline distribution of vehicle models with respect to fuel economy and footprint. Figures III-1 and III-2 show passenger car and light truck models, respectively, in the 2007 plans. Figures III-3 and III-4 show passenger car and light truck models, respectively, in the 2008 plans. A comparison of Figures III-1 and III-3 shows that the number of passenger cars models with footprints between roughly 41 and 52 square feet has increased considerably, and that the number of passenger cars model with relatively high fuel economy levels (*e.g.*, above 35 mpg) has increased. Conversely, a comparison of Figures III-2 and III-3 shows less pronounced differences between the 2007 and 2008 plans, although the number of small light truck models decreased (due to reclassification).

Figure III-1. Planned Fuel Economy vs. Footprint, Passenger Cars in 2007 Plans

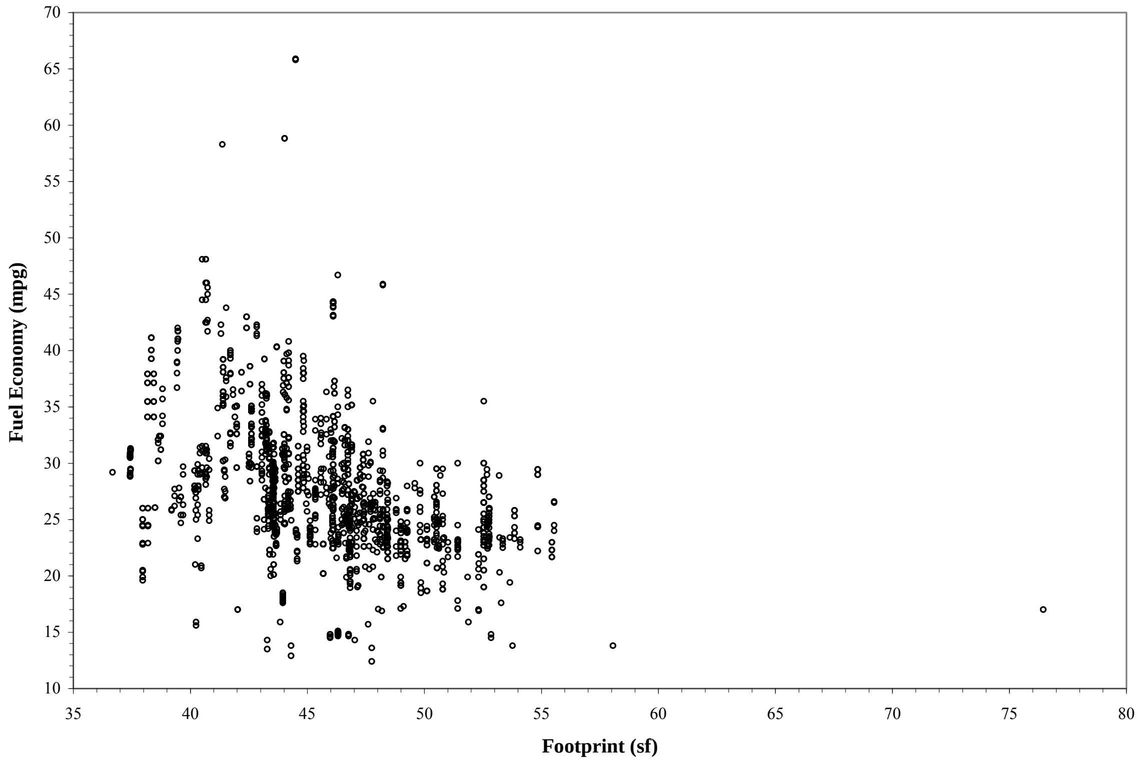


Figure III-2. Planned Fuel Economy vs. Footprint, Light Trucks in 2007 Plans

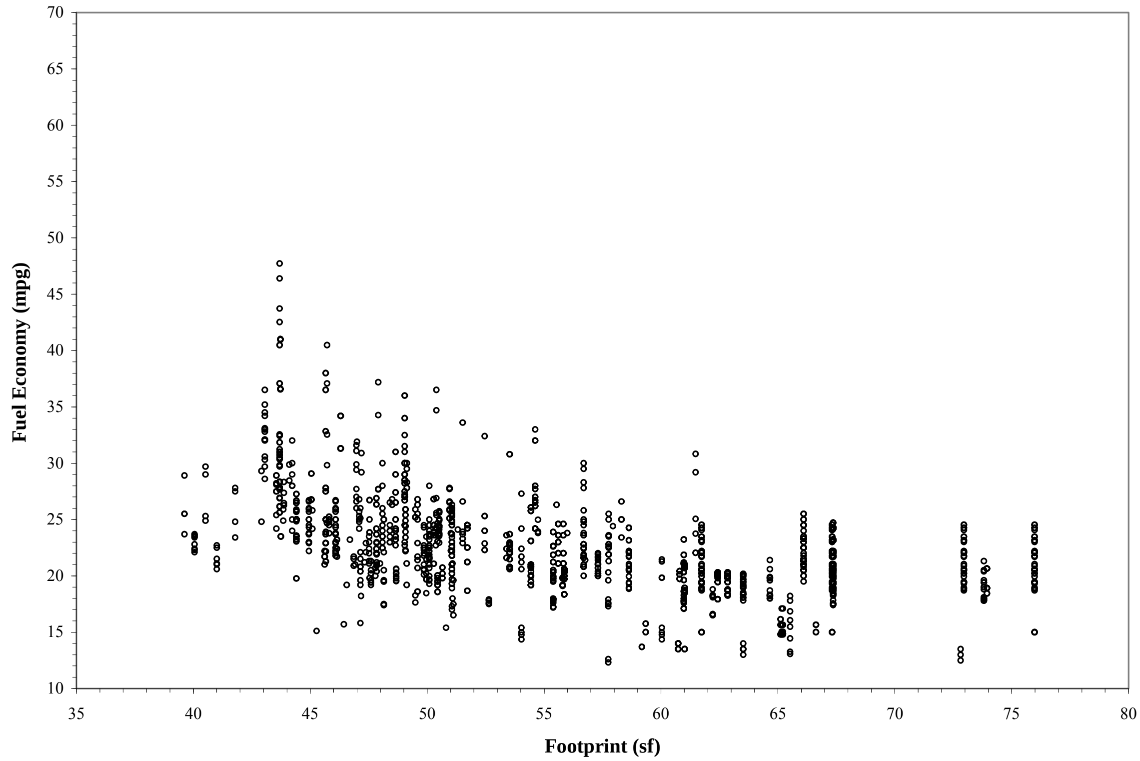


Figure III-3. Planned Fuel Economy vs. Footprint, Passenger Cars in 2008 Plans

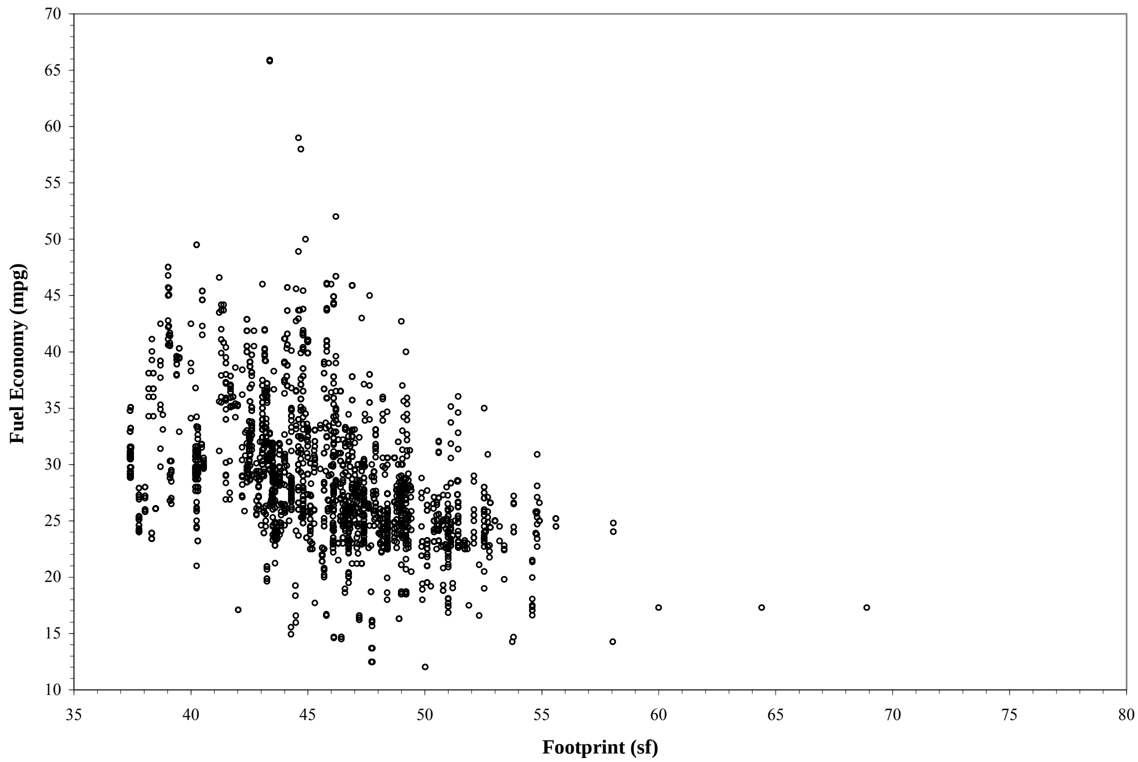
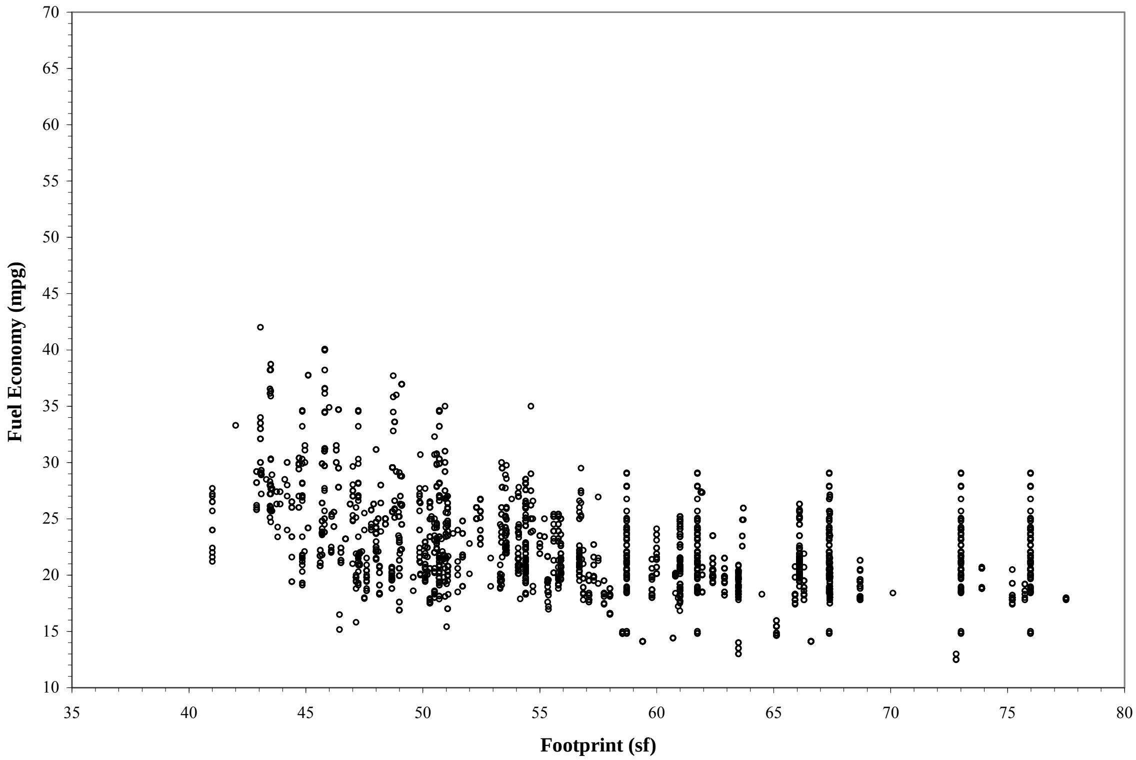


Figure III-4. Planned Fuel Economy vs. Footprint, Light Trucks in 2008 Plans



NHTSA's expectations regarding manufacturers' market shares (the basis for which is discussed below) have also changed since 2007. For example, the agency previously forecast that Chrysler, Ford, and General Motors would account for about 54 percent of the MY 2011-2015 light vehicle market, while Honda, Hyundai, Nissan, and Toyota would account for about 36 percent. Currently, NHTSA expects that Chrysler, Ford, and General Motors will account for about 51 percent of the MY 2011-2015 light vehicle market, while Honda, Hyundai, Nissan, and Toyota will account for about 39 percent.[80] These changes are reflected below in Tables III-1 and III-2, which show the agency's 2007 and 2008 sales forecasts.[81]

[80] This accounts for Ford's sale of the Jaguar and Land Rover brands to Tata Motors. It does not make any attempt to recent reports regarding discussions of other potential mergers and acquisitions in the light vehicle sector.

[81] NHTSA notes that its estimates reflect significant shifts in some manufacturers' relative shares of passenger cars and light trucks in some model years. For example, although the light truck shares of Chrysler, Honda, Nissan, and Toyota are lower in MY 2015 than in MY 2011, Ford's light truck share increases considerably in MY 2015, and those of General Motors and Hyundai are somewhat higher in MY 2015 than in MY 2011. As explained below, although NHTSA normalized each manufacturer's overall market share to produce a realistically-sized fleet, the product mix for each manufacturer that submitted product plans was preserved. The agency has reviewed manufacturers' product plans in detail, and understands that manufacturers intend to shift vehicle mix during MY 2011-MY 2015.

Table III-1. 2007 Sales Forecast

Manufacturer	Passenger MY 2011	MY 2012	MY 2013	MY 2014	MY 2015	Nonpassenger MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	346.6	342.9	339.9	333.6	330.7	66.9	68.8	70.6	72.5	73.3
Chrysler	586.5	580.3	575.2	564.6	559.6	1,659.0	1,705.7	1,748.7	1,797.8	1,817.4
Ferrari	1.6	1.6	1.5	1.5	1.5					
Ford	1,299.2	1,285.4	1,274.1	1,250.5	1,239.5	1,563.8	1,607.8	1,648.3	1,694.6	1,713.1
Fuji (Subaru)	133.6	132.2	131.0	128.6	127.4	105.2	108.2	110.9	114.0	115.3
General Motors	1,824.9	1,805.5	1,789.7	1,756.4	1,740.9	2,037.3	2,094.7	2,147.4	2,207.8	2,231.8
Honda	923.8	914.0	906.0	889.2	881.3	731.1	751.7	770.7	792.3	800.9
Hyundai	533.3	527.7	523.0	513.3	508.8	263.4	270.8	277.6	285.4	288.5
Lotus	1.6	1.6	1.6	1.6	1.5					
Maserati	2.8	2.7	2.7	2.7	2.6					
Mercedes	215.0	212.8	210.9	207.0	205.2	76.9	79.1	81.1	83.4	84.3
Mitsubishi	114.7	113.5	112.5	110.4	109.5	36.6	37.7	38.6	39.7	40.1
Nissan	706.9	699.3	693.2	680.4	674.3	469.1	438.7	451.6	466.4	472.2
Porsche	27.2	27.0	26.7	26.2	26.0	6.8	7.0	7.2	7.4	7.5
Suzuki	79.0	78.2	77.5	76.1	75.4	51.6	53.0	54.4	55.9	56.5
Toyota	1,359.9	1,344.4	1,332.7	1,307.9	1,296.4	1,182.7	1,216.0	1,246.6	1,281.6	1,295.6
Volkswagen	379.7	375.7	372.4	365.5	362.3	13.5	13.9	14.2	14.6	14.8
Total/Average	8,536.6	8,444.8	8,370.8	8,215.4	8,142.8	8,264.0	8,453.2	8,667.8	8,913.4	9,011.3

Table III-2. 2008 Sales Forecast

Manufacturer	Passenger MY 2011	MY 2012	MY 2013	MY 2014	MY 2015	Nonpassenger MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	340.9	351.9	354.3	351.2	351.1	96.2	99.3	100.0	99.1	99.1
Chrysler	707.3	691.8	821.4	741.1	759.2	1,215.9	1,293.4	1,177.4	1,240.0	1,221.6
Daimler	52.9	54.6	55.0	54.5	54.5	23.0	23.8	23.9	23.7	23.7
Ferrari	1.9	1.9	1.9	1.9	1.9					
Ford	1,615.0	1,633.9	1,524.5	1,551.6	1,308.6	1,143.9	1,214.1	1,343.1	1,290.5	1,533.1
General Motors	1,700.1	1,857.8	1,666.8	1,651.9	1,651.7	1,844.1	1,800.8	2,017.0	1,999.1	1,998.8
Honda	1,249.9	1,290.2	1,299.1	1,287.6	1,287.4	469.5	484.7	488.0	483.7	483.6
Hyundai	655.1	696.1	727.0	683.6	640.9	221.3	208.6	183.9	219.2	261.8
Maserati	4.4	4.5	4.6	4.5	4.5					
Mitsubishi	209.8	196.4	192.7	203.1	197.1	16.9	37.7	43.0	30.5	36.5
Nissan	789.4	792.8	846.2	838.7	838.6	479.3	516.9	472.4	468.2	468.2
Porsche	13.5	13.9	14.0	13.9	13.9	25.8	26.6	26.8	26.6	26.6
Subaru	92.1	95.1	95.7	94.9	94.8	126.7	130.8	131.7	130.6	130.5
Suzuki	103.8	107.2	107.9	107.0	107.0	21.6	22.3	22.5	22.3	22.3
Tata	35.0	41.9	37.3	35.1	34.6	25.7	20.7	25.8	27.4	27.9
Toyota	1,405.1	1,503.9	1,527.3	1,447.4	1,447.2	1,094.5	1,076.3	1,070.7	1,127.4	1,127.3
Volkswagen	310.7	320.7	322.9	320.0	320.0	45.2	46.7	47.0	46.6	46.6
Total/Average	9,286.9	9,654.7	9,598.6	9,387.9	9,112.9	6,849.7	7,002.6	7,173.2	7,234.9	7,507.4

Additionally, the updated production plans submitted by manufacturers for the final rule include significantly more advanced technology (in terms of quantity, not necessarily in terms of more technically-advanced technology) than the product plans used for the NPRM had indicated. These changes are consistent with most manufacturers' indications that their product planning was informed by expectations that fuel prices considerably higher than those in EIA's AEO 2008 reference case forecast would prevail during MYs 2011-2015.

Manufacturers' plans show significant application of the following engine technologies by MY 2015 (percent of the entire fleet having that technology is shown in the parentheses): intake cam phasing (30 percent), dual cam phasing (49 percent), stoichiometric gasoline direction injection (30 percent), turbocharging and downsizing (13 percent), combustion restart (10 percent) and diesels (2 percent). Regarding transmission technologies, manufacturers' plans show significant application of the following technologies by MY 2015: 6-, 7-, or 8-speed automatic transmissions (47 percent), dual clutch transmissions (12 percent), and hybrids (6 percent). Manufacturers' plans also show significant application of electric power steering (42 percent) by MY 2015.

The updated product plans also show increasing numbers of mid-size ladder-frame SUVs being planned for redesign as unibody SUVs/crossover vehicles before MY 2015. Additionally, some ladder-frame SUVs and mid-size pickup trucks are planned to be discontinued altogether and replaced with totally new products that have unibody construction. Some of the trend for mid-size SUVs being replaced by unibody vehicles is already visible in the marketplace.

Concerning engine trends, the manufacturers' plans show a significant amount of engine downsizing. This downsizing is of two major types: first, replacing existing engines with smaller displacement engines while keeping the same number of cylinders per engine; second, replacing existing engines with engines having a smaller number of cylinders (*e.g.*, 6-cylinder engines instead of 8-cylinder engines and 4-cylinder engines instead of 6-cylinder engines). The plans indicate that for many of the engines being downsized, the replacement engines have some form of advanced valve actuation (*e.g.*, variable valve lift) combined with other technologies, such as engine friction reduction or direct injection. When such changes occurs, the replacement engines appear to provide higher fuel economy with maximum power and torque similar to the engines they are replacing, although it is not clear from manufacturers' product plans whether and, if so, how vehicle prices and other performance measures (*e.g.*, launch, gradeability) will be affected.

When engines are planned to be replaced with fewer-cylinder engines (*e.g.*, smaller V6 engines instead of large V8 engines), the plans show some of these engines having some form of advanced valve actuation, combined with direct injection and turbocharging. Some of these engines also have combustion restart. These engines also provide maximum power and torque similar to the engines they are replacing while delivering higher fuel economy, although impacts on price and performance measures are also uncertain.

For some selected technologies, Table III-3 compares MY 2015 penetration rates in manufacturers' product plans from the 2007 plans to those from the 2008 plans. While planned use of dual clutch or automated manual transmissions (AMTs) in both passenger car and light truck fleets has dropped, planned use of continuously variable transmission transmissions (CVTs) in passenger cars has increased. Planned use of stoichiometric gasoline direct injection (GDI) and turbocharged and downsized gasoline engines has increased significantly in both fleets, as has planned use of electric power steering (EPS). In addition, the penetration rates of hybrid electric vehicles in product plans have doubled.

Table III-3. Average MY 2015 Penetration Rates in Product Plans

	2007 Plans		2008 Plans	
	Passenger Car	Light Truck	Passenger Car	Light Truck
Dual Clutch or Auto. Manual Trans.	15%	11%	8%	8%
Continuously Variable Transmission	9%	3%	12%	4%
Stoich. Gasoline Direct Injection	19%	22%	30%	29%
Turbocharging & Downsizing	8%	9%	13%	13%
Diesel Engine	1%	3%	0%	4%
Electric Power Steering	21%	5%	43%	39%
Hybrid Electric Vehicles	4%	2%	8%	4%

Manufacturers have also, in 2008, indicated plans to sell more dual-fuel or flexible-fuel vehicles (FFVs) than indicated in the plans they submitted to NHTSA in 2007. FFVs create a potential market for alternatives to petroleum-based gasoline and diesel fuel. For purposes of determining compliance with CAFE standards, the fuel economy of a FFV is, subject to limitations, adjusted upward to account for this potential.[82] For rulemaking purposes, NHTSA is precluded from "taking credit" for the compliance flexibility by accounting for manufacturers' ability to earn and use credits in determining what standards would be "maximum feasible." Some manufacturers plan to produce a considerably greater share of FFVs than can earn full credit under EPCA. Table III-4 presents the projected average FFV share of the market.

[82] *See* 49 U.S.C. §§ 32905 and 32906.

Table III-4. Flexible Fuel Vehicle (FFV) Share of Manufacturers' Plans

Model Year	NPRM	Final
2011	14%	17%
2012	16%	17%
2013	15%	21%
2014	15%	19%
2015	15%	18%

Consistent with these expected trends toward wider application of fuel-saving technologies, the product plan data indicates that almost all manufacturers expect to produce a more efficient fleet than they had planned in 2007. However, because manufacturers' product plans also reflect simultaneous changes in fleet mix and other vehicle characteristics, the relationship between increased technology utilization and increased fuel economy cannot be isolated with any certainty. To do so would require an apples-to-apples "counterfactual" fleet of vehicles that are, except for technology and fuel economy, identical—for example, in terms of fleet mix and vehicle performance and utility. As a result, NHTSA's baseline market forecast shows industry-wide average fuel economy levels significantly higher than shown in the NPRM:

Table III-5. Average Fuel Economy (mpg) in Baseline Forecast

Model Year	NPRM	Final	Increase
2011	26.0	26.5	0.5
2012	26.2	27.4	1.2
2013	26.5	27.8	1.3
2014	26.5	28.2	1.7
2015	26.5	28.3	1.8

These changes are shown in greater detail below in Table III-6a, which shows manufacturer-specific CAFE levels (not counting CAFE credits that some manufacturers expect to earn by producing flexible fuel vehicles) planned in 2007 for passenger cars and light trucks. Table III-6b shows the combined averages of these planned CAFE levels.

Tables III-7a and III-7b show corresponding information from manufacturers' 2008 plans. These tables show that, with very few exceptions, manufacturers are planning to increase overall average fuel economy beyond the levels shown in the plans they submitted in 2007. For example, Chrysler, Ford, General Motors, and Hyundai are expected to increase combined average fuel economy by 2.0-2.5 mpg by MY 2015, and Nissan is expected to achieve an increase of 4.0 mpg. However, Honda indicated plans for modest increases—about 0.7 mpg by MY 2015. Among manufacturers that submitted product plans in both 2007 and 2008, only Toyota's planned CAFE levels declined relative to plans submitted in 2007; the decline was a comparatively small 0.0-0.5 mpg.

Table III-6a. 2007 Planned CAFE Levels (Passenger and Nonpassenger)

	Passenger					Nonpassenger				
Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	26.9	26.9	26.9	26.9	26.9	21.3	21.3	21.3	21.3	21.3
Chrysler	28.2	28.2	31.3	31.2	31.3	23.5	23.8	24.4	25.0	25.4
Ferrari	14.6	14.6	14.6	14.6	14.6					
Ford	28.2	30.5	30.5	30.5	30.5	23.6	24.1	25.3	25.3	25.3
Fuji (Subaru)	27.1	27.1	27.1	27.1	27.1	27.1	27.1	27.1	27.1	27.0
General Motors	28.2	27.8	27.8	27.8	27.8	21.6	21.8	21.8	21.8	21.8
Honda	34.8	34.8	34.8	34.8	34.8	25.0	25.0	25.0	25.0	25.0
Hyundai	32.7	32.7	32.7	32.7	32.7	24.5	24.5	24.5	24.5	24.5
Lotus	29.2	29.2	29.2	29.2	29.2					
Maserati	15.9	15.9	15.9	15.9	15.9					
Mercedes	25.1	25.1	25.1	25.1	25.1	18.7	18.7	18.7	18.7	18.7
Mitsubishi	29.8	30.2	30.4	30.6	30.6	24.9	23.8	26.6	26.7	26.7
Nissan	30.6	31.2	31.2	31.2	31.2	20.9	21.0	21.0	21.0	21.0
Porsche	24.5	24.5	24.5	24.5	24.5	17.3	17.3	17.3	17.3	17.3
Suzuki	29.6	29.6	29.6	29.6	29.6	22.8	22.8	22.8	22.8	22.8
Toyota	34.3	34.3	34.4	34.4	34.4	23.3	23.1	23.4	23.4	23.4
Volkswagen	28.8	28.8	28.8	28.8	28.8	20.1	20.1	20.1	20.1	20.1
Total/Average	30.0	30.3	30.5	30.5	30.6	22.9	23.1	23.5	23.6	23.7

Table III-6b. 2007 Planned CAFE Levels (Combined)

Combined

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	25.8	25.8	25.7	25.7	25.7
Chrysler	24.6	24.8	25.8	26.3	26.6
Ferrari	14.6	14.6	14.6	14.6	14.6
Ford	25.5	26.6	27.3	27.3	27.3
Fuji (Subaru)	27.1	27.1	27.1	27.1	27.1
General Motors	24.3	24.2	24.1	24.1	24.1
Honda	29.6	29.6	29.5	29.4	29.3
Hyundai	29.4	29.4	29.3	29.2	29.2
Lotus	29.2	29.2	29.2	29.2	29.2
Maserati	15.9	15.9	15.9	15.9	15.9
Mercedes	23.0	23.0	22.9	22.8	22.8
Mitsubishi	28.5	28.3	29.3	29.4	29.5
Nissan	25.8	26.3	26.2	26.1	26.0
Porsche	22.6	22.5	22.5	22.4	22.4
Suzuki	26.5	26.5	26.4	26.3	26.3
Toyota	28.1	27.8	28.1	27.9	27.9
Volkswagen	28.4	28.4	28.3	28.3	28.3
Total/Average	26.0	26.2	26.5	26.5	26.5

Table III-7a. 2008 Planned CAFE Levels (Passenger and Nonpassenger)

	Passenger					Nonpassenger				
Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	27.0	27.0	27.0	27.0	27.0	23.0	23.0	23.0	23.0	23.0
Chrysler	28.2	28.1	30.7	31.6	32.5	23.1	23.9	24.3	26.5	26.9
Daimler	25.2	25.2	25.2	25.2	25.2	20.6	20.6	20.6	20.6	20.6
Ferrari	16.2	16.2	16.2	16.2	16.2					
Ford	29.3	32.1	32.7	33.4	34.7	22.5	23.9	24.4	25.7	26.8
General Motors	30.3	30.9	30.7	30.7	30.7	21.4	22.9	23.5	23.5	23.5
Honda	32.3	32.3	32.3	32.3	32.3	25.2	25.2	25.2	25.2	25.2
Hyundai	31.7	32.5	33.1	33.8	33.9	26.0	26.2	26.2	26.1	26.1
Maserati	18.2	18.2	18.2	18.2	18.2					
Mitsubishi	29.3	29.4	29.5	31.2	31.0	26.7	24.1	24.4	25.6	25.6
Nissan	31.3	31.8	35.0	35.0	35.0	21.4	23.0	23.9	23.9	23.9
Porsche	27.2	27.2	27.2	27.2	27.2	20.0	20.0	20.0	20.0	20.0
Subaru	28.6	28.6	28.6	28.6	28.6	28.6	28.6	28.6	28.6	28.6
Suzuki	28.7	28.7	28.7	28.7	28.7	24.0	24.0	24.0	24.0	24.0
Tata	24.7	25.6	26.2	26.5	26.4	23.9	24.3	24.5	22.8	23.1
Toyota	33.2	33.3	33.3	33.2	33.2	22.7	22.6	22.8	22.7	22.7
Volkswagen	28.5	28.5	28.5	28.5	28.5	20.1	20.1	20.1	20.1	20.1
Total/Average	30.4	31.2	31.7	32.0	32.2	22.6	23.5	23.9	24.4	24.7

Table III-7b. 2008 Planned CAFE Levels (Combined)

Combined

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	26.0	26.0	26.0	26.0	26.0
Chrysler	24.7	25.2	26.6	28.2	28.8
Daimler	23.6	23.6	23.6	23.6	23.6
Ferrari	16.2	16.2	16.2	16.2	16.2
Ford	26.0	28.0	28.2	29.4	29.9
General Motors	24.9	26.4	26.3	26.3	26.3
Honda	30.0	30.0	30.0	30.0	30.0
Hyundai	30.0	30.8	31.5	31.5	31.2
Maserati	18.2	18.2	18.2	18.2	18.2
Mitsubishi	29.1	28.4	28.4	30.3	30.0
Nissan	26.6	27.6	30.0	30.0	30.0
Porsche	22.0	22.0	22.0	22.0	22.0
Subaru	28.6	28.6	28.6	28.6	28.6
Suzuki	27.8	27.8	27.8	27.8	27.8
Tata	24.4	25.1	25.5	24.8	24.8
Toyota	27.6	27.8	28.0	27.6	27.6
Volkswagen	27.1	27.1	27.1	27.1	27.1
Total/Average	26.5	27.4	27.8	28.2	28.3

Tables III-8 through III-10 summarize other changes in manufacturers' product plans between those submitted to NHTSA in 2007 (for the NPRM) and 2008 (for the final rule). These tables present average vehicle footprint, curb weight, and power-to-weight ratios for each of the seven largest manufacturers, and for the overall industry. The tables do not identify manufacturers by name, and do not present them in the same sequence.

Table III-8 shows that manufacturers' latest plans reflect no change (measurable at 0.1 square foot resolution) in overall average vehicle size, but suggests that manufacturers currently plan to sell larger trucks than they reported previously. However, this planned increase from 53.5 to 54.4 square feet is attributable to the reassignment of many vehicles from the light truck to the passenger car fleet. Without this reclassification, the average light truck footprint would have decreased slightly, falling from 53.5 to 53.2 square feet. Similarly, without this reclassification, the average passenger car footprint would have remained nearly unchanged, falling from 45.6 to 45.5 square feet.

Table III-8. Average Planned MY 2015 Vehicle Footprint (Square Feet)

	NPRM			Final		
	PC	LT	Ave.	PC	LT	Ave.
Manufacturer 1	46.7	56.5	52.2	46.7	56.5	52.1
Manufacturer 2	43.7	47.8	45.2	46.3	52.1	48.0
Manufacturer 3	46.7	55.8	51.2	44.9	52.8	48.4
Manufacturer 4	45.3	54.6	49.1	45.2	55.5	48.9
Manufacturer 5	45.8	53.6	50.3	46.2	56.3	51.6
Manufacturer 6	48.3	52.0	51.1	48.2	54.1	51.8
Manufacturer 7	44.7	50.1	47.3	45.1	49.9	46.4
Industry Average	45.6	53.5	49.7	45.8	54.4	49.7

Table III-9 shows that manufacturers' latest plans reflect a small decline in overall average vehicle weight, but suggests that manufacturers currently plan to sell heavier trucks than they reported previously. However, this planned increase from 4,555 to 4,632 pounds is attributable to the reassignment of many vehicles from the light truck to the passenger car fleet. Without this reclassification, the average light truck weight would have decreased slightly, falling from 4,555 to 4,488 pounds. Similarly, without this reclassification, the average passenger car footprint would have remained nearly unchanged, falling from 3,327 to 3,315 square feet.

Table III-9. Average Planned MY 2015 Vehicle Curb Weight (Pounds)

	NPRM			Final		
	PC	LT	Ave.	PC	LT	Ave.
Manufacturer 1	3,151	4,277	3,714	3,197	4,329	3,692
Manufacturer 2	3,617	4,513	4,302	3,593	4,694	4,272
Manufacturer 3	3,071	4,025	3,416	3,241	4,240	3,531
Manufacturer 4	3,124	4,209	3,640	3,254	4,191	3,510
Manufacturer 5	3,539	5,232	4,490	3,597	5,016	4,374
Manufacturer 6	3,214	4,473	3,732	3,295	4,529	3,737
Manufacturer 7	3,370	4,319	3,921	3,447	4,601	4,069
Industry Average	3,327	4,555	3,972	3,390	4,632	3,951

Table III-10 shows that manufacturers' latest plans reflect a small increase (about 1 percent) in overall average performance, and suggests that increases will mostly occur in the light truck fleet. Considering that this 3.2 percent increase in light truck performance is accompanied by a 1.7 percent increase in light truck curb weight, this suggests that (1) the vehicles being reassigned to the passenger car fleet are among the less powerful (per pound) of the vehicles previously assigned to the light truck fleet and (2) manufacturers are planning to install somewhat more powerful engines in many light trucks than previously reported to NHTSA.

Table III-10. Average Planned MY 2015 Vehicle Power-to-Weight Ratio (hp/lb)

	NPRM			Final		
	PC	LT	Ave.	PC	LT	Ave.
Manufacturer 1	0.068	0.062	0.064	0.061	0.061	0.061
Manufacturer 2	0.055	0.052	0.054	0.061	0.065	0.062
Manufacturer 3	0.051	0.056	0.053	0.053	0.059	0.056
Manufacturer 4	0.068	0.056	0.061	0.063	0.059	0.061
Manufacturer 5	0.060	0.054	0.058	0.059	0.056	0.058
Manufacturer 6	0.065	0.060	0.062	0.061	0.059	0.060
Manufacturer 7	0.052	0.053	0.052	0.052	0.058	0.054
Industry Average	0.060	0.057	0.059	0.060	0.059	0.060

These overall trends mask the fact that manufacturers' plans did not all change in the same ways. In terms of planned average footprint, changes in manufacturers' plans ranged from a 5 percent decrease to a 9 percent increase. In terms of planned average curb weight and power-to-weight ratio, these ranges covered -4 percent to 4 percent and -4 percent to 15 percent, respectively.

NHTSA recognizes that some manufacturers' plans to increase vehicle performance reflect an intention to apply some fuel-saving technologies in ways that do not hold performance and utility constant, and therefore do not achieve the same fuel economy increases that NHTSA would assume when estimating the effect of adding these technologies for the sole purpose of complying with CAFE standards. This is by no means a new phenomenon—vehicle performance, amenities, and utility have been generally increasing for more than a century. Manufacturers have applied innumerable technological advances during that time, and although they have achieved significant fuel economy gains, they have not applied these technological advances for the sole purpose of increasing fuel economy. When actually applying a given technology to a given vehicle, a manufacturer does so in a way that balances multiple vehicle characteristics, and not just fuel economy. For example, while a manufacturer might make both a gasoline and diesel version of a given sedan, the diesel version might offer more weight-increasing amenities (*e.g.*, luxury seating) and significantly better performance (*e.g.*, torque). In this case, the diesel version would have greater value, and would command a higher price.

The Union of Concerned Scientists (UCS) and some other commenters suggested that manufacturers' product plans, and NHTSA's use of these plans, may have at least the appearance of wrongdoing.[83] Such comments cite a "lack of transparency" ultimately traceable to the fact that the submitted product plans contain confidential business information, which the agency is prohibited by federal law from disclosing, as discussed above. However, NHTSA believes these perceptions may also arise because UCS and others realize that manufacturers often use technology to increase performance (and other vehicle characteristics), not just to increase fuel economy. If so, NHTSA rejects the notion that for manufacturers to do so constitutes any form of "wrongdoing." Manufacturers compete in a marketplace that puts value on vehicle amenities, performance, and utility, not just on fuel economy.

When NHTSA estimates the cost and effect of adding technologies in response to CAFE standards, the agency is treating these technologies as being applied <u>solely</u> for that purpose; therefore, the agency's analysis reflects an attempt to hold amenities, performance, and utility constant. However, NHTSA's analysis estimates means by which manufacturers <u>could</u> comply with CAFE standards. Manufacturers determine how they actually <u>will</u> comply. If a manufacturer plans to apply technologies in ways that increase vehicle performance, NHTSA cannot arbitrarily assume away those performance

[83] *See*, *e.g.*, UCS, p. 14.

increases, certainly not without accounting for the value those performance increases represent.

Similarly, NHTSA believes some commenters' concerns regarding transparency stem from dissatisfaction with manufacturers' plans to change the mix of vehicles they will produce in the future. However, manufacturers are constantly changing their plans based on what they anticipate the market will demand. NHTSA cannot arbitrarily assume, for example, that the market in 2015 will be the same as the market in 2007, much less that the only new vehicle models will be advanced technology vehicles that have been the focus of specific announcements or press reports.

Expected model years in which each vehicle model will be redesigned or freshened constitute another important aspect of NHTSA's market forecast. As discussed in Section IV, the Volpe model, which NHTSA has used to perform analysis supporting today's rulemaking, times the addition of most technologies to coincide with either a vehicle redesign or a vehicle freshening. Product plans submitted to NHTSA preceding both the NPRM and the final rule contained manufacturers' estimates of vehicle redesign and freshening schedules. However, as discussed in Section IV, NHTSA estimated that in the future, most vehicles would be redesigned on a 5-year schedule, with vehicle freshening (*i.e.*, refresh) occurring every 2-3 years after a redesign. After applying these estimates, the shares of manufacturers' passenger car and light truck estimated to be redesigned in each of MYs 2011-2015 were as summarized below for the seven largest manufacturers. Table III-11 shows estimated redesign schedules (as percentages of each manufacturer's fleet expected to be redesigned in each model year) from the market forecast used by NHTSA in the analysis documented in the NPRM. To protect confidential information, manufacturers are not identified by name. Table III-12 presents corresponding estimates from the analysis supporting today's final rule. To further protect confidential information, the numbering of individual manufacturers is different from that shown in Table III-11.

Table III-11. Estimated Redesign Schedules (NPRM)

	Passenger Car					Light Truck					Average				
	2011	2012	2013	2014	2015	2011	2012	2013	2014	2015	2011	2012	2013	2014	2015
Company 1	62%	19%	4%	15%	0%	14%	56%	0%	0%	30%	46%	31%	3%	10%	11%
Company 2	20%	36%	57%	4%	0%	19%	0%	42%	24%	12%	19%	9%	46%	20%	9%
Company 3	9%	51%	13%	31%	5%	9%	18%	46%	6%	15%	9%	36%	29%	18%	10%
Company 4	10%	18%	4%	9%	62%	19%	36%	22%	10%	2%	15%	28%	14%	9%	27%
Company 5	11%	34%	28%	19%	11%	23%	29%	26%	0%	15%	16%	32%	28%	11%	13%
Company 6	22%	20%	0%	20%	21%	14%	29%	39%	7%	12%	18%	25%	21%	13%	16%
Company 7	38%	9%	0%	54%	0%	0%	26%	35%	20%	20%	21%	17%	16%	38%	9%
Overall	19%	23%	10%	23%	20%	14%	23%	35%	11%	13%	17%	23%	23%	17%	16%

Table III-12. Estimated Redesign Schedules (Final)

	Passenger Car					Light Truck					Average				
	2011	2012	2013	2014	2015	2011	2012	2013	2014	2015	2011	2012	2013	2014	2015
Company 1	19%	35%	31%	20%	15%	0%	49%	11%	9%	56%	11%	41%	21%	15%	37%
Company 2	34%	10%	21%	24%	22%	27%	4%	6%	41%	70%	29%	6%	12%	34%	51%
Company 3	5%	45%	2%	34%	16%	0%	21%	0%	26%	52%	3%	35%	1%	31%	32%
Company 4	7%	31%	57%	8%	7%	0%	45%	38%	0%	15%	5%	37%	50%	5%	9%
Company 5	19%	35%	31%	20%	15%	0%	49%	11%	9%	56%	11%	41%	21%	15%	37%
Company 6	34%	73%	15%	40%	8%	28%	50%	2%	13%	69%	33%	68%	13%	34%	26%
Company 7	27%	9%	35%	15%	1%	28%	40%	20%	12%	0%	28%	17%	31%	14%	1%
Overall	20%	31%	22%	20%	16%	9%	27%	18%	23%	37%	15%	30%	20%	21%	25%

As these tables reveal, we continue to estimate that manufacturers' redesigns will not be uniformly distributed across model years. NHTSA has observed that manufacturers in fact do redesign more vehicles in some years than in others. NHTSA staff have closely examined manufacturers' planned redesign schedules, contacting some manufacturers for clarification of some plans, and confirmed that these plans remain unevenly distributed over time.

NHTSA understands that a manufacturer may, under some circumstances, including the ability to time the application of technologies strategically to coincide with planned redesigns, elect in one model year to apply more technology than needed to meet its required CAFE level in that year. However, for two reasons, NHTSA has decided not to attempt to represent this type of manufacturer response to CAFE standards. First, the agency is not confident that it has the statutory authority to base its determination of the maximum feasible CAFE standard in a given model year on manufacturers' ability to overcomply during prior model years in which more vehicles were redesigned. Second, the agency has determined that properly accounting for manufacturers' ability to "look ahead" to future standards and apply additional technology in earlier model years would represent a complex undertaking requiring considerable theoretical effort and analytical development and testing. NHTSA will consider making such changes to the Volpe model in the future.

2. Once NHTSA has the product plans, how does it develop the baseline?

In all cases, manufacturers' respective sales volumes were normalized to produce passenger car and light truck fleets which reflected manufacturers' respective MY 2008 market shares within the construct of the projected aggregate vehicle sales volumes that were forecasted in EIA's 2008 Annual Energy Outlook. NHTSA does so in order to develop a market forecast that is realistic in terms of both its overall size and manufacturers' market shares. The product mix for each manufacturer that submitted product plans was preserved and in the case of those than did not submit plans, the product mix was the same as indicated in their pre-model year 2008 CAFE data.

CBD commented that this method of establishing the baseline fleet "has illegally constrained [NHTSA's] analysis by locking [NHTSA] into the assumption that a manufacturer's fleet mix need not, and will not, change in response to" increasing consumer demand for vehicles with improved fuel economy. Whether NHTSA should incorporate market shifts in its modeling has been a theme in comments for the past several CAFE rulemakings. Comments with regard to market shift tend to address two different issues. First, commenters suggest that NHTSA assume a higher fuel economy baseline than manufacturer product plans indicate, due to market shifts occurring because consumers demand higher fuel economy even without CAFE standards. The Mercatus Center raised this point in comments to the NPRM. Second, commenters suggest that NHTSA should incorporate the market shifts that result *due to* CAFE regulation, as manufacturers adjust vehicle prices and fuel economy levels, and consumers respond to those changes. The Alliance recommented that NHTSA use NERA's nested logit model, for example, since it attempts to account for "actual consumer demand behavior" to address this issue.

NHTSA agrees in principle that some kind of "market shift" model could provide useful information regarding the possible effects of potential new CAFE standards. NHTSA recognizes that the product plans on which the agency relies to determine CAFE stringency represent a snapshot, and are subject to change in response to consumer demand, whether driven by CAFE or by extrinsic factors. Although NHTSA has now spent several years considering how to incorporate market shift issues into its analysis of potential CAFE standards, the agency has still not been able to develop credible coefficients specifying such a model, and we have therefore continued to refrain in the final rule from integrating a market share model into the Volpe model.[84] However,

[84] NHTSA is aware that Resources for the Future (RFF) has drafted a report regarding its examination of consumer behavior modeling. Although a market share model, as currently envisioned by NHTSA, would

manufacturer product plans do already, at a minimum, reflect whatever market shifts the manufacturers believe will occur in the absence of regulations. Additionally, the agency conducts a separate analysis of potential changes in manufacturers' overall sales volumes. NHTSA will continue to consider ways in which to incorporate market shift modeling into its analysis for future rulemakings.

Thus, the baseline fleet, or the baseline market forecast, essentially consists of the vehicles present in the normalized and completed product plans, before NHTSA applies technologies to them. Manufacturers typically provide product plans not only for the years covered by the rulemaking, but also for prior years—so for purposes of this rulemaking, NHTSA has product plans from many manufacturers beginning with MY 2008. As discussed above, NHTSA uses the baseline market forecast as a way of gauging what manufacturer fuel economy levels would exist in the absence of new CAFE standards. In order to provide a point of reference for estimating the costs and benefits of new standards, NHTSA assumes that, without new standards, the fuel economy standards would remain at the level of the MY 2010 standards. However, the raw baseline market forecast, which again, is based on the product plans, does not show all manufacturers in compliance with the MY 2010 standards. This results from manufacturers' ability to use compliance flexibilities, like credits (AMFA and otherwise) and fines, to meet the standards, which NHTSA is statutorily prohibited from considering in setting the standards.

In order to ensure that its analysis does not "take credit" for such flexibilities, NHTSA must adjust the baseline market forecast upwards. For manufacturers whose

also need to address manufacturer behavior (in particular, regarding pricing), NHTSA will consider RFF's work as a possible basis for future changes to NHTSA's analytical methods.

product plans show fuel economy levels below the MY 2010 standards, NHTSA adjusts them upwards by adding technology to the manufacturer's fleet in order to get the manufacturer into compliance without use of credits or payment of fines. For manufacturers whose product plans meet or exceed the MY 2010 standards, NHTSA incorporates them as-is. NHTSA develops an adjusted baseline because the costs and benefits of reaching the MY 2010 standards were already accounted for in prior rulemakings, just as the costs and benefits of reaching the MY 2011-2015 standards are accounted for in the current rulemaking. To avoid double-counting the costs to manufacturers (and the benefits to society) required to meet the MY 2010 standards, NHTSA develops this adjusted baseline, which the agency then uses in analyzing the MY 2011-2015 standards.

The Alliance commented that NHTSA should use an "actual" baseline instead of a "projected" baseline. The Alliance stated that "NHTSA assumes that manufacturers were going to increase fuel economy significantly in numerous ways apart from a congressional or agency mandate to do so," and argued that "by failing to consider the price increases needed to reach its 'projected baseline,' NHTSA underestimates the increase in vehicle prices by about $260 per vehicle for cars and $920 per vehicle for trucks on average."

As explained, NHTSA would be double-counting to incorporate the costs of meeting the MY 2010 standards in the cost/benefit analysis for the current rulemaking. NHTSA discusses these costs, however, in the FRIA in Chapter I.

3. How does NHTSA's market forecast reflect current market conditions?

NHTSA's market forecast, which is based significantly on confidential product plans provided to the agency by vehicle manufacturers, reflects the agency's best judgment at the time it was developed. Manufacturers submitted plans during the summer of 2008. In preceding months, the industry had begun to show signs of stress, and the agency believes manufacturers' revised plans submitted after the NPRM were informed by this. NHTSA is well aware that market conditions have deteriorated since late summer, just as the agency is aware that gasoline prices have fallen considerably in recent months.

The agency notes, as mentioned above, that manufacturers' product plans were submitted along with manufacturers' indications that these plans were generally informed by expectations that relatively high fuel prices would prevail in the future. Although NHTSA did not request that manufacturers provide comprehensive and detailed forecasts of the world economy, including markets for credit and petroleum, the agency believes that manufacturers anticipated that, at least from MY 2011 forward, the economic environment would look much less dire than more recent events would suggest. The agency believes these expectations were consistent with those embodied in the EIA's AEO 2008, upon which the agency has based the fuel prices and total light vehicle market size used in the analysis supporting today's final rule.

NHTSA is cautiously hopeful that conditions will, indeed, quickly rebound, and our market forecast remains consistent with that expectation. In any event, were NHTSA to adopt more pessimistic expectations, those expectations would need to be reflected in other economic estimates—in particular of petroleum prices. Were NHTSA to apply economic estimates that assume credit markets remain very constricted during MYs

2011-2015, it would, for internal consistency, apply considerably reduced estimates of the overall number of light vehicles sold in the U.S., and considerably lower estimates of gasoline and diesel fuel prices.

NHTSA has concluded that the forecasts it has applied in its current rulemaking reflect the best internally consistent information available. The agency will, of course, update these forecasts in future rulemakings.

IV. Fuel economy-improving technologies

A. NHTSA analyzes what technologies can be applied beyond those in the manufacturers' product plans

One of the key statutory factors that NHTSA must consider in setting maximum feasible CAFE standards for each model year is the availability and feasibility of fuel saving technologies. When manufacturers submit their product plans to NHTSA, they identify the technologies they are planning for each vehicle model in each model year. They also provide their assessments of the costs and effectiveness of those fuel saving technologies. The agency uses the manufacturers' product plan data to ascertain the "baseline" capabilities and average fuel economy of each manufacturer. Given the agency's need to consider economic practicability in determining how quickly additional fuel saving technologies can be added to the manufacturers' vehicle planned fleets, the agency researches and develops, based on the best available information and data, its own list of technologies that it believes will be ready for implementation during the model years covered by the rulemaking,. This includes developing estimates of the costs and effectiveness of each technology and lead time needs. The resultant technology assumptions form an input into the Volpe model. The model simulates how manufacturers can comply with a given CAFE level by adding technologies beyond those they planned in a systematic, efficient and reproducible manner. The following sections describe NHTSA's technology assumptions and methodology for estimating the applicability of fuel-saving technologies to MY 2011-2015 passenger cars and light trucks.

B How NHTSA decides which technologies to include

1. How NHTSA did this historically, and how for the NPRM

In the agency's last two CAFE rulemakings, which established light truck CAFE standards for MYs 2005-2007 and MYs 2008-2011, NHTSA relied on the 2002 National Academy of Sciences' report, "Effectiveness and Impact of Corporate Average Fuel Economy Standards"[85] ("the 2002 NAS Report") for estimating potential fuel economy effectiveness values and associated retail costs of applying combinations of technologies in 10 classes of production vehicles. The NAS study was commissioned by the agency, at the direction of Congress, in order to provide independent and peer reviewed estimates of cost and effectiveness numbers. The NAS list was determined by a panel of experts formed by the National Academy of Sciences, and was then peer-reviewed by individuals chosen for their diverse perspectives and technical expertise in accordance with procedures approved by the Report Review Committee of the National Research.

In the NPRM for the MY 2011-2015 CAFE standards, NHTSA explained that there has been substantial advancement in fuel-saving automotive technologies since the publication of the 2002 NAS Report. New technologies, i.e., one that were not assessed in the NAS report, have appeared in the market place or are expected to appear in the

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[85] National Research Council, "Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards," National Academy Press, Washington, DC (2002). *Available at* http://www.nap.edu/openbook.php?isbn=0309076013 (last accessed October 11, 2008).

timeframe of this rulemaking. Also, new studies have been conducted and reports issued by several other organizations providing new or different information regarding the fuel economy technologies that will be available and their costs and effectiveness values. To aid the agency in assessing these developments, NHTSA contracted with the NAS to update the fuel economy section, Chapter 3, of the 2002 NAS Report. However, as NHTSA explained, the NAS update was not available in time for this rulemaking.

Accordingly, NHTSA worked with EPA staff to update the technology assumptions. NHTSA used the results as a basis for its NPRM and EPA staff published them in a report and submitted it to the NAS committee.[86]

2. NHTSA's contract with Ricardo for the final rule

NHTSA specifically sought comment on the estimates, which it had developed jointly with EPA, of the availability, applicability, cost, and effectiveness of fuel-saving technologies, and the order in which the technologies were applied. *See* 73 FR 24352, 24367. To aid the agency in analyzing those comments and increasing the accuracy, clarity and transparency of its technology assumptions and methodologies employed in developing them, it hired an international consulting firm, Ricardo, which specializes in automotive engineering consulting. Ricardo, which describes itself as an eco-innovation technology company, is a leading independent provider of technology, product innovation, engineering solutions, software and strategic consulting. Its skill base includes the state-of-the-art in low emissions and fuel-efficient powertrain and vehicle technology. Its customers include government agencies here and abroad and the world's

[86] EPA Staff Technical Report: Cost and Effectiveness Estimates of Technologies Used to Reduce Light-Duty Vehicle Carbon Dioxide Emissions, EPA 420-R-08-008, March 2008.

automotive, transport and new-energy industries.[87] For example, it has provided technical consulting on low CO_2 strategies to the UK Department for Transport (DfT).[88] Additionally, in December 2007, Ricardo completed an important study for EPA titled "A Study of Potential Effectiveness of Carbon Dioxide Reducing Vehicle Technologies,"[89] which EPA staff used in developing the July 2008 ANPRM on regulating GHGs from motor vehicles.[90]

Ricardo's role was as a technical advisor to NHTSA staff. In this capacity, Ricardo helped NHTSA undertake a thorough and robust review of the NPRM technology assumptions and all comments received on those assumptions, based on both old and new public and confidential manufacturer information. NHTSA and Ricardo staff reviewed and compared comments on the availability and applicability of technologies, and the logical progression between them. NHTSA also reviewed and compared the methodologies used for determining the costs and effectiveness of the technologies as well as the specific estimates provided. Relying on the technical expertise of Ricardo and taking into consideration all the information available, NHTSA revised its estimates of the availability and applicability of many technologies, and revised its estimate of the order in which the technologies were applied and how they are differentiated by vehicle class, as well as the costs and effectiveness estimates and used the revised numbers in analyzing alternative levels of stringency. .

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[87] More information about Ricardo's work is available at their website, http://www.ricardo.com (last accessed September 20, 2008). Its 2007 Annual Report provides a comprehensive view of some of its current work. *See* http://www.ricardo.com/investors/download/annualreport2007.pdf (last accessed September 22, 2008).
[88] Ricardo UK Ltd., "Understanding manufacturers' responses to policy measures to incentivise fuel efficiency," Oct. 5, 2007. *Available at* http://www.dft.gov.uk/consultations/closed/co2emissions/ricardoreport.pdf (last accessed Oct. 4, 2008).
[89] A slightly updated (June 2008) version of Ricardo's study for EPA is available on EPA's website, at http://www.epa.gov/otaq/technology/420r08004a.pdf (last accessed September 20, 2008).
[90] *73 FR 44354 (July 30, 2008).*

While NHTSA sought Ricardo's expertise and relied significantly on their assistance as a neutral expert in developing its technical assumptions, it retained responsibility for the final estimates. The agency believes that the representation of technologies—that is, estimates of the availability, applicability, cost, and effectiveness of fuel-saving technologies, and the order in which the technologies were applied—used in this rulemaking is more accurate and the best available.

C. What technology assumptions has NHTSA used for the final rule?

1. How do NHTSA's technology assumptions in the final rule differ from those used in the NPRM?

This final rule uses the same basic framework as the NPRM. However, NHTSA made several changes to its technology assumptions based on comments and information received during the rulemaking. As in the NPRM and the MY 2008-2011 light truck rule, the agency relied on the Volpe model CAFE Compliance and Effects Modeling System which was developed by the Department or Transportation's Volpe National Transportation Systems Center (Volpe Center) to apply technologies. The model, known as the Volpe model, is the primary tool the agency uses in conducting a "compliance analysis" of various CAFE stringencies. The Volpe model relied on the same types of technology related inputs as in previous rules, including market data files, technology cost and effectiveness estimates by vehicle classification, technology synergies, phase-in rates, learning curve adjustments, and technology decision trees.

Regarding the decision trees, both the structure of the trees and ordering of the technologies were revised. The decision trees have been expanded so that NHTSA is better able to track the incremental and net/cumulative cost and effectiveness of each technology, which substantially improves the "accounting" of costs and effectiveness for the final rule.[91] The revised decision trees also have improved integration, accuracy, and technology representations.

In revising the decision trees, NHTSA updated, combined, split and/or renamed technologies. Several technologies were added, while others were deleted. The three technologies that were deleted because they do not appear in either public or confidential data as available in the MY 2011-2015 timeframe are: Camless Valve Actuation, Lean-Burn Gasoline Direct-Injection and Homogenous Charge Compression Ignition. NHTSA also added three advanced technologies based on confidential manufacturer submissions which showed these technologies as being definitively included in vehicles in the MY 2011-2015 timeframe. These technologies are: Combustion Restart, Exhaust Gas Recirculation Boost, and Plug-in Hybrids.

The Volpe model was modified to allow a non-linear phase-in rate across the five model years, rather than a constant phase-in rate as was used in the NPRM and in previous rules. Most technology applications have tighter phase-in caps in the early years to provide for additional lead time.

[91] In addition to the (simplified) decision trees, as published in this document, NHTSA also utilized "expanded" decision trees in the final rule analysis. Expanded decision trees graphically represent each unique path, considering the branch points available to the Volpe model, which can be utilized for applying fuel saving technologies. For instance, the engine decision tree shown in this document has 20 boxes representing engine technologies, whereas the expanded engine decision tree requires a total of 45 boxes to accurately represent all available application variants. Expanded decision trees presented a significant improvement, compared to the NPRM analysis, in the overall assessment and tracking of applied technologies since they allowed NHTSA staff to accurately view and assess both the incremental and the accumulated, or net cost and effectiveness at any stage of technology application in a decision tree. Because of the large format of the expanded decision trees, they could not be included in the Federal Register, so NHTSA refers the reader to Docket No. NHTSA-2008-0177. Expanded decision trees for the engine, electrification/transmission/hybridization, and the vehicle technologies (three separate decision trees) were developed for each of the 12 vehicle technology application classes (the vehicle subclasses discussed in Section IV.D.4) and the three expanded decision trees for the Large Car subclass have been placed in the docket as an example for the reader's information.

In the NPRM, NHTSA applied volume-based learning factors to technology costs for the first time. These learning factors were developed using the parameters of learning threshold, learning rate (decremented over two cycles), and the initial (unlearned) cost. In the NPRM, NHTSA applied a learning rate discount of 20 percent each time a technology was projected for use on 25,000 vehicles per manufacturer, which was the threshold volume for learning rate discounts. The discounts were only taken twice, at 25,000 and 50,000 vehicles. A technology was viewed as being fully learned out at 100,000 units.

In the final rule, NHTSA continues to use volume-based learning factors, but with significant revisions. First, the volume learning is now applied on an industry basis as opposed to a manufacturer basis. This takes into account the fact that the automobile industry shares best practices and that manufacturers learn from that sharing to produce their vehicles at lower costs. For the final rule, the revised learning threshold is set to 300,000 vehicles per year by the automobile industry. This number was developed based on comments indicating that many of the publicly available technology cost estimates are based on production quantities of 900,000 to 1.5 million vehicles by at least 3 manufacturers. Volume learning is only applied to hybrid technologies in the final rule.

The final rule also uses a time-based learning factor, in response to public comments from Ford and others. This learning factor was not applied in the NPRM. Time based learning is applied to widely available, high volume, stable and mature technologies typically purchased under negotiated multi-year contractual agreement with suppliers. This type of an agreement is typical of most supplier-provided fuel saving technologies. With time-based learning, the initial cost of a technology is reduced by a fixed amount in its second and subsequent year of availability. A fixed rate 3 percent year-over-year cost reduction is applied up to a maximum of 12 percent cost reduction.

In the NPRM NHTSA divided vehicles into ten subclasses based on technology applicability: four for cars and six for trucks. NHTSA assigned passenger cars into one of the following subclasses: Subcompact, Compact, Midsize, or Large Car. NHTSA assigned light trucks into one of the following subclasses: Minivan, Small SUV, Medium SUV, Large SUV, Small Pickup Truck, or Large Pickup Truck. In its 2007 NPRM for MY 2011-2015, NHTSA included some differentiation in cost and effectiveness numbers between the various classes to account for differences in technology costs and effectiveness that are observed when technologies are applied on to different classes and subclasses of vehicles.

For the final rule, NHTSA, working with Ricardo, increased the accuracy of its technology assumptions by reexamining the subclasses developed for the purpose of modeling technology application. For passenger cars, NHTSA divided vehicles into eight subclasses based on technology applicability by creating a performance class under each of the four subclasses. For trucks, NHTSA established four subclasses, including a minivan subclass, and small, midsize and large SUV/Pickup/Van subclasses. NHTSA also provided more differentiation in the costs and effectiveness values by vehicle subclass. The agency found it important to make that differentiation because the agency estimated that some technologies would have different implications for large vehicles than for smaller vehicles.

In summary, the revisions to NHTSA's methodology for technology application and cost and effectiveness estimates are designed to respond to comments, many of which focused on various inaccuracies and lack of clarity in the NPRM. NHTSA believes that the methodology for the final rule is much clearer, more accurate, and more representative of likely manufacturer behavior, although, of course, manufacturers are free to respond to the CAFE standards with whatever application of technology they choose. The revised technology related assumptions help substantially ensure the technological feasibility and economic practicability of the MY 2011-2015 CAFE standards promulgated in this final rule.

2. How are the technologies applied in the model?

For the final rule, as in the NPRM, NHTSA made significant use of the CAFE Volpe model as discussed above. The NPRM contained a detailed discussion of the Volpe model and specifically stated its two primary objectives as 1) identifying technologies that manufacturers could apply in order to comply with a specified CAFE standard, and 2) calculating the cost and effects of manufacturers' technology applications. The NPRM also discussed other modeling systems and approaches that NHTSA considered to accomplish these same objectives, and also discusses why ultimately the Agency chose to use the Volpe model (see 79 FR 24352, 24391).

The Volpe model relies on several inputs and data files to conduct the compliance analysis, and each of these are discussed in detail in the NPRM. Many of these inputs contain economic and environmental data required for the full CAFE analysis. However, for the purposes of applying technologies to manufacturers' future fleets, the subject of this section, the Volpe model primarily uses three data files, one that contains data on the vehicles being manufactured, one that identifies the appropriate stage within the vehicle's life-cycle for the technology to be applied, and one that contains data/parameters regarding the available technologies the model can apply. These inputs are discussed below.

The Volpe model begins with an "initial state" of the domestic vehicle market, which in this case is the market for passenger cars and light trucks to be sold during the period covered by the final rule. The vehicle market is defined on a model, engine, and transmission basis, such that each defined vehicle model refers to a separately-defined engine and a separately-defined transmission. For the final rule, this represented roughly 5,500 cars and trucks, 700 engines, and 600 transmissions. The information, which is stored in a file called the "vehicle market forecast," consists of various data provided to NHTSA by vehicle manufacturers.[92] In addition to containing data about each vehicle, engine, and transmission, this file also contains information for each technology under consideration as it pertains to the specific vehicle (whether the vehicle is equipped with it or not), the model year the vehicle is undergoing redesign, and information about the vehicle's subclass for purposes of technology application.

The market forecast file provides NHTSA the ability to identify, on a technology by technology basis, which technologies may already be present (manufactured) on a particular vehicle, engine, or transmission, or which technologies are not applicable (due to technical considerations) to a particular vehicle, engine, or transmission. These identifications are made on a model-by-model, engine-by-engine, and transmission-by-transmission basis. For example, if Manufacturer X advises NHTSA that Vehicle Y will be manufactured with Technology Z, then for this vehicle Technology Z will be shown as

[92] The market forecast is developed by NHTSA using the product plan information provided to the agency by individual vehicle manufacturers in response to NHTSA's requests. The submitted product plans contain confidential business information (CBI), which the agency is prohibited by federal law from disclosing. As the agency receives new product plan information in response to future requests, the market forecast is updated.

used. Or alternatively, NHTSA might conclude based on its own assessment that for a given four cylinder engine, Manufacturer A cannot utilize a particular Technology C due to an engineering issue that prohibits it. In this case, NHTSA would, in the market forecast file, indicate that Technology C should not be applied to this particular engine (*i.e.*, is unavailable). Since multiple vehicle models may be equipped with this engine, this may affect multiple models. In using this aspect of the market forecast file, NHTSA ensures the Volpe model only applies technologies in an appropriate manner, since before any application of a technology can occur, the model checks the market forecast to see if it is either already present or unavailable.

Manufacturers typically plan vehicle changes to coincide with certain stages of a vehicle's life cycle that are appropriate for the change, or in this case the technology being applied. For instance, some technologies (*e.g.*, those that require significant revision) are nearly always applied only when the vehicle is expected to be redesigned. Other technologies can be applied only when the vehicle is expected to be refreshed or redesigned and some others can be applied at any time, regardless of whether a refresh or redesign event is conducted. Accordingly, the model will only apply a technology at the particular point deemed suitable. These constraints are intended to produce results consistent with manufacturers' product planning practices. For each technology under consideration, NHTSA stipulates whether it can be applied any time, at refresh/redesign, or only at redesign. The data forms another input to the Volpe model, as discussed in detail below, called the Technology Refresh and Redesign Application table (Table IV-6). Each manufacturer identifies its planned redesign model year for each of its vehicles, and this data is also stored in the market forecast file. Vehicle redesign/refresh assumptions are discussed in Section IV.C.9 below.

As discussed in Section IV.C.4 on vehicle subclasses below, NHTSA assigns one of 12 subclasses to each vehicle manufactured in the rulemaking period. The vehicle subclass data is used for the purposes of technology application. Each vehicle's class is stored in the market forecast file. When conducting a compliance analysis, if the Volpe model seeks to apply technology to a particular vehicle, it checks the market forecast to see if the technology is available and if the refresh/redesign criteria are met. If these conditions are satisfied, the model determines the vehicle's subclass, which it then uses to reference another input called the technology input file.

In the technology input file, NHTSA has developed a separate set of technology data variables for each of the twelve vehicle subclasses. Each set of variables is referred to as an "input sheet," so for example, the subcompact input sheet holds the technology data that is appropriate for the subcompact subclass. Each input sheet contains a list of technologies available for members of the particular vehicle subclass. The following items are provided for each technology: a brief description, its abbreviation, the decision tree with which it is associated, the (first) year in which it is available, the upper and lower cost and effectiveness (fuel consumption reduction) estimates, the learning type and rate, the cost basis, its applicability, and the phase-in values for each of MY 2011-2015.

The input sheets are another method NHTSA uses to determine how to properly apply, or in some cases constrain, a technology's application, as well as to establish the costs and fuel consumption changes that occur as it is applied. Examples of how technologies are applied (or constrained) include the "Applicability" variable: if it is set to "TRUE," then the technology can be applied to all members of the vehicle subclass (a value of "FALSE" would prevent the Volpe model from applying the technology to any member). Another example would be the "Year Available" variable, which if set to "2012" means the model can apply it to MY 2012 and later members, but cannot apply the technology to MY 2011 models. The "Learning Type" and "Learning Rate" define reductions in technology costs, if any are appropriate, that the Volpe model may apply under certain conditions, as discussed in the Learning Curve section below. "Phase-in Values" are intended to address the various constraints that limit a manufacturer's ability to apply technologies within a short period of time. For phase-ins, once the model applies a given technology to a percentage of a given manufacturers' fleet up to a specified phase-in cap, the model then ceases to apply it further instead applying other technologies. Phase-in caps are also discussed below in Section IV.C.10.

Perhaps the most important data contained in the input sheets are the cost and effectiveness information associated with each technology. One important concept to understand about the cost and effectiveness values is that they are "incremental" in nature, meaning that the estimates are "referenced" to some prior technology state in the decision tree in which the applied technology is represented, typically the preceding technology. Therefore, when considering values shown in the input sheet, the reader must understand that in all but a few cases they cannot fully deduce the accumulated or "NET" cost and effectiveness, referenced back to the base condition (*i.e.*, start of the decision tree), without performing a more detailed analysis. The method for conducting this analysis, and a brief example of how it is done, is discussed in the Decision Tree section below. For the final rule, to help readers better understand Volpe model net or accumulated costs and fuel consumption reductions, NHTSA has published net values to key technology locations on the decision trees (*e.g.*, to diesel engine conversion, or a strong hybrid). See the Tables showing Approximate Net Technology Costs and Approximate Net Technology Effectiveness, located in Section IV.E below. The tables have been produced for each of the four vehicle subclasses in the passenger car, performance passenger car, and light truck vehicle groups.

The incremental costs of some technologies are dependent on certain factors specific to the vehicle to which they are applied. For instance, when the Material Substitution technology is applied, the cost of application is based on a cost per unit weight reduction, in dollars per pound, since the weight removed is a percentage of the curb weight of the vehicle (which differs from one vehicle to the next). Similarly, some engine technologies need to be calculated on a cost per cylinder basis, or a cost per configuration basis (*i.e.*, a cost per bank basis, so that a V-configured engine would cost twice as much as an in-line, single bank engine). For each technology, the input sheet also contains a Cost Basis variable which indicates whether the costs need to be adjusted in this manner. This functionality, some of which is new for the final rule, allows NHTSA to estimate more accurately the costs of technology application, since in the NPRM the vehicles in a subclass were assumed to have common cylinder counts and configurations (thus the costs were underestimated for some vehicles and overestimated for others).

Lastly for the technology input file, the term "synergy" as it applies to the Volpe modeling process refers to the condition that occurs when two or more technologies are applied to a vehicle and their effects interact with each other, resulting in a different net effect than the combination of the individual technologies. The term synergy usually connotes a positive interaction (*e.g.*, 1 + 1 is more than 2), but as used here it also includes negative interactions (*e.g.*, 1 + 1 is less than 2). Synergies are discussed in greater detail below in Section IV.C.7, and the values for the synergy factors NHTSA used in the final rule are stored in the technology input file.

In some cases more than one decision tree path can lead to a subsequently applied technology. For example, the power split hybrid technology can be reached from one of two prior transmission technologies (CVT or DCTAM). Accordingly the incremental cost and effectiveness for applying the technology may vary depending on the path and the modifications made in the prior technology. To ensure accurate tracking of net costs and effectiveness, the Volpe model utilizes path correction factors, as discussed further in the decision tree discussion below. This functionality is an improvement to the final rule, and the specific factors used are stored in the technology input sheets. A copy of the final rule input sheets, titled "2011-2015_LV_CAFE_FinalRuleInputSheets20081019.pdf," can be obtained from the final rule docket.

One additional concept to understand about how the Volpe model functions is called an "engineering constraint," a programmatic method of controlling technology application that is independent of those discussed above. NHTSA has determined that some technologies are only suitable or unsuitable when certain vehicle, engine, or transmission conditions exist. For example, secondary axle disconnect is only suitable for 4WD vehicles, and cylinder deactivation is unsuitable for any engine with fewer than 6 cylinders, while material substitution is only available for vehicles with curb weights greater than 5,000 pounds. Additionally, in response to comments received, an engineering constraint was added for purposes of the final rule to prevent the cylinder deactivation technology from being applied to vehicles equipped with manual transmissions, due primarily to driveability and NVH concerns documented by the commenter. Where appropriate and required, NHTSA has utilized engineering constraints to ensure accurate application of the fuel saving technologies.

3. Technology application decision trees

Several changes were made to the Volpe model between the analysis reported in the NPRM and the final rule. This section will discuss two of those changes: first, the updates to the set of technologies; and second, the updates to the logical sequence for progressing through these technologies, which NHTSA describes as “decision trees.”

As discussed above, the set of technologies considered by the agency has evolved since the NPRM. The set of technologies now included in the Volpe model is shown below in Table IV-1, with abbreviations used by the model to refer to each technology in the interest of brevity. Section IV.D below explains each technology in much greater detail, including definitions and cost and effectiveness values.

Table IV-1. Revised Final Rule Technology Set for Volpe Model

Technology	Abbreviation
Low Friction Lubricants	LUB
Engine Friction Reduction	EFR
VVT - Coupled Cam Phasing (CCP) on SOHC	CCPS
Discrete Variable Valve Lift (DVVL) on SOHC	DVVLS
Cylinder Deactivation on SOHC	DEACS
VVT - Intake Cam Phasing (ICP)	ICP
VVT - Dual Cam Phasing (DCP)	DCP
Discrete Variable Valve Lift (DVVL) on DOHC	DVVLD
Continuously Variable Valve Lift (CVVL)	CVVL
Cylinder Deactivation on DOHC	DEACD
Cylinder Deactivation on OHV	DEACO
VVT - Coupled Cam Phasing (CCP) on OHV	CCPO
Discrete Variable Valve Lift (DVVL) on OHV	DVVLO
Conversion to DOHC with DCP	CDOHC
Stoichiometric Gasoline Direct Injection (GDI)	SGDI
Combustion Restart	CBRST
Turbocharging and Downsizing	TRBDS
Exhaust Gas Recirculation (EGR) Boost	EGRB
Conversion to Diesel (from CBRST)	DSLC
Conversion to Diesel (from TRBDS)	DSLT
Electric Power Steering	EPS
Improved Accessories	IACC
12V Micro-Hybrid	MHEV
Higher Voltage/Improved Alternator	HVIA
Integrated Starter Generator	ISG
6-Speed Manual/Improved Internals	6MAN
Improved Auto. Trans. Controls/Externals	IATC
Continuously Variable Transmission	CVT
6/7/8-Speed Auto. Trans with Improved Internals	NAUTO
Dual Clutch or Automated Manual Transmission	DCTAM
Power Split Hybrid	PSHEV
2-Mode Hybrid	2MHEV
Plug-in Hybrid	PHEV
Material Substitution (1%)	MS1
Material Substitution (2%)	MS2
Material Substitution (5%)	MS5
Low Rolling Resistance Tires	ROLL
Low Drag Brakes	LDB
Secondary Axle Disconnect	SAX
Aero Drag Reduction (10%)	AERO

As in the NPRM, each technology is assigned to one of the five following categories based on the system it affects or impacts: engine, transmission, electrification/accessory, hybrid or vehicle. Each of these categories has its own decision tree that the Volpe model uses to apply technologies sequentially during the compliance analysis. The decision trees were designed and configured to allow the Volpe model to apply technologies in a cost-effective, logical order that also considers ease of implementation. For example, effective software or control logic changes are implemented before replacing a component or system with a completely redesigned one, which is typically a much more expensive option.

Each technology within the decision trees has an incremental cost and an incremental effectiveness estimate associated with it, and the estimates are specific to a particular vehicle subclass (see the tables provided below in Section IV.D). Each technology's incremental estimate takes into account its position in the decision tree path. If a technology is located further down the decision tree, the estimates for the costs and effectiveness values attributed to that technology are influenced by the incremental estimates of costs and effectiveness values for prior technology applications. In essence, this approach accounts for "in-path" effectiveness synergies and cost effects that occur between the technologies in the same path. When comparing cost and effectiveness estimates from various sources and those provided by commenters, it is vital that the estimates are evaluated in the proper context, especially as concerns their likely position in the decision trees and other technologies that may be present or missing. Not all estimates provided by commenters can be considered an "apples-to-apples" comparison with those used by the Volpe model, since in some cases the order of application, or included technology content, is inconsistent with that assumed in the decision tree.

For the final rule, significant revisions have been made to the sequence of technology applications within the decision trees, and in some cases the paths themselves have been modified and additional paths have been added. The additional paths allow for a more accurate application of technology, insofar as the model now considers the existing configuration of the vehicle when applying technology. In this analysis, single overhead camshaft (SOHC), dual overhead camshaft (DOHC) and overhead valve (OHV) configured engines now have separate paths that allow for unique path-dependent versions of certain engine technologies. Thus, the cylinder deactivation technology (DEAC) now consists of three unique versions that depend on whether the engine being evaluated is an SOHC, DOHC or OHV design; these technologies are designated by the abbreviations DEACS, DEACD and DEACO, respectively, to designate which engine path they are located on. Similarly the last letter for the Coupled Cam Phasing (CCP) and Discrete Variable Valve Lift (DVVL) abbreviations are used to identify which path the technology is applicable to.

Use of separate valvetrain paths and unique path-dependent technology variations also ensures that the incremental cost and effectiveness estimates properly account for technology effects so as not to "double-count." For example, in the SOHC path, the incremental effectiveness estimate for DVVLS assumes that some pumping loss reductions have already been accomplished by the preceding technology, CCPS, which reduces or diminishes the effectiveness estimate for DVVLS because part of the efficiency gain associated with the reduction of the pumping loss mechanism has already occurred. Commenters pointed out several instances in the NPRM where double-counting appeared to have occurred, and the accounting approach used in the final rule resolves these concerns.

In reviewing NPRM comments, NHTSA noted several questions regarding the retention of previously applied technologies when more advanced technologies (*i.e.*, those further down the decision tree) were applied. In response, NHTSA has clarified the final rule discussions on this issue. In both the NPRM and final rule, as appropriate and feasible, previously-applied technologies are retained in combination with the new technology being applied, but this is not always the case. For instance, one exception to this would be the application of diesel technology, where the entire engine is assumed to be replaced, so gasoline engine technologies cannot carry over. This exception for diesels, along with a few other technologies, is documented below in the detailed discussion of changes to each decision tree and corresponding technologies.

As the Volpe model steps through the decision trees and applies technologies, it accumulates total or "NET" cost and effectiveness values. Net costs are accumulated using an additive approach while net effectiveness estimates are accumulated multiplicatively. To help readers better understand the accumulation process, and in response to comments expressing confusion on this subject, the following examples demonstrate how the Volpe model calculates net values.

Accumulation of net cost is explained first as this is the simpler process. This example uses the Electrification/Accessory decision tree sequentially applying the EPS, IACC, MHEV, HVIA and ISG technologies to a subcompact vehicle using the cost and effectiveness estimates from its input sheet. As seen in Table IV-2 below, the input sheet cost estimates have a lower and upper value which may be the same or a different value (*i.e.*, a single value or a range) as shown in columns two and three. The Volpe model first averages the values (column 4), and then sums the average values to calculate the net cost of applying each technology (column 5). Accordingly, the net cost to apply the MHEV technology for example would be (\$112.50 + \$192.00 + \$372.00 = \$676.50). Net costs are calculated in a similar manner for the all decision trees.

Table IV-2. Sample Volpe Model Net Cost Calculation

Example Net Cost Calculation: Elect./Acc. Path, Subcompact Vehicle Subclass				
Tech. Abrev.	**Lower INCR Cost**	**Upper INCR Cost**	**Avg. INCR Cost**	**NET Cost**
EPS	\$ 105.00	\$ 120.00	\$ 112.50	**\$ 112.50**
IACC	\$ 173.00	\$ 211.00	\$ 192.00	**\$ 304.50**
MHEV	\$ 372.00	\$ 372.00	\$ 372.00	**\$ 676.50**
HVIA	\$ 84.00	\$ 84.00	\$ 84.00	**\$ 760.50**
ISG	\$ 1,713.00	\$ 1,713.00	\$ 1,713.00	***\$ 2,473.50***

The same decision tree, technologies, and vehicle are used for the example demonstrating the model's net effectiveness calculation. Table IV-3 below shows average incremental effectiveness estimates in column two; this value is calculated in the same manner as the cost estimates above (average of lower and upper value taken from the input sheet). To calculate the change in fuel consumption due to application of the EPS technology with incremental effectiveness of 1.5 percent (or 0.015 in decimal form, column 3), when applied multiplicatively, means that the vehicle's current fuel consumption 'X' would be reduced by a factor of (1 – 0.015) = 0.985,[93] or mathematically 0.985*X. To represent the changed fuel consumption in the normal

[93] A decrease in fuel consumption (FC) means the fuel economy (FE) will be increased since fuel consumption and economy are related by the equation FC = 1/FE.

fashion (as a percentage change), this value is subtracted from 1 (or 100%) to show the net effectiveness in column 5.

As the IACC technology is applied, the vehicle's fuel consumption is already reduced to 0.985 of its original value. Therefore the reduction for an additional incremental 1.5 percent results in a new fuel consumption value of 0.9702, or a net 2.98 percent effectiveness, as shown in the table. Net effectiveness is calculated in a similar manner for the all decision trees. It should be noted that all incremental effectiveness estimates were derived with this multiplicative approach in mind; calculating the net effectivenss using an additive approach will yield a different and incorrect net effectiveness.

Table IV-3. Sample Volpe Model Net Effectiveness Calculation

Example Net Effectiveness Calculation: Elect./Acc. Path, Subcompact Vehicle Subclass				
Tech. Abrev.	**Avg. INCR Eff. %**	**Avg. INCR Eff. (decimal)**	**Multiplicative FC Reduction Current FC * (1-Avg INCR)**	**Net Effect. (1 - Red)**
EPS	1.50%	0.0150	1 * (1 - 0.015) = 0.985	1.50%
IACC	1.50%	0.0150	0.985 * (1 - 0.015) = 0.9702	2.98%
MHEV	1.95%	0.0195	0.9702 * (1 - 0.0195) = 0.9513	4.87%
HVIA	0.55%	0.0055	0.9513 * (1 - 0.0055) = 0.9461	5.39%
ISG	6.10%	0.0610	0.9461 * (1 - 0.061) = 0.8884	11.16%

To improve the accuracy of accumulating net cost and effectiveness estimates for the final rule, "path-dependent corrections" were employed. The NPRM analysis had the potential to either overestimate or underestimate net cost and effectiveness depending on which decision tree path the Volpe model followed when applying the technologies. For example, if in the NPRM analysis a diesel technology was applied to a vehicle that followed the OHV path, the net cost and effectiveness could be different from the net estimates for a vehicle that followed the OHC path even though the intention was to have the same net cost and effectiveness. In order to correct this issue, the final rule analysis has added path-dependent correction tables to the input sheets. The model uses these tables to correct net cost and effectiveness estimate differences that occur when multiple paths lead into a single technology that is intended to have the same net cost and effectiveness no matter which path was followed.[94] Path-dependent corrections were used when applying cylinder deactivation (on the DOHC path), turbocharging and downsizing, diesel and strong hybrids. This is essentially an accounting issue and the path-dependent corrections are meant to remedy the accuracy issues reported in the NPRM comment responses.

The following paragraphs explain, in greater detail, the revisions to the decision trees and technologies from the NPRM to the final rule. Revisions were made in response to comments received and pursuant to NHTSA's analysis, and were made to improve the accuracy of the Volpe compliance analysis, or to correct other concerns from the NPRM analysis.

Engine Technology Decision Tree

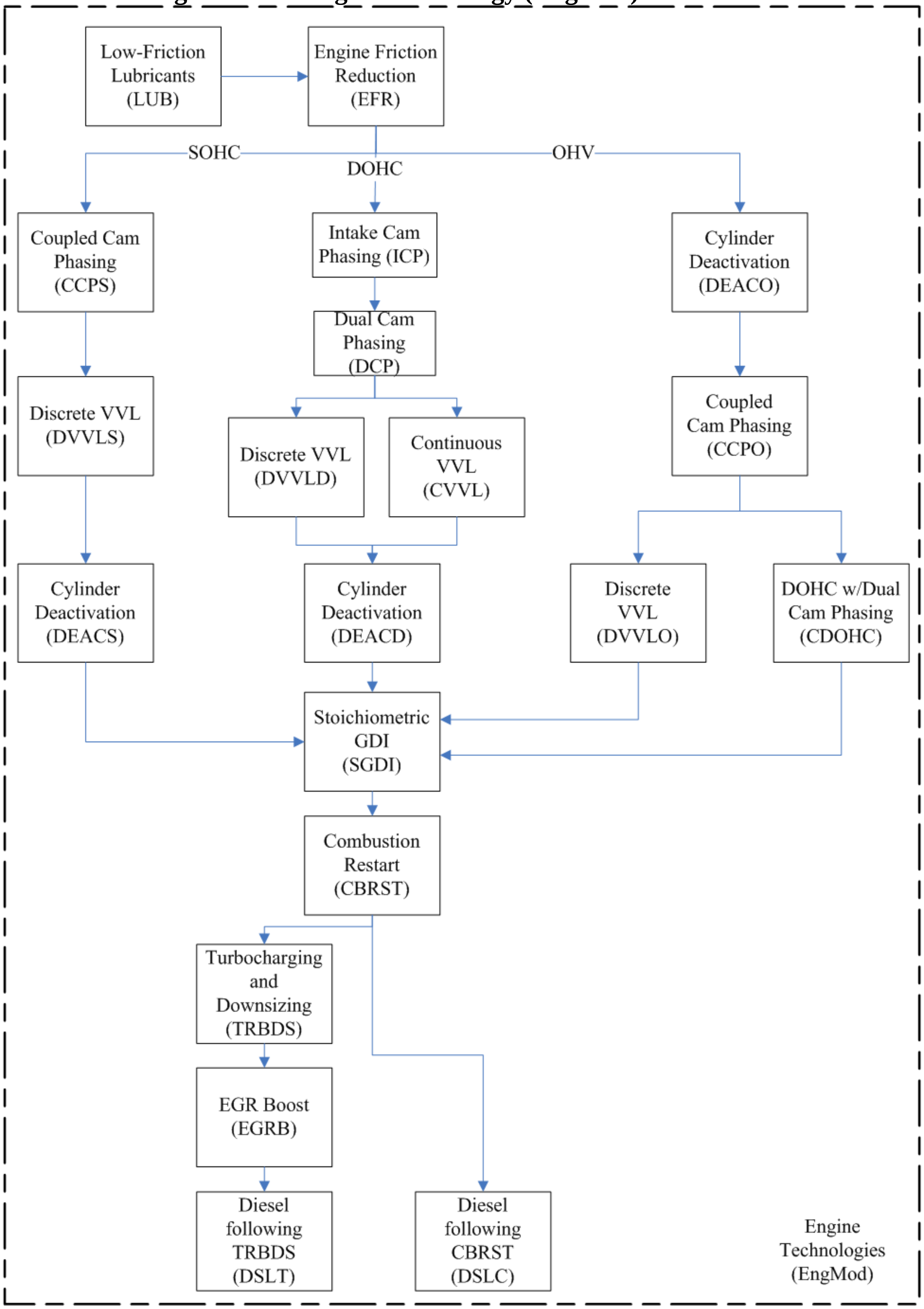
Figure IV-1 below shows the final rule decision tree for the engine technology category. For the final rule, NHTSA removed camless valve actuation (CVA), lean-burn GDI (LBDI), and homogenous charge compression ignition (HCCI) from the decision trees because these technologies were determined to be unavailable in the

[94] The correction tables are used for path deviations within the same decision tree. However, there is one exception to this rule, specifically that the tables are used to keep the model from double-counting cost and effectiveness estimates when both the CBRST and MHEV are applied to the same vehicle. Both technologies try to accomplish the same goal of reducing fuel consumption, by limiting idle time, but through different means. If either of these technologies exists on a vehicle and the Volpe model applies the other, the correction tables are used to remove the cost and effectiveness estimates for CBRST, thus ensuring that double-counting does not occur.

MY 2011-2015 timeframe. The NPRM decision trees included these technologies, but the availability dates were beyond the MY 2011-2015 timeframe, which prevented the Volpe model from applying these technologies. NHTSA did not receive any new information or comments that suggested these technologies would be available in the 2011-2015 timeframe, so NHTSA removed them from the decision trees. At the top of the engine decision tree Low Friction Lubricants (LUB) and Engine Friction Reduction (EFR) technologies are retained as utilized in the NPRM.

As stated above, SOHC, DOHC and OHV engines have separate paths, whereas as the NPRM only made the distinction between OHC and OHV engines. The separation of SOHC and DOHC engines allowed the model to more accurately apply unique path-dependent valvetrain technologies including variations of Variable Valve Timing (VVT), Variable Valve Lift (VVL) and cylinder deactivation that are tailored to either SOHC or DOHC engines. This separation also allowed for a more accurate method of accounting for net cost and effectiveness compared to the NPRM. For both the SOHC and DOHC paths, VVL technologies were moved upstream of cylinder deactivation in response to comments from the Alliance, additional confidential manufacturer comments and submitted product plan trends, and NHTSA's analysis. Confidential comments stated that applying cylinder deactivation to an OHC engine is more complex and expensive than applying it to an OHV engine. The Alliance additionally stated that cylinder deactivation is very application-dependent, and is more effective when applied to vehicles with high power-to-weight ratios. Taking in account the application-specific nature of cylinder deactivation and the fact the VVL technologies are more suitable to a broader range of applications, NHTSA moved VVL technologies “upstream” of cylinder deactivation on the SOHC and DOHC to more accurately represent how a manufacturer might apply these technologies.

Figure IV-1. Engine Technology (EngMod) Decision Tree



On the OHV path, the ordering of cylinder deactivation (DEACO) then Coupled Cam Phasing (CCPO), which is opposite the order of the SOHC and DOHC paths, was retained as defined in the NPRM. This ordering depicts most accurately how manufacturers would actually implement these technologies and was reflected in the submitted product plans for OHV engines, which are largely used on trucks with high power-to-weight ratios. After the application of CCPO on the OHV decision tree, the model chooses between Discrete Variable Valve Lift (DVVLO) and the conversion to a dual overhead camshaft engine (CDOHC). This conversion now includes Dual Cam Phasing (DCP) instead of Continuously Variable Valve Lift (CVVL) because it is assumed that DCP, with its higher application rates, would more likely be applied than CVVL, with its lower application rates.

At this stage, and similar to the NPRM, the decision tree paths all converge into Stoichiometric Gasoline Direct Injection (SGDI). All previously applied technologies are retained with the assumption that SGDI is applied in addition to the pre-existing engine technologies. After SGDI, a newly defined technology, Combustion Restart (CBRST), has been added.

The "branch point" after CBRST has been limited to two paths instead of the three paths in NPRM. This is due to the removal of HCCI from the final rule decision trees. The final rule engine decision tree allowed the model to apply either Turbocharging and Downsizing (TRBDS) or the conversion to diesel (DSLC). TRBDS is considered to be a completely new engine that has been converted to DOHC, if not already converted, with only LUB, EFR, DCP, SGDI and CBRST applied.

The conversion to diesel is also considered to be a completely new engine that replaces the gasoline engine (although it carries over the LUB and EFR technologies). If the model chooses to follow the TRBDS path, the next technology that can be applied is another newly-added technology, EGR Boost (EGRB). After EGRB, the model is allowed to then convert the engine to diesel (DSLT). It should be noted that the path-dependent variations of diesel, (DSLC) and (DSLT), result in the exact same technology. The net cost and effectiveness estimates are the same for both but DSLT's incremental cost and effectiveness estimates are slightly lower to account for the TRBDS and EGRB technologies that have already been applied.

Electrification/Accessory Technology Decision Tree

This path, shown in Figure IV-2, was named simply "Accessory Technology" in the NPRM. Electric Power Steering (EPS) is now the first technology in this decision tree, since it is a primary enabler for both mild and strong hybrids. Improved Accessories (IACC) has been redefined to include only an intelligent cooling system and follows EPS (in the NPRM, IACC was the first technology in the tree). The 42-volt Electrical System (42V) technology has been removed because it is no longer viewed as the voltage of choice by manufactures and is being replaced by higher voltage systems. Micro-Hybrid (MHEV), which follows IACC, has been added as a 12-volt stop/start system to replace Integrated Starter/Generator with Idle-Off (ISGO), which was on the "Transmission/Hybrid Technology" decision tree in the NPRM. Higher Voltage / Improved Alternator (HVIA), a higher efficiency alternator that can incorporate higher voltages (greater than 42V) follows MHEV. Integrated Starter Generator Hybrid (ISG) replaced IMA/ISAD/BSG Hybrid (which was also on the Transmission/Hybrid

Technology decision tree in the NPRM) as a higher voltage hybrid system with limited regenerative capability. ISG takes into account all the previously applied Electrification/Accessory technologies and is the final step necessary in order to convert the vehicle to a (full) strong hybrid. All Electrification/Accessory technologies can be applied to both automatic and manual transmission vehicles.

Transmission Technology Decision Tree

This decision tree, shown in Figure IV-2, contains two paths: one for automatic transmissions and one for manual transmissions. On the automatic path, the Aggressive Shift Logic (ASL) and Early Torque Converter Lockup (TORQ) technologies from the NPRM have been combined into an Improved Auto Trans Controls/Externals (IATC) technology, as both these technologies typically include only software or calibration-related transmission modifications. This technology was moved to the top of the decision tree since it was deemed to be easier and less expensive to implement than a major redesign of the existing transmission. The 5-Speed Automatic Transmission (5SP) technology from the NPRM has been deleted due to several factors. First, the updated decision tree logic seeks to optimize the current hardware as an initial step, instead of applying an expensive redesign technology. Second, NHTSA determined an industry trend of 4-speed automatics going directly to 6-speed automatics, as reflected in the submitted product plans. And finally, confidential manufacturer comments indicated that in some cases 5-speed transmissions offered little or no fuel economy improvement over 4-speed transmissions (primarily due to higher internal mechanical and hydraulic losses, and increased rotating mass), making the technology less attractive from a cost and effectiveness perspective. In the final rule, both 4-speed and 5-speed automatic transmissions get the IATC technology applied first, before progressing through the rest of the transmission decision tree.

After IATC the decision tree splits into a “Unibody only” and “Unibody or Ladder Frame” paths, which is identical to the NRPM version of the decision tree. Both of these paths represent a conversion to new and fully optimized designs. The Unibody only path contains the Continuously Variable Transmission (CVT) technology, while the Unibody or Ladder Frame path has the 6-Speed Automatic Transmission (6SP) technology being replaced by 6/7/8-Speed Automatic Transmission with Improved Internals (NAUTO). The NAUTO technology represents a new generation of automatics with lower internal losses from gears and hydraulic systems.

The NPRM technology “Automated Manual Transmission (AMT)” has been renamed Dual Clutch Transmission/Automated Manual Transmission (DCTAM) to more accurately reflect the true intent of this technology to be a Dual Clutch Transmission (DCT). The NPRM’s use of the abbreviation “AMT” was confusing to many commenters, including the Alliance, BorgWarner, Chrysler, Ford and General Motors, and appeared to indicate that the NPRM analysis applied true automated manual transmissions, which exhibit a torque interrupt characteristic that many in the industry feel will not be customer acceptable. DCT does not have the torque interrupt concern. The technology DCTAM for the final rule assumes the use of a DCT type transmission only.

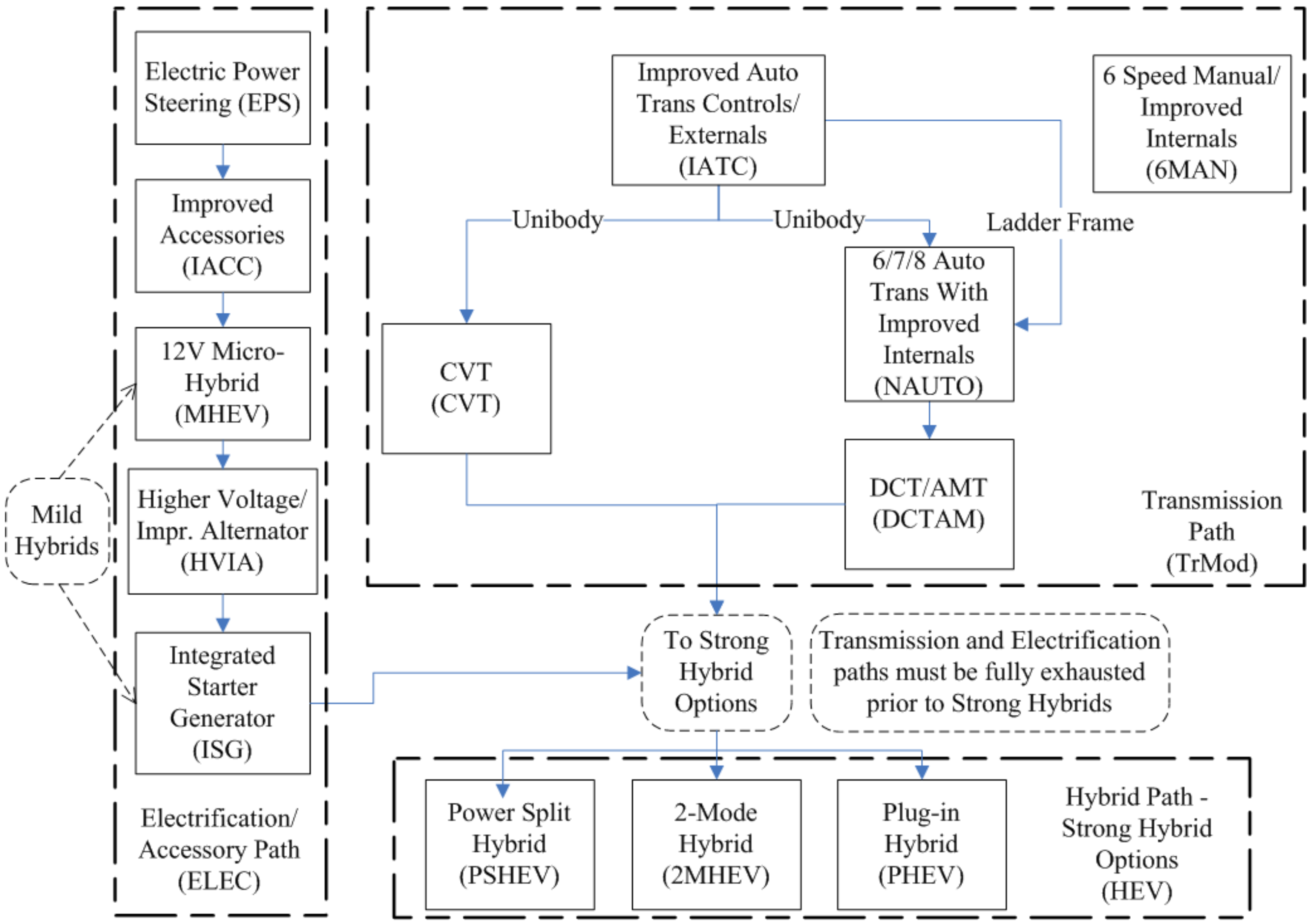
The manual transmission path only has one technology application, like the NPRM. However, the technology being applied has been defined as conversion to a 6-Speed Manual with Improved Internals (6MAN) instead of a conversion to a 6/7/8-Speed

Manual Transmission as defined in the NRPM. Extremely limited use of manual transmissions with more than 6 speeds is indicated in the updated product plans, so NHTSA believes this is a more accurate option for replacing a 4 or 5-speed manual transmission.

Hybrid Technology Decision Tree

The strong hybrid options, 2-Mode (2MHEV) and Power Split (PSHEV), are no longer sequential as defined in the NPRM's Transmission/Hybrid decision tree. For the final rule, the model only applies strong hybrid technologies when both the Electrification/Accessory and Transmission (automatic transmissions only) technologies have been fully added to the vehicle, as seen in Figure IV-2. The final rule analysis and logic ensures that the model does not double-count the cost and effectiveness estimates for previously applied technologies that are included (*e.g.*, EPS) or replaced (*e.g.*, transmission) by strong hybrid systems, which is responsive to General Motors' comment stating that the NPRM analysis had the potential to double-count effectiveness estimates when applying strong hybrids. For the final rule analysis, when the Volpe model applies strong hybrids it now takes into account that some of the fuel consumption reductions have already been accounted for when technologies like EPS or IACC have been previously applied. Once all the Electrification/Accessory and Transmission technologies have been applied, the model is allowed to choose between the application of 2MHEV, PSHEV and the newly added Plug-in Hybrid Vehicle (PHEV). The NPRM decision tree required the Volpe model to step through 2MHEV in order to apply PSHEV. This updated final rule decision tree is a more realistic representation of how manufacturers might apply strong hybrids, and allows the Volpe model to choose the strong hybrid that is most appropriate for each vehicle based on its vehicle subclass or the most cost-effective technology application. The PHEV technology was added to the decision tree in the final rule based upon information in the public domain and submitted product plans showing that limited quantities of these vehicles will be available from some manufacturers in this timeframe.

Figure IV-2. Electrification/Accessory, Transmission and Hybrid Technology Decision Tree

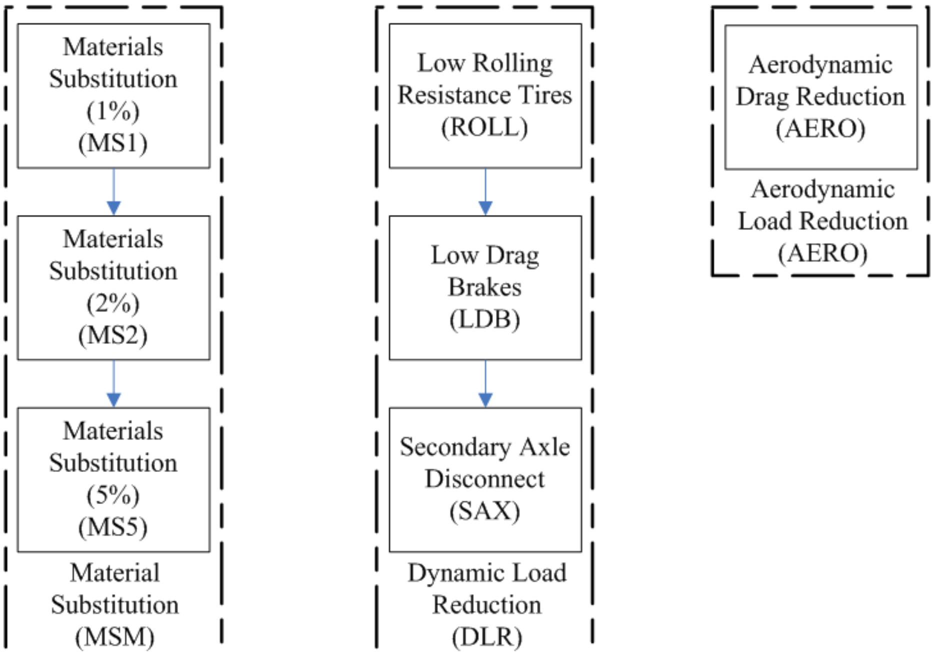


Vehicle Technology Decision Tree

Material Substitution (MS1), (MS2) and (MS5) are now located on dedicated material substitution path in the Vehicle Technology Decision Tree, shown in Figure IV-3. Low Rolling Resistance Tires (ROLL), Low Drag Brakes (LDB) and Secondary Axle Disconnect (SAX) now reside as a separate path, due to the relocation of material substitution technologies. Secondary Axle Disconnect has been redefined for the final rule to apply to 4WD vehicles only to more accurately reflect feasible applications of this technology. Aerodynamic Drag Reduction (AERO) remains a separate tree, and is now a

10 percent reduction for both car and truck classes (excluding performance cars, which are exempt).

Figure IV-3. Vehicle Technology Decision Tree



4. Division of vehicles into subclasses based on technology applicability, cost and effectiveness

In assessing the feasibility of technologies under consideration, the agency evaluated whether each of these technologies could be implemented on all types and sizes of vehicles and whether some differentiation is necessary with respect to the potential to apply certain technologies to certain types and sizes of vehicles, and with respect to the cost incurred and fuel consumption achieved when doing so. The 2002 NAS Report differentiated technology application using ten vehicle classes (4 cars classes and 6 truck classes, including subcompact cars, compact cars, midsize cars, large cars, small SUVs, midsize SUVs, large SUVs, small pickups, large pickups, and minivans), but did not determine how cost and effectiveness values differ from "class" to "class." NAS's purpose in separating vehicles into these "classes" was to create groups of "like" vehicles, i.e., vehicles similar in size, powertrain configuration, weight, and consumer use, and for which similar technologies are applicable. This vehicle differentiation is done solely for the purpose of applying technologies to vehicles and assessing their incremental costs and effectiveness, and should not be confused with, the regulatory classifications pursuant to 49 CFR Part 523 discussed in Chapter XI.

The Volpe model, which NHTSA has used to perform analysis supporting today's notice, divides the vehicle fleet into subclasses based on model inputs, and applies subclass-specific estimates, also from model inputs, of the applicability, cost, and effectiveness of each fuel-saving technology. Therefore, the model's estimates of the cost to improve the fuel economy of each vehicle model depend upon the subclass to which the vehicle model is assigned.

In its MY 2005-2007 and MY 2008-2011 light truck CAFE standards as well as NPRM, NHTSA performed analysis using the same vehicle classes defined by NAS in its 2002 Report. In its 2008 NPRM for MY 2011-2015, NHTSA included some differentiation in cost and effectiveness numbers between the various classes to account for differences in technology costs and effectiveness that are observed when technologies are applied on to different classes and subclasses of vehicles. The agency found it important to make that differentiation because the agency estimated that, for example, engine turbocharging and downsizing would have different implications for large vehicles than for smaller vehicles. For the final rule, NHTSA, working with Ricardo, increased the accuracy of its technology assumptions by reexaming the subclasses developed for the purpose of modeling technology application and by providing more differentiation in the costs and effectiveness values by vehicle subclass.

In the request for comments accompanying the NPRM, NHTSA asked manufacturers to identify the style of each vehicles model they submit in their product plans from eight possible groupings (convertible, coupe, hatchback, pickup, sedan, sport utility, van, or wagon) or sixteen possible market segments (cargo van, compact car, large car, large pickup, large station wagon, midsize car, midsize station wagon, mini-compact, minivan, passenger van, small pickup, small station wagon, special purpose, sport utility truck, subcompact car, and two-seat car). NHTSA also requested that manufacturers identify many specific characteristics relevant to each vehicle model, such as the number of cylinders of the vehicle's engine and other engine, transmission and vehicle characteristics. This information was evaluated by NHTSA staff, entered in NHTSA's market data file, and used by NHTSA to assess how to divide the vehicles into subclasses for purposes of differentiating the applicability, effectiveness, and cost of available technologies.

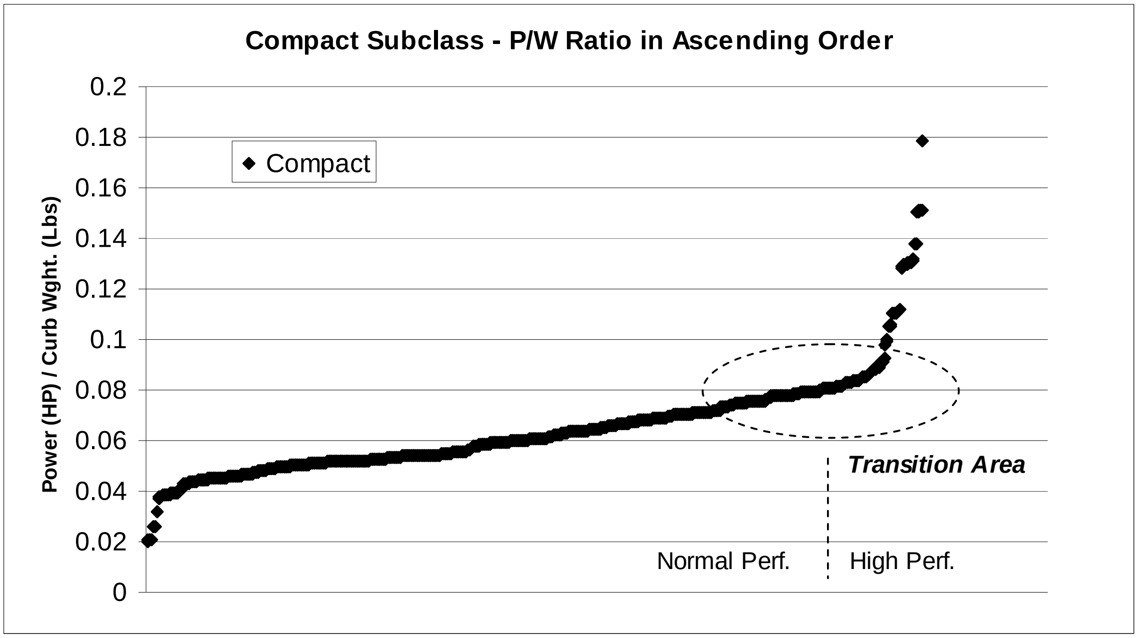
In response to the NPRM, the Alliance commented that NHTSA's classification approach is not robust enough. With regard to subclasses of cars, the Alliance stated that NHTSA did not distinguish high-performance and sports cars which cannot accommodate certain technologies without changing the purpose and configuration of the vehicle. With regard to subclasses of trucks, the Alliance argued that SUVs were not adequately distinguished by size. The Alliance further stated the classification used by Sierra Research in its report to distinguish groups of like vehicles for technology application purposes was more realistic and representative of differences in market segments than NHTSA's classification. The Alliance suggested that NHTSA consider the classes identified by Sierra Research in the final rule.

NHTSA is not adopting Sierra's approach to classification for the following reasons. First, Sierra's classification scheme is too dependent on vehicle characteristics for which NHTSA often did not receive complete information from manufacturers. For example, although NHTSA requested that manufacturers provide estimates of the aerodynamic drag coefficient of each vehicle model planned for MY2011-2015, the agency received no estimates for many vehicles. NHTSA believes manufacturers are too far from production on many vehicles to confidently provide such estimates. Second, Sierra's classification scheme is, for NHTSA's purposes, excessively fine-grained. Sierra's analysis relied on 25 subclasses in total, 13 for cars and 12 for trucks. While their report provided tables comparing their classes to those of NHTSA's and cited product examples for each class, it did not provide a reason for why this detailed differentiation would significantly improve the outcome. NHTSA's review of the Sierra report did not reveal many differences in technology-application between these subclasses. In addition, the agency does not believe that the effort required by the agency to create a more detailed yet more complex modeling structure based on 25 subclasses would result in significant improvement in the accuracy of the results. Sierra may have found this additional differentiation important for the full vehicle simulation approach that the Alliance claimed should be used throughout NHTSA's analysis. However, as discussed below, NHTSA has concluded that this approach is neither necessary nor practical for CAFE analysis.

The agency agrees with the Alliance, however, that some refinement in the classification approach used by NHTSA in the NPRM is merited in order to ensure the practicability of technologies being added. The agency also believes that the limited differentiation in costs and effectiveness values by vehicle class needs to be expanded in order to better account for fuel savings and costs.

For the final rule, NHTSA first reexamined the Volpe model technology output files from the NPRM to identify where and why technologies may have been inappropriately applied by the model. Where this reexamination revealed logical errors, the Volpe model was revised accordingly. However, the review revealed that most of the observed inaccuracies resulted from the manner in which vehicles were assigned to subclasses for the purpose of technology applications. NHTSA also reviewed the confidential vehicle level information received from manufacturers, how manufacturers classified their vehicles by style or market segment groupings requested by NHTSA and the specific engine, transmission and other vehicle characteristics identified by the manufacturers for each vehicle model. This conclusion was among those that led NHTSA to assign more staff to perform quality control when reviewing and integrating manufacturers' product plans.

In order to improve the accuracy of technology application modeling, NHTSA examined at the car and truck segments separately. First, for the car segment, NHTSA plotted the footprint distribution of vehicles in the product plans and divided that distribution into four equivalent footprint range segments. The footprint ranges were named Subcompact, Compact, Midsize, and Large classes in ascending order. Cars were then assigned to one of these classes based on their specific footprint size. Vehicles in each range were then manually reviewed by NHTSA staff to evaluate and confirm that they represented a fairly reasonable homogeneity of size, weight, powertrains, consumer use, etc. However, as the Alliance pointed out, some vehicles in each group were sports or high-performance models. Since different technologies and cost and effectiveness estimates are appropriate for these vehicles, NHTSA created a performance subclass within each car class to maximize the accuracy of technology application. To determine which cars would be assigned to the performance subclasses, NHTSA graphed (in ascending rank order) the power-to-weight ratio for each vehicle in a class. An example of the Compact subclass plot is shown below. The subpopulation was then manually reviewed by NHTSA staff to determine an appropriate transition point between "performance" and "non-performance" models within each class.



A total of eight classes (including performance subclasses) were identified for the car segment: Subcompact, Subcompact Performance, Compact, Compact Performance, Midsize, Midsize Performance, Large, Large Performance. In total, the number of cars that were ultimately assigned to a performance subclass was less than 10 percent. The table below shows the difference in the classification between the NPRM and Final Rule and provides examples of the types of vehicles assigned to each.

NPRM Car Subclasses

Class	**Example vehicles**
Subcompact	Chevy Aveo, Chevy Corvette, Ford Mustang (V8), Honda Civic, Mazda Miata, Saturn Sky
Compact	Audi S4 Quattro, Chevy Camaro (V6), Chevy Cobalt, Daimler CL600, Mazda RX8, Nissan Sentra
Midsize	Bentley Arnage, Cadillac CTS, Honda Accord, Nissan Altima & G37 Coupe, Toyota Camry
Large	Audi A8, Cadillac DTS, Hyundai Azera

Final Rule Car Subclasses

Class	**Example vehicles**
Subcompact	Chevy Aveo, Honda Civic
Subcompact Performance	Mazda Miata, Saturn Sky
Compact	Chevy Cobalt, Nissan Sentra and Altima
Compact Performance	Audi S4 Quattro, Mazda RX8
Midsize	Chevy Camaro (V6), Toyota Camry, Honda Accord, Hyundai Azera
Midsize Performance	Chevy Corvette, Ford Mustang (V8), Nissan G37 Coupe
Large	Audi A8, Cadillac CTS and DTS
Large Performance	Bentley Arnage, Daimler CL600

For light trucks, in reviewing the updated manufacturer product plans and in reconsidering how to divide trucks into classes and subclasses based on technology applicability, NHTSA found less of a distinction between SUVs and pickup trucks than appeared to exist in earlier rulemakings. Manufacturers appear to be planning fewer ladder-frame and more unibody pickups, and many pickups will share common powertrains with SUVs. Consequently, NHTSA condensed the classes available to trucks, such that SUVs and pickups are no longer divided. Recognizing structural differences between various types of "Vans," NHTSA revisited how it assigned the different types of "Vans." Instead of merging minivans, cargo vans, utility and multi-passenger type vans under the same class, as it did for the NPRM and in previous rules, NHTSA formed a separate minivan class, because minivans (*e.g.*, the Honda Odyssey) are expected to remain closer in terms of structural and other engineering characteristics than vans *(e.g.*, Ford's E-Series—also known as Econoline—vans) intended for more passengers and/or heavier cargo.

The remaining vehicles (other vans, pickups, and SUVs) were then segregated into three footprint ranges and assigned a class of Small Truck/SUV, Midsize Truck/SUV, and Large Truck/SUV based on their footprints. NHTSA staff then manually reviewed each population for inconsistent vehicles based on engine cylinder count, weight (curb and/or gross), or intended usage, since these are important considerations for technology application, and reassigned vehicles to classes as appropriate. This system produced four truck segment classes—minivans and small, medium, and large SUVs/Pickups/Vans. The table below shows the difference in the classification between the NPRM and Final Rule

NPRM Truck Subclasses

Class	Example vehicles
Minivans	Dodge Caravan, Ford Econoline, Toyota Sienna
Small Truck	Chevy Colorado, Toyota Tacoma, Ford Ranger
Large Truck	Chevy Silverado
Small SUV	Ford Escape, Nissan Rouge
Midsize SUV	Jeep Wrangler 4-door, Volvo XC70
Large SUV	Toyota Sequoia

Final Rule Truck Subclasses

Class	Example vehicles
Minivans	Dodge Caravan, Toyota Sienna
Small SUV/Pickup/Van	Ford Escape & Ranger, Nissan Rogue,
Midsize SUV/Pickup/Van	Chevy Colorado, Jeep Wrangler 4-door, Volvo XC70, Toyota Tacoma
Large SUV/Pickup/Van	Chevy Silverado, Ford Econoline, Toyota Sequoia

Based on a close review of detailed output from the Volpe model, NHTSA has concluded that its revised classification for purposes of technology applicability substantially improves the overall accuracy of the results as compared to the system employed in the NPRM. The new method uses footprint as a first indicator for both the car and truck segments, and all are then manually reviewed for the types of technologies applicable to them and revised by NHTSA to ensure that they have been properly assigned. The addition of the performance subclasses in the car segment and the condensing of classes in the truck segment further refine the system. The new method increases the accuracy of technology application without overly complicating the Volpe modeling process, and the revisions address comments received in response to the NPRM.

5. How did NHTSA develop technology cost and effectiveness estimates for the final rule?

In the NPRM, NHTSA employed technology cost and effectiveness estimates developed in consultation with EPA. They represented NHTSA and EPA staff's best assessment of the costs for each technology considered based on the available public and confidential information and data sources that the agencies had back in 2007 when the rulemaking was initiated. EPA published the results of this collaboration in a report and submitted it to the NRC committee on fuel economy of light-duty vehicles.[95]

Public comments on the NPRM's technology cost estimates generally fell into four categories: (1) that costs are underestimated because NHTSA did not account for all changes/costs required to apply a technology or because although NHTSA correctly identified all the changes required, it did not cost those changes appropriately; (2) that costs are underestimated because the Retail Price Equivalent (RPE) factors have been applied incorrectly to technologies; (3) that costs are either over- or underestimated because learning curves have been applied incorrectly to technologies; and (4) that cost assumptions are overly simplified as applied to the full range of fleet vehicles and do not properly account for the differences in cost impacts across vehicle and engine types (*e.g.*, technologies applied to a sub-compact car will be unique to those same technologies

[95] EPA Staff Technical Report: Cost and Effectiveness Estimates of Technologies Used to Reduce Light-Duty Vehicle Carbon Dioxide Emissions. EPA420-R-08-008, March 2008.

applied to a large SUV). Many commenters also stated that they found it difficult to understand how NHTSA and EPA had derived the cost estimates. In addition to commenting on NHTSA's methodology, many commenters, particularly manufacturers, also submitted their own cost estimates for each technology and requested that NHTSA consider them for the final rule.

As explained above, NHTSA contracted with Ricardo to aid the agency in analyzing the comments on the technology assumptions used in the NPRM, and relied considerably on Ricardo's expertise in developing the final technology cost and effectiveness estimates based on that analysis. For every technology included in NHTSA's analysis of technology costs and effectiveness, Ricardo and NHTSA engineers reviewed the comments thoroughly and exercised their expertise in assessing the merits of the comments, and in resolving the differences and determining which estimates should be used for the final rule.

For each technology, NHTSA relied on Ricardo's experience with "bill of materials" (BOM) costing. Some commenters criticized NHTSA for not using a BOM as the basis for its cost analysis. The 2008 Martec report,[96] which updated the Martec report on which the 2004 NESCCAF study was based, was submitted to NHTSA's NPRM docket for the agency's consideration. This report provides cost estimates developed on a "bill of materials" basis and methodology. NHTSA, with Ricardo's assistance, reviewed the methodology in the Martec report and found it to be the most defensible of the available sources due to the transparency and precision of its approach.

A bill of materials in a general sense is a list of components that make up a system—in this case, an item of fuel economy-improving technology. In order to

[96] Martec, "Variable Costs of Fuel Economy Technologies," June 1, 2008.

determine what a system costs, one of the first steps is to determine its components and what they cost. In cases in which it was not practicable for the agency and Ricardo to estimate the cost of each component on a BOM basis because there was a shift to a more advanced technology and or because of difficulty in accounting for the sum of costs of all added components less the sum of costs of all deleted components (*e.g.*, in the transition from a gas engine to a diesel engine), incremental costs were estimated to be those of the entire new technology platform (in this example, the diesel engine) less those of the entire old technology platform (in this example, the gas engine). This "net difference" process was only used where developing a ground-up description of all component changes necessitated by the incremental technology was deemed to be impracticable.

With that framework in mind, Ricardo and NHTSA engineers proceeded with reviewing cost information for each major component of each technology. They compared the multiple sources available in the docket and assessed their validity. While NHTSA and Ricardo engineers relied considerably on the 2008 Martec Report for costing contents of some technologies, they did not do so for all. When relevant publicly available information and data sets, including the 2008 Martec report, were determined to be incomplete or non-existent, NHTSA looked to prior published data, including the NPRM, or to values provided to NHTSA by commenters familiar with the material costs of the described technologies.

Generally, whenever cost information for a technology component existed in a non-confidential and publicly available report submitted to the NPRM docket and that information agreed with Ricardo's independent review of cost estimates based on Ricardo's historical institutional knowledge, Ricardo and NHTSA cited that information.

Ricardo and NHTSA were able to take that approach frequently, as is evident in the explanation of the cost figures of each technology. When that approach was not possible, but there was confidential manufacturer data that had been submitted to NHTSA in response to the NPRM, and those costs were consistent with Ricardo's independently-reviewed cost estimates, NHTSA and Ricardo cited those data. When multiple confidential data sources differed greatly and conflicted with the Martec valuation or when the technical assumptions described by NHTSA for purposes of this rulemaking did not match exactly with the content costed by either Martec or other commenters, NHTSA and Ricardo engineers used component-level data that was not in question to build up a partial cost, substituting Ricardo's institutional knowledge for the remaining gaps in component level data.

Occasionally, NHTSA and Ricardo found that some cost information submitted by the public was either not very clearly described or revealed a lack of knowledge on the part of the commenter about NHTSA's methodology. In those cases, and in cases for which no cost data (either public or confidential) was available, NHTSA worked with Ricardo either to confirm the estimates it used in the NPRM, or to revise and update them.

In several cases, values described in the NPRM were simply adjusted from 2006 dollars to 2007 dollars, using a ratio of GDP values for the associated calendar years. In many instances, an RPE factor of 1.5 was determined to have been omitted from the cost estimates provided in the NPRM, so NHTSA applied the multiplier where necessary to calculate the price to the consumer.

Finally, in response to comments stating that cost estimates for individual technologies should be varied, based on the type and size of vehicle to which they are applied, NHTSA worked with Ricardo to account for that. Additionally, application of some technologies might be more or less expensive, depending on content (*e.g.*, with or without a noise attenuation package), for particular vehicles. In these cases, NHTSA and Ricardo described a range of costs for this technology, and referred to sources that indicate the appropriate boundaries of that range.

The agency notes that several technologies considered in the final rule have been updated with substantially different cost estimates relative to those costs described in the NPRM. Specifically, RPE estimates for turbocharging and downsizing (TRBDS), diesel technologies (DSLT) and hybrid technologies (ISG, PSEV, 2MODE) are much higher than the costs cited in the NPRM for those technologies. This is due in large part to the updated cost estimates of the 2008 Martec Report and others, referenced in the final rule, which reflect the dramatic rise of global costs for raw materials associated with the above technologies since the 2004 Martec report and other prior referenced cost estimates were conducted. The NPRM costs were not updated to reflect that rise in commodities prices. As described in the 2008 Martec Report, advanced battery technologies with substantial copper, nickel or lithium content, and engine technologies employing high temperature steels or catalysts with considerable platinum group metals usage, have experienced tremendous inflation of raw material prices since the cost studies referenced in the NPRM were conducted. Updated sources of automotive technology estimates account for current (as of the time the sources were developed) spot prices of nickel, platinum, lithium, copper, dysprosium and rhodium. These commodities have demonstrated cost inflation amounting to between 300 and 750 percent of global prices at the time of the original NESCCAF study[97] and this is reflected in the higher costs described in the final rulemaking. NHTSA is aware that commodity prices, like those for steel and platinum group metals described above, have dropped over the last several months, just as the agency is aware that fuel prices have fallen considerably over the same time period. The agency notes, as mentioned above, that manufacturers' product plans were submitted along with manufacturers' indications that these plans were generally informed by expectations that relatively high fuel and commodity prices would prevail in the future. Therefore, for consistency in our analysis and in the expectation that economic conditions will improve by the MY 2011-2015 time frame, the agency relies on the commodity prices reflected in, for example, the 2008 Martec report, just as the agency relies on EIA's High Price Case for fuel price estimates.

Some commenters referenced the price differential between vehicles with advanced technologies and more standard versions as evidence of those advanced technologies' costs, and argued that NHTSA should consider these price differentials in its cost estimation process. In response, NHTSA believes that the "bottom-up, material cost based" cost estimation methodology employed for the final rule is preferable to estimating costs based on manufacturer price differentials between versions of vehicle models. Wherever possible, technologies were costed based on the estimation of variable material cost impacts to vehicle manufacturers at a fixed point in time (in 2007 dollar terms) for a prescribed set of component changes anticipated to be required in implementing the technology on a particular platform (*e.g.*, wastegate turbo, increased high nickel alloyed exhaust manifolds, air charge cooler, etc. for TRBDS). The content

[97] 2008 Martec report, at 13-20.

assumptions are modified or scaled to account for differences across the range of vehicle sizes and functional requirements and associated material cost impacts are adjusted to account for the revised content. The material cost impacts to the vehicle manufacturers are then summed and converted to retail price equivalent impacts by multiplying by 1.5, as is often performed in prior published works to account for fixed costs and other overheads incurred in the implementation of new vehicle technologies but not contained in the variable material price impacts to the manufacturers.

In employing this methodology, NHTSA relied on information provided to NHTSA by those most cognizant of the variable material cost impacts on vehicle manufacturers, specifically the suppliers and vehicle manufacturers themselves. Though this estimation process relies on often confidential data and employs a simplifying assumption in relating all variable material costs to retail impacts through the use of a consistent 1.5 RPE, the methodology is preferable to a "top-down, retail price based" methodology as might be used by comparing retail price differences of vehicles with different technologies. The "bottom-up" approach offers the benefits of providing a consistent and reasonable assessment of true, total costs for all technologies independent of geographic, or strategic pricing policies by vehicle manufacturers that could result in selling products at sub-standard or even negative margins. For many vehicle manufacturers, contribution to corporate profit varies dramatically across vehicle segment. Given that vehicle pricing is often decoupled from true costs and will vary with sales cycle, product maturity, geography, vehicle class, and marquee, a "top-down" approach, while offering improved data transparency, is inherently limited in providing a consistent means of cost estimation. As such, NHTSA has adopted the described "bottom-up" cost estimation approach and has attempted to mitigate transparency issues with a reliance on Martec 2008 (where in agreement with other provided cost data) which provides a detailed description of the costed content. Fundamentally, NHTSA believes that a "bottom-up" cost estimation methodology with a common RPE adjustment factor offers an intuitive, consistent process across all technologies, whether mature or otherwise, that avoids the pitfalls of reliance on significantly more variable and volatile pricing policies.

Regarding estimates for technology effectiveness, NHTSA, working with Ricardo, also reexamined its NPRM estimates and those in the EPA Staff Technical Report,[98] which largely mirrored NHTSA's NPRM estimates. We compared these estimates to estimates provided in comments, reports and confidential data received in response to our NPRM. Comments on the NPRM's effectiveness estimates generally fell into three categories: (1) that NHTSA did not account sufficiently for fuel economy or performance impacts because it used the Volpe model approach rather than full vehicle simulation; (2) that the synergy values used did not properly account for technology interactions; and (3) that NHTSA made errors when using estimates provided by manufacturers. In addition to commenting on NHTSA's methodology, many commenters, particularly manufacturers, also submitted their own fuel consumption reduction estimates for each technology and requested that NHTSA consider them for the final rule. NHTSA addresses comments relating to vehicle simulation in Section IV.C.8 and synergies in Section IV.C.7, but the section below describes NHTSA's process for

[98] EPA Staff Technical Report: Cost and Effectiveness Estimates of Technologies Used to Reduce Light-Duty Vehicle Carbon Dioxide Emissions. EPA420-R-08-008, March 2008.

developing effectiveness estimates for the final rule, which addresses the comments regarding NHTSA's use of estimates submitted by manufacturers.

For each technology, NHTSA also relied on Ricardo's experience with "bill of materials" (BOM) technology descriptions. Some commenters argued that the same BOM used as the basis for the cost analysis could and should be used to define the technologies being studied for effectiveness. In fact, Ricardo's methodology for cost and effectiveness estimates for this rule was to define a vehicle class-specific BOM or BOMs, depending upon the number of variants possible within a class and within a decision tree. These BOMs were defined for the baseline configuration for each class and then for each incremental step in the decision tree. Use of a consistently-defined BOM is very important to estimating the impacts of technologies accurately, as it helps to ensure that technologies are not applied to baseline vehicles that already contain the technology (with the exception of items that are not well-defined such as aerodynamic drag reduction, reduced rolling resistance tires, weight reduction, and engine friction reduction.)

In defining these BOMs, Ricardo relied on its experience working with industry over many years and its recent experience preparing the December 2007 study for EPA. Ricardo built on its vehicle simulation work for EPA to help NHTSA evaluate appropriate effectiveness values for individual fuel-saving technologies. In considering the comments, NHTSA and Ricardo evaluated the 10 "vehicle subclasses" used in the NPRM for applicability of technologies and determined that the cost and effectiveness estimates could be more accurate by revising the "vehicle subclasses" as described above so that they better represented the parameters of the vehicles they included. This, in turn, enabled NHTSA and Ricardo to distinguish more clearly the differences in fuel consumption reduction occurring when a technology is added to different vehicles.

Then, with the BOM framework applied to more precisely-defined vehicle subclasses, NHTSA and Ricardo engineers reviewed effectiveness information from multiple sources for each technology. Together, they compared the multiple sources available in the docket and assessed their validity, taking care to ensure that common BOM definitions and other vehicle attributes such as performance, refinement, and drivability were not compromised.

Generally, whenever relevant effectiveness information for a technology component existed in a non-confidential and publicly-available report submitted to the NPRM docket, and that information agreed with Ricardo's independent review of estimates based on Ricardo's historical institutional knowledge, NHTSA and Ricardo cited that information. NHTSA and Ricardo were able to take that approach frequently, as is evident in the explanation of the effectiveness for each technology. When that approach was not possible, but there was confidential manufacturer data that had been submitted to NHTSA in response to the NPRM, and those values were consistent with Ricardo's independently-reviewed estimates, NHTSA and Ricardo cited those data. When multiple confidential data sources differed greatly or when the technical assumptions described by NHTSA for purposes of this rulemaking did not match the content included in Ricardo's study for EPA or in other comments, NHTSA and Ricardo engineers relied on Ricardo's experience and an understanding of the maximum theoretical losses that could be eliminated by particular technologies to build up an effectiveness estimate, substituting Ricardo's institutional knowledge for the remaining gaps in data.

Occasionally, NHTSA and Ricardo found that some fuel consumption reduction information submitted by the public was either not very clearly described or revealed a lack of knowledge on the part of the commenter about NHTSA' methodology. In those cases, and in cases for which no effectiveness data (either public or confidential) was available, NHTSA worked with Ricardo either to confirm the estimates it used in the NPRM, or to revise and enhance them.   In other cases, the commenters appeared unsure how to evaluate the data from the NPRM, and so NHTSA and Ricardo provided more detailed explanations on the process used or the components involved.

In response to comments stating that estimates for individual technologies should be varied based on the type and size of vehicle to which they are applied, NHTSA worked with Ricardo to account for those differences mostly through the refined vehicle subclass definitions. However, even after making these adjustments, there are still some classes that require spanning different engine architectures and performance thresholds. Just as the application of some technologies might be more or less expensive, depending on content (*e.g.*, with or without a noise attenuation package), particular vehicle technologies may have more or less impact between classes where maintaining equivalent performance led to a reduced effectiveness. In these cases, NHTSA and Ricardo described a range of effectiveness values for this technology, and referred to sources that indicate the appropriate boundaries of that range.

With Ricardo's assistance, the technology cost and effectiveness estimates for the final rule were developed consistently, using this systematic approach. This approach, combined with the BOM methodology for cost and effectiveness, expanded number and types of vehicle subclasses and the changes to the synergies effects described below, not only help to address the concerns raised by commenters, but also represent a considerable improvement in terms of accuracy and transparency over the approach used to develop the effectiveness estimates in the NPRM. While NHTSA still believes that the ideal estimates for the final rule would be those that have been through a peer-reviewed process such as that used for the 2002 NAS Report, and will continue to work with NAS, as required by EISA, to update the technology cost and effectiveness estimates for subsequent CAFE rulemakings, the cost and effectiveness estimates developed by NHTSA with Ricardo's assistance for this final rule are the best currently available. NHTSA is confident in their accuracy.

6. Learning curves

As explained in the NPRM, historically NHTSA did not explicitly account for the cost reductions a manufacturer might realize through learning achieved from experience in actually applying a technology. However, based on its work with EPA, in the NPRM NHTSA employed a learning factor for certain newer, emerging technologies. The "learning curve" describes the reduction in unit incremental production costs as a function of accumulated production volume and small redesigns that reduce costs.

The NPRM implemented technology learning curves by using three parameters: (1) the initial production volume that must be reached before cost reductions begin to be realized (referred to as "threshold volume"); (2) the percent reduction in average unit cost that results from each successive doubling of cumulative production volume (usually referred to as the "learning rate"); and (3) the initial cost of the technology. The majority of technologies considered in the NPRM did not have learning cost reductions applied to them.

NHTSA assumed that learning-based reductions in technology costs occur at the point that a manufacturer applies the given technology to the first 25,000 cars or trucks, and are repeated a second time as it produces another 25,000 cars or trucks for the second learning step.[99] NHTSA explained that the volumes chosen represented the agency's best estimate for where learning would occur, and that they were better suited to NHTSA's analysis than using a single number for the learning curve factor, because each manufacturer would implement technologies at its own pace in the rule, rather than assuming that all manufacturers implement identical technology at the same time.

NHTSA further assumed that after having produced 25,000 cars or trucks with a specific part or system, sufficient learning will have taken place such that costs will be lower by 20 percent for some technologies and 10 percent for others. For those technologies, NHTSA additionally assumed that another cost reduction would be realized after another 25,000 units. If a technology was already in widespread use (*e.g.*, on the order of several million units per year) or expected to be so by the MY 2011-2012 time frame, NHTSA assumed that the technology was "learned out," and that no more cost reductions were available for additional volume increases. If a technology was not estimated to be available until later in the rulemaking period, like MY 2014-2015, NHTSA did not apply learning for those technologies until those model years. Most of the technologies for which learning was applied after MY 2014 were adopted from the 2004 NESCCAF study, which was completed by Martec. Whenever source data, like the

[99] NHTSA treated car and truck volumes separately for determining those sales volumes.

2004 NESCCAF study, indicated that manufacturer cost reduction from future learning would occur, NHTSA took that information into account.

Comments received regarding NHTSA's approach to technology cost reductions due to manufacturer learning generally disagreed with the agency's method. The Alliance, AIAM, Honda, GM, and Chrysler all commented that NHTSA had substantially overestimated, and essentially "double-counted," learning effects by applying learning reductions to component costs, specifically Martec estimates, which were already at high volume. The Alliance submitted the 2008 Martec Report, which stated that NHTSA had "misstated" Martec's approach to cost reductions due to learning in the NPRM. As Martec explained,

> Martec did not ask suppliers to quote prices that would be valid for three years, and Martec did not receive cost reductions from suppliers for some components in years two and three. Rather, industry respondents were asked to establish mature component pricing on a forward basis given the following conditions: at least three (3) manufacturers demanding 500,000 units per year and at least three (3) globally-capable suppliers available to supply the needs of each manufacturer. In no case did Martec ask industry respondents to provide low volume, launch or transition costs for fuel consumption/CO_2 reducing technologies. Martec specifically designed the economic parameters in order to capture the effects of learning which is a reality in the low margin, high capital cost, high volume, highly competitive global automotive industry. Applying additional reductions attributable to "learning" based on 25,000 unit improvements in cumulative volume after production launch (as described on pages 118-125 of the NHTSA NPRM) on top of Martec's mature costs is an error. Martec's costs are based on 1.5-2.0 equivalent modules of powertrain capacity (500,000 units/year) so 25,000 unit incremental changes in cumulative production, as defined by NHTSA, will have no effect on costs.

The 2008 Martec Report also stated that current industry practice consists of using competitive bidding based on long-term, high-volume contracts that are negotiated before technology implementation decisions are made. Martec stated that this practice considers the effects of volume, learning, and capital depreciation. Martec also indicated that most of the technologies evaluated in the study are in high volume production in the global automotive industry today, and thus this forms a solid basis from which to estimate future costs.

Honda also commented on NHTSA's 25,000 unit (per manufacturer per year) volume threshold stating that, in their experience, costs were only likely to decrease due to learning at volumes exceeding about 300,000 units per year per manufacturer. GM agreed, stating that suppliers do not respond to, change processes, or change contract terms for relatively small volume changes like NHTSA's 25,000 unit increment, thus volume changes of this magnitude have no effect on component pricing. GM also commented that its learning cycles are based on time, not volume, and agreed with Martec's assessment that contracts with suppliers typically specify volumes and costs over a period, which are usually equal to a product life cycle, a 4- to 5-year period.

Ford commented that base costs in the automotive industry are determined by a target setting process, where manufacturers develop pricing with suppliers for a set period, and manufacturers receive cost reductions from the suppliers due to learning as time passes, apparently at a set amount year over year for several years. Ford also commented that NHTSA's approach to learning curves had not accounted for current economic factors, like increases in commodity and energy prices, and cited the example of costs of batteries for hybrids and PHEVs which Ford stated "are not likely to depend solely on experience learned, but, to a large extent, on the additional energy and material costs they incur relative to the vehicles without the new technology." Ford commented that NHTSA should account for these costs, and the factor of declining vehicle sales, in its learning curve approach.

BorgWarner, a components supplier, commented that learning-related costs savings are valid for technologies that "*start at low* volume" (commenter's emphasis). BorgWarner argued, however, that NHTSA's assumed learning curve would not apply to the technologies it supplies to manufacturers,[100] since these components are well-developed and in high volume use already, and are thus already "learned out." BorgWarner further commented that an increase in demand could in fact lead to higher prices if demand for raw materials exceeded supply.

UCS, in contrast, commented that NHTSA had not accounted for *enough* cost reductions due to learning. UCS stated that NHTSA should have provided "source data" for manufacturer-specific learning curves, and argued that NHTSA's approach was "fundamentally flawed" for two primary reasons: first, because NHTSA had not considered the fact that manufacturers engage in joint ventures to develop new technologies, and second, because manufacturers may also learn from one another "through the standard practice of tearing down competitors' products." UCS argued that NHTSA's learning-based cost reductions should account for these methods of learning. UCS further stated that NHTSA should not "treat[] car and truck sales volumes separately when estimating learning curves" because there may be much overlap in terms of technology application, especially for vehicles like crossovers which may be either cars or trucks. UCS concluded that NHTSA should use EPA's suggested learning factor of 20 percent, citing EPA's Staff Technical Report.

Public Citizen agreed that NHTSA should account for economies of scale, but argued that NHTSA should not have relied on initial cost estimates from industry, which

[100] BorgWarner manufacturers and supplies turbochargers, dual clutch transmissions, variable valve timing systems, diesel engine components (EGR and starting), aggressive shift logic and early torque convertor lockup systems.

the commenter stated were "often overestimated." Public Citizen cited a 1997 briefing paper by the Economic Policy Institute in support of this point, and argued that compliance cost estimates were often much lower than actual costs. Public Citizen concluded that NHTSA's use of learning curve factors "impedes transparency" in NHTSA's analysis.

Agency response: Based on the comments received and on its work with Ricardo, NHTSA has revised its approach to accounting for technology cost reductions due to manufacturer learning. The method of learning used in the NPRM has been retained, but the threshold volume has been revised and is now calculated on an industry-wide production basis. Learning of this type, which NHTSA now refers to as "volume-based" learning, is applied to a smaller number of technologies in comparison to the NPRM. Additionally NHTSA has adopted a fixed rate, year-over-year (YOY) cost reduction for widely-available, high-volume, mature technologies, in response to comments from Ford and others. NHTSA refers to this type cost reduction as "time-based" learning. For each technology, if learning is applicable, only one type of learning is applied, either volume-based or time-based (*i.e.*, the types are independent of each other). These revisions are discussed below.

For volume-based learning, NHTSA considered comments from UCS and decided to revise the method used to calculate the threshold volume from a per-manufacturer to an industry-wide production volume basis. NHTSA agreed with UCS' comment that cars and trucks may share common components—this is true across many makes and models which share common engines, transmissions, accessory systems, and mild or strong hybrid systems, all of which can potentially utilize the technologies under consideration.

These systems are often manufactured by suppliers who contract with multiple OEMs, all of whom benefit (in the form of cost reductions for the technology) from the supplier's learning. The 2008 Martec Report and the BorgWarner comments additionally both indicated that when manufacturers demand components in high volumes, suppliers are able to pass on learning-based savings to all manufacturers with whom they contract. Thus, it made sense to NHTSA to revise its method of determining whether the threshold volume has been achieved from an annual per-manufacturer to an annual industry-wide production volume basis.

NHTSA also changed the threshold volume for volume-based learning from 25,000 to 300,000 units. The 2008 Martec Report and comments from multiple manufacturers indicated that 25,000 units was far too small a production volume to affect component costs. In response, NHTSA began with the Martec estimate that technologies were fully learned-out at 1.5 million units of production (which met the production needs of three manufacturers, according to that report). NHTSA then applied two cycles of learning in a reverse direction to determine what the proper threshold volume would be for these conditions. One cycle would be applied at 750,000 units (1.5 million divided by 2, which would represent the second volume doubling) and one at 375,000 units (750,000 divided by 2, which would represent the first volume doubling). NHTSA thus estimated that the Martec analysis would suggest a threshold volume of 375,000 units. However, the agency notes that Martec stated that it chose the 1.5 million units number specifically because Martec knew it was well beyond the point where learning is a factor, which means that 1.5 million was beyond the cusp of the learning threshold. NHTSA therefore concluded that 375,000 units should represent the upper bound for the threshold volume for Martec's analysis.

Having determined this, NHTSA sought to establish a lower bound for the threshold volume. The 2008 Martec report indicated that production efficiencies are maximized at 250,000-350,000 units (which averages to 300,000 units), and that manufacturers consequently target this range when planning and developing manufacturing operations. Honda also cited this production volume. Thus, for three manufacturers, the annual volume requirement would be 900,000 units.[101] NHTSA concluded this could also represent high volume where learned costs could be available, and considered it as a lower bound estimate. With the upper and lower values established, and given that Martec specifically indicated that 1.5 million did not represent the cusp of the learning threshold, NHTSA chose the mid-point of 1.2 million units as the best estimate of annual industry volumes where learned costs would be experienced. For proper forward learning, this would mean the first learning cycle would occur at 300,000 and the second at 600,000. Accordingly NHTSA has established the threshold volume for the final rule at 300,000 industry units per year.

Having established the threshold volume, NHTSA next considered which technologies to apply volume learning to. Comments confirmed that NHTSA had been correct in the NPRM to assume that learning would be applicable to low-volume, emerging technologies that could benefit from economies of scale, so NHTSA consulted confidential product plans to determine the volumes of technologies to be applied by manufacturers during the rulemaking period. If the product plans indicated that the

[101] An industry volume of 900,000 would imply a threshold volume of 225,000 units according to NHTSA's analysis. This is still nine times the value used at the NPRM.

technologies would be in high-volume use (*i.e.*, above 600,000 units produced annually for cars and trucks by all manufacturers) at the beginning of its first year of availability, then volume-based learning was not considered applicable, since at this volume the technology would be available at learned cost. If the volume was below 600,000 units annually, then NHTSA also looked at the Volpe model's application of the technology. If the model applied more than 600,000 units within the first year of availability, NHTSA did not apply volume-based learning. If neither manufacturers nor the model applied more than 600,000 units within the first year, then volume learning was applied to the technology.

Based on this analysis, NHTSA determined that volume-based learning would be applicable to three technologies for purposes of the final rule: integrated starter generator, 2-mode hybrid, and plug-in hybrid. For these three technologies, and where the agency's initial cost estimates reflected full learning, NHTSA reverse-learned the cost by dividing the estimate by the learning rate twice to properly offset the learned cost estimate. NHTSA used a 20 percent learning rate in the NPRM for these technologies, and concluded that that rate was still applicable for the final rule. This learning rate was validated using manufacturer-submitted current and forecast cost data for advanced-battery hybrid vehicle technology, and accepted industry forecasts for U.S. sales volumes of these same vehicles. This limited study indicated that cost efficiencies were approximately 20 percent for a doubling of U.S. market annual sales of a particular advanced battery technology, and the learning rate was thus used as a proxy for other advanced vehicle technologies.

Commenters also indicated that learning-related cost reductions could occur not only as a result of production volume changes, but also as a function of time. For example, Ford stated that technology cost reductions were negotiated as part of the contractual agreement to purchase components from suppliers, a target-setting process which Ford described as common in the automotive industry. In this arrangement suppliers agree to reduce costs on a fixed percentage year over year according to negotiated terms. GM described a cost reduction process that occurs over the course of a product life cycle, typically no less than 4-5 years, where costs are reduced as production experience increases. GM stated that its cost reductions included engineering, manufacturing, investment, and material costs, and were also defined through supplier contracts that anticipate volume and costs over the whole period. The components involved are assumed to be high volume, mature technologies being used in current vehicle production. These are the types of components that would typically be subject to "cost-down"[102] efforts that target savings through small, incremental design, manufacturing, assembly, and material changes on a recurring or periodic basis.

In response to these comments, NHTSA has adopted this approach as an additional type of learning related cost reduction, referring to it as "time-based" learning. For purposes of the final rule, time-based learning is applied to high-volume, mature technologies likely to be purchased by OEMs on a long-term contractual basis. This would include most of the fuel-saving technologies under consideration, except those where volume-based learning is applied, or those where components might consist of commodity materials, such as oil or rubber, where pricing fluctuations prevent long-term

[102] Cost-down efforts are a common practice in competitive manufacturing environments like the automotive industry.

or fixed value contracts. NHTSA has used a 3 percent reduction rate for time-based learning, based on confidential manufacturer information and NHTSA's understanding of current industry practice. Thus, if time-based learning is deemed applicable, then in year two of a technology's application, and in each subsequent year (if any), the initial cost is reduced by 3 percent. This approach is responsive to comments about compliance costs estimation, and improves the accuracy of projecting future costs compared to the NPRM.

With regard to the comments from UCS, NHTSA recognizes that joint-venture collaboration and competitor tear-downs are methods used by manufacturers for designing and developing new products and components, but notes that these methods are used prior to the manufacturing stage, and thus are not considered manufacturing costs. NHTSA has received no specific manufacturer learning curve-related data, and thus has no "source data" to disclose. NHTSA continues to use a 20 percent learning factor for volume-based learning, which is consistent with EPA's learning factor recommended by UCS for NHTSA's use.

With regard to the comments from Public Citizen, although NHTSA reviewed the paper cited by the commenter, the agency found its analysis largely irrelevant to NHTSA's estimation of cost reduction factors due to automobile manufacturer learning, and thus declines to adopt its findings.

Table IV-4 below shows the applicability and type of learning applied in the final rule.

Table IV-4—Application of learning-related cost reductions for technologies

Technology	Abbr.	Learning Type	Learning Rate
Low Friction Lubricants	LUB		
Engine Friction Reduction	EFR		
VVT - Coupled Cam Phasing (CCP) on SOHC	CCPS	TIME	3%
Discrete Variable Valve Lift (DVVL) on SOHC	DVVLS	TIME	3%
Cylinder Deactivation on SOHC	DEACS	TIME	3%
VVT - Intake Cam Phasing (ICP)	ICP	TIME	3%
VVT - Dual Cam Phasing (DCP)	DCP	TIME	3%
Discrete Variable Valve Lift (DVVL) on DOHC	DVVLD	TIME	3%
Continuously Variable Valve Lift (CVVL)	CVVL	TIME	3%
Cylinder Deactivation on DOHC	DEACD	TIME	3%
Cylinder Deactivation on OHV	DEACO	TIME	3%
VVT - Coupled Cam Phasing (CCP) on OHV	CCPO	TIME	3%
Discrete Variable Valve Lift (DVVL) on OHV	DVVLO	TIME	3%
Conversion to DOHC with DCP	CDOHC	TIME	3%
Stoichiometric Gasoline Direct Injection (GDI)	SGDI	TIME	3%
Combustion Restart	CBRST	TIME	3%
Turbocharging and Downsizing	TRBDS	TIME	3%
Exhaust Gas Recirculation (EGR) Boost	EGRB	TIME	3%
Conversion to Diesel following CBRST	DSLC	TIME	3%
Conversion to Diesel following TRBDS	DSLT	TIME	3%
Electric Power Steering	EPS	TIME	3%
Improved Accessories	IACC	TIME	3%
12V Micro-Hybrid	MHEV	TIME	3%
Higher Voltage/Improved Alternator	HVIA	TIME	3%
Integrated Starter Generator	ISG	VOLUME	20%
6-Speed Manual/Improved Internals	6MAN	TIME	3%
Improved Auto. Trans. Controls/Externals	IATC	TIME	3%
Continuously Variable Transmission	CVT	TIME	3%
6/7/8-Speed Auto. Trans with Improved Internals	NAUTO	TIME	3%
Dual Clutch or Automated Manual Transmission	DCTAM	TIME	3%
Power Split Hybrid	PSHEV	TIME	3%
2-Mode Hybrid	2MHEV	VOLUME	20%
Plug-in Hybrid	PHEV	VOLUME	20%
Material Substitution (1%)	MS1		
Material Substitution (2%)	MS2		
Material Substitution (5%)	MS5		
Low Rolling Resistance Tires	ROLL		
Low Drag Brakes	LDB	TIME	3%
Secondary Axle Disconnect – 4WD	SAX	TIME	3%
Aero Drag Reduction	AERO	TIME	3%

7. Technology synergies

When two or more technologies are added to a particular vehicle model to improve its fuel efficiency, the resultant fuel consumption reduction may sometimes be higher or lower than the product of the individual effectiveness values for those items.[103] This may occur because one or more technologies applied to the same vehicle partially address the same source or sources of engine, drivetrain or vehicle losses. Alternately, this effect may be seen when one technology shifts the engine operating points, and therefore increases or reduces the fuel consumption reduction achieved by another technology or set of technologies. The difference between the observed fuel consumption reduction associated with a set of technologies and the product of the individual effectiveness values in that set is referred to for purposes of this rulemaking as a "synergy." Synergies may be positive (increased fuel consumption reduction compared to the product of the individual effects) or negative (decreased fuel consumption reduction).

For the NPRM, the Volpe model was modified to estimate the interactions of technologies using estimates of incremental synergies associated with a number of technology pairs identified by NHTSA. The use of discrete technology pair incremental synergies is similar to that in DOE's National Energy Modeling System (NEMS).[104]

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[103] More specifically, the products of the differences between one and the technology-specific levels of effectiveness in reducing fuel consumption. For example, not accounting for interactions, if technologies A and B are estimated to reduce fuel consumption by 10% (i.e., 0.1) and 20% (i.e., 0.2) respectively, the "product of the individual effectiveness values" would be 1 – 0.1 times 1 – 0.2, or 0.9 times 0.8, which equals 0.72, corresponding to a combined effectiveness of 28% rather than the 30% obtained by adding 10% to 20%. The "synergy factors" discussed in this section further adjust these multiplicatively combined effectiveness values.

[104] U.S. Department of Energy, Energy Information Administration, *Transportation Sector Module of the National Energy Modeling System: Model Documentation 2007*, May 2007, Washington, DC, DOE/EIA-M070(2007), at 29-30. *Available at* http://tonto.eia.doe.gov/ftproot/modeldoc/m070(2007).pdf (last accessed Oct. 24, 2008).

Inputs to the Volpe model incorporate NEMS-identified pairs, as well as additional pairs for the final rule from the set of technologies considered in the Volpe model. However, to maintain an approach that was consistent with the technology sequencing developed by NHTSA, new incremental synergy estimates for all pairs were obtained from a first-order "lumped parameter" analysis tool created by EPA.[105]

The lumped parameter tool is a spreadsheet model that represents energy consumption in terms of average performance over the fuel economy test procedure, rather than explicitly analyzing specific drive cycles. The tool begins with an apportionment of fuel consumption across several loss mechanisms and accounts for the average extent to which different technologies affect these loss mechanisms using estimates of engine, drivetrain and vehicle characteristics that are averaged over the EPA fuel economy drive cycle. Results of this analysis were generally consistent with those of full-scale vehicle simulation modeling performed by Ricardo, Inc. However, regardless of a generally consistent set of results for the vehicle class and set of technologies studied, the lumped parameter tool is not a full vehicle simulation and cannot replicate the physics of such a simulation.

Many comments were received that stated this and pointed to errors in the synergies listed in the NPRM being in some cases inaccurate or even directionally incorrect. NHTSA recognizes that the estimated synergies applied for the NPRM were not all correct, and has reevaluated all estimated synergies applied in the analysis supporting today's final rule. In response to commenters calling for NHTSA to use full vehicle simulation, either in the first instance or as a check on the synergy factors that

[105] EPA Staff Technical Report: Cost and Effectiveness Estimates of Technologies Used to Reduce Light-duty Vehicle Carbon Dioxide Emissions; EPA420-R-08-008, March 2008.

NHTSA developed, the agency has concluded that the vehicle simulation analyses conducted previously by Ricardo provide a sufficient point of reference, especially considering the time constraints for establishing the final rule. NHTSA did, however, improve the predictive capability of the lumped parameter tool.

The lumped parameter tool was first updated with the new list of technologies and their associated effectiveness values. Second, NHTSA conducted a more rigorous qualitative analysis of the technologies for which a competition for losses would be expected, which led to a much larger list of synergy pairings than was present in the NRPM. The types of losses that were analyzed were tractive effort, transmission/drivetrain, engine mechanical friction, engine pumping, engine indicated (combustion) efficiency and accessory (see Table IV-5). As can be seen from Table IV-5, engine mechanical friction, pumping and accessory losses are improved by various technologies from engine, transmission, electrification and hybrid decision trees and must be accounted for within the model with a synergy value. The updated lumped parameter model was then re-run to develop new synergy estimates for the expanded list of pairings. That list is shown in Tables IV-6a-d. The agency notes that synergies that occur within a decision tree are already addressed within the incremental values assigned and therefore do not require a synergy pair to address. For example, all engine technologies take into account incremental synergy factors of preceding engine technologies, and all transmission technologies take into account incremental synergy factors of preceding transmission technologies. These factors are expressed in the fuel consumption improvement factors in the input files used by the Volpe model.

For applying incremental synergy factors in separate path technologies, the Volpe model uses an input table (see Tables IV-6a-d) which lists technology pairings and incremental synergy factors associated with those pairings, most of which are between engine technologies and transmission/electrification/hybrid technologies. When a technology is applied to a vehicle by the Volpe model, all instances of that technology in the incremental synergy table which match technologies already applied to the vehicle (either pre-existing or previously applied by the Volpe model) are summed and applied to the fuel consumption improvement factor of the technology being applied. Synergies for the strong hybrid technology fuel consumption reductions are included in the incremental value for the specific hybrid technology block since the model applies technologies in the order of the most effectiveness for least cost and also applies all available electrification and transmission technologies before applying strong hybrid technologies.

As another possible alternative to using synergy factors, NHTSA has also considered modifying the Volpe model to apply inputs—for each vehicle model—specifying the share of total fuel consumption attributable to each of several energy loss mechanisms. The Agency has determined that this approach, discussed in greater detail below, cannot be implemented at this time because the requisite information is not available.

Table IV-5. Loss Factors Considered in Synergy Analysis

Lumped Parameter Synergy Analysis	VEHICLE Tractive Effort	TRANS Drivetrain Losses	ENGINE Mechanical Friction	ENGINE Pumping Losses	ENGINE Accessory Losses	ENGINE Indicated Efficiency
ENGINE						
Low Friction Lubricants			+			
Engine Friction Reduction			+			
VVT - Coupled Cam Phasing (CCP) on SOHC			-	+		+
Discrete Variable Valve Lift (DVVL) on SOHC			-	+		
Cylinder Deactivation on SOHC			+	+		
VVT - Intake Cam Phasing (ICP)			-	+		+
VVT - Dual Cam Phasing (DCP)			-	+		+
Discrete Variable Valve Lift (DVVL) on DOHC			-	+		
Continuously Variable Valve Lift (CVVL)			-	+		
Cylinder Deactivation on DOHC			+	+		
Cylinder Deactivation on OHV			+	+		
VVT - Coupled Cam Phasing (CCP) on OHV			-	+		+
Discrete Variable Valve Lift (DVVL) on OHV			-	+		
Conversion to DOHC with DCP			-	+		+
Stoichiometric Gasoline Direct Injection (GDI)						+
Combustion Restart			+	+	+	
Turbocharging and Downsizing			-	+		
Exhaust Gas Recirculation (EGR) Boost						+
Conversion to Diesel				+		+
ELECTRIFICATION/ACCESSORY						
Electric Power Steering					+	
Improved Accessories					+	
12V Micro-Hybrid			+	+	+	
Higher Voltage/Improved Alternator					+	
Integrated Starter Generator			+	+	+	
TRANSMISSION (MANUAL)						
6-Speed Manual/Improved Internals		+		+		
TRANSMISSION (AUTOMATIC)						
Improved Auto. Trans. Controls/Externals		+		+		
Continuously Variable Transmission		-		+		
6/7/8-Speed Auto. Trans with Impr. Internals		+		+		
Dual Clutch/Automated Manual Transmission		+				
(STRONG) HYBRID						
Power Split Hybrid		+	+	+	+	
2-Mode Hybrid		+	+	+	+	
Plug-in Hybrid		+	+	+	+	
VEHICLE						
Material Substitution (1%)	+					
Material Substitution (2%)	+					
Material Substitution (5%)	+					
Low Rolling Resistance Tires	+					
Low Drag Brakes	+					
Secondary Axle Disconnect - 4WD		+				
Aero Drag Reduction	+					

+ Technology has a positive effect on fuel consumption
- Technology has a negative effect on fuel consumption

Table IV-6a. Synergy pairings and values

Synergies		Fuel Consumption Improvement Synergy values by Vehicle Subclass Positive values are positive synergies, negative values are dissynergies.					
Technology A	Technology B	Subcompact PC	Subcompact Perf. PC	Compact PC	Compact Perf. PC	Midsize PC	Midsize Perf. PC
CCPS	6MAN	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%
CCPS	IATC	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%
CCPS	CVT	-0.8%	-0.8%	-0.8%	-0.8%	-0.8%	-0.8%
CCPS	NAUTO	-0.4%	-0.4%	-0.4%	-0.4%	-0.4%	-0.4%
CCPS	MHEV	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%
CCPS	ISG	-0.9%	-0.9%	-0.9%	-0.9%	-0.9%	-0.9%
DVVLS	6MAN	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%
DVVLS	IATC	-0.5%	-0.5%	-0.5%	-0.5%	-0.5%	-0.5%
DVVLS	CVT	-1.4%	-1.4%	-1.4%	-1.4%	-1.4%	-1.4%
DVVLS	NAUTO	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%
DVVLS	MHEV	-0.8%	-0.8%	-0.8%	-0.8%	-0.8%	-0.8%
DVVLS	ISG	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%
DEACS	6MAN	n.a.	n.a.	n.a.	-0.2%	n.a.	-0.2%
DEACS	IATC	n.a.	n.a.	n.a.	-0.6%	n.a.	-0.6%
DEACS	CVT	n.a.	n.a.	n.a.	-1.7%	n.a.	-1.7%
DEACS	NAUTO	n.a.	n.a.	n.a.	-0.9%	n.a.	-0.9%
DEACS	MHEV	n.a.	n.a.	n.a.	-0.9%	n.a.	-0.9%
DEACS	ISG	n.a.	n.a.	n.a.	-1.1%	n.a.	-1.1%
ICP	6MAN	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%
ICP	IATC	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%
ICP	CVT	-0.8%	-0.8%	-0.8%	-0.8%	-0.8%	-0.8%
ICP	NAUTO	-0.4%	-0.4%	-0.4%	-0.4%	-0.4%	-0.4%
ICP	MHEV	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%
ICP	ISG	-0.9%	-0.9%	-0.9%	-0.9%	-0.9%	-0.9%
DCP	6MAN	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%
DCP	IATC	-0.4%	-0.4%	-0.4%	-0.4%	-0.4%	-0.4%
DCP	CVT	-1.3%	-1.3%	-1.3%	-1.3%	-1.3%	-1.3%
DCP	NAUTO	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%
DCP	MHEV	-0.8%	-0.8%	-0.8%	-0.8%	-0.8%	-0.8%
DCP	ISG	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%
DVVLD	6MAN	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%
DVVLD	IATC	-0.6%	-0.6%	-0.6%	-0.6%	-0.6%	-0.6%
DVVLD	CVT	-1.8%	-1.8%	-1.8%	-1.8%	-1.8%	-1.8%
DVVLD	NAUTO	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%
DVVLD	MHEV	-0.9%	-0.9%	-0.9%	-0.9%	-0.9%	-0.9%
DVVLD	ISG	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%
DEACD	6MAN	n.a.	n.a.	n.a.	-0.2%	n.a.	-0.2%
DEACD	IATC	n.a.	n.a.	n.a.	-0.6%	n.a.	-0.6%
DEACD	CVT	n.a.	n.a.	n.a.	-1.8%	n.a.	-1.8%
DEACD	NAUTO	n.a.	n.a.	n.a.	-1.0%	n.a.	-1.0%
DEACD	MHEV	n.a.	n.a.	n.a.	-0.9%	n.a.	-0.9%
DEACD	ISG	n.a.	n.a.	n.a.	-1.1%	n.a.	-1.1%
CVVL	6MAN	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%
CVVL	IATC	-0.6%	-0.6%	-0.6%	-0.6%	-0.6%	-0.6%
CVVL	CVT	-1.8%	-1.8%	-1.8%	-1.8%	-1.8%	-1.8%
CVVL	NAUTO	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%
CVVL	MHEV	-0.9%	-0.9%	-0.9%	-0.9%	-0.9%	-0.9%
CVVL	ISG	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%

Table IV-6b. Synergy pairings and values

Synergies		Fuel Consumption Improvement Synergy values by Vehicle Subclass Positive values are positive synergies, negative values are dissynergies.					
Technology A	Technology B	Subcompact PC	Subcompact Perf. PC	Compact PC	Compact Perf. PC	Midsize PC	Midsize Perf. PC
DEACO	6MAN	n.a.	n.a.	n.a.	-0.1%	n.a.	-0.1%
DEACO	IATC	n.a.	n.a.	n.a.	-0.5%	n.a.	-0.5%
DEACO	CVT	n.a.	n.a.	n.a.	-1.4%	n.a.	-1.4%
DEACO	NAUTO	n.a.	n.a.	n.a.	-0.8%	n.a.	-0.8%
DEACO	MHEV	n.a.	n.a.	n.a.	-0.9%	n.a.	-0.9%
DEACO	ISG	n.a.	n.a.	n.a.	-1.2%	n.a.	-1.2%
CCPO	6MAN	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%
CCPO	IATC	-0.6%	-0.6%	-0.6%	-0.6%	-0.6%	-0.6%
CCPO	CVT	-1.7%	-1.7%	-1.7%	-1.7%	-1.7%	-1.7%
CCPO	NAUTO	-0.9%	-0.9%	-0.9%	-0.9%	-0.9%	-0.9%
CCPO	MHEV	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%
CCPO	ISG	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%
DVVLO	6MAN	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%
DVVLO	IATC	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%
DVVLO	CVT	-2.0%	-2.0%	-2.0%	-2.0%	-2.0%	-2.0%
DVVLO	NAUTO	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%
DVVLO	MHEV	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%
DVVLO	ISG	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%
CDOHC	6MAN	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%
CDOHC	IATC	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%
CDOHC	CVT	-2.0%	-2.0%	-2.0%	-2.0%	-2.0%	-2.0%
CDOHC	NAUTO	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%
CDOHC	MHEV	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%
CDOHC	ISG	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%
CBRST	6MAN	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%
CBRST	IATC	-0.6%	-0.6%	-0.6%	-0.6%	-0.6%	-0.6%
CBRST	CVT	-1.8%	-1.8%	-1.8%	-1.8%	-1.8%	-1.8%
CBRST	NAUTO	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%
CBRST	MHEV	-2.1%	-2.1%	-2.1%	-2.1%	-2.1%	-2.1%
CBRST	ISG	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%
CBRST	EPS	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%
CBRST	IACC	-0.4%	-0.4%	-0.4%	-0.4%	-0.4%	-0.4%
CBRST	HVIA	-0.3%	-0.3%	-0.3%	-0.3%	-0.3%	-0.3%
TRBDS	6MAN	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%
TRBDS	IATC	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%
TRBDS	CVT	-2.4%	-2.4%	-2.4%	-2.4%	-2.4%	-2.4%
TRBDS	NAUTO	-1.3%	-1.3%	-1.3%	-1.3%	-1.3%	-1.3%
TRBDS	MHEV	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%
TRBDS	ISG	-1.3%	-1.3%	-1.3%	-1.3%	-1.3%	-1.3%
DSLC	6MAN	-0.3%	-0.3%	-0.3%	-0.3%	-0.3%	-0.3%
DSLC	IATC	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
DSLC	CVT	-2.9%	-2.9%	-2.9%	-2.9%	-2.9%	-2.9%
DSLC	NAUTO	-1.7%	-1.7%	-1.7%	-1.7%	-1.7%	-1.7%
DSLC	MHEV	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%
DSLC	ISG	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%
DSLT	6MAN	-0.3%	-0.3%	-0.3%	-0.3%	-0.3%	-0.3%
DSLT	IATC	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
DSLT	CVT	-2.9%	-2.9%	-2.9%	-2.9%	-2.9%	-2.9%
DSLT	NAUTO	-1.7%	-1.7%	-1.7%	-1.7%	-1.7%	-1.7%
DSLT	MHEV	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%
DSLT	ISG	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%

Table IV-6c. Synergy pairings and values

Synergies		Fuel Consumption Improvement Synergy values by Vehicle Subclass Positive values are positive synergies, negative values are dissynergies.					
Technology A	**Technology B**	**Large PC**	**Large Perf. PC**	**Minivan LT**	**Small LT**	**Midsize LT**	**Large LT**
CCPS	6MAN	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%
CCPS	IATC	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%
CCPS	CVT	-0.8%	n.a.	-0.8%	-0.8%	-0.8%	n.a.
CCPS	NAUTO	-0.4%	-0.4%	-0.4%	-0.4%	-0.4%	-0.4%
CCPS	MHEV	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%	n.a.
CCPS	ISG	-0.9%	-0.9%	-0.9%	-0.9%	-0.9%	n.a.
DVVLS	6MAN	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%
DVVLS	IATC	-0.5%	-0.5%	-0.5%	-0.5%	-0.5%	-0.5%
DVVLS	CVT	-1.4%	n.a.	-1.4%	-1.4%	-1.4%	n.a.
DVVLS	NAUTO	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%
DVVLS	MHEV	-0.8%	-0.8%	-0.8%	-0.8%	-0.8%	n.a.
DVVLS	ISG	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%	n.a.
DEACS	6MAN	-0.2%	-0.2%	-0.2%	n.a.	-0.2%	-0.2%
DEACS	IATC	-0.6%	-0.6%	-0.6%	n.a.	-0.6%	-0.6%
DEACS	CVT	-1.7%	n.a.	-1.7%	n.a.	-1.7%	n.a.
DEACS	NAUTO	-0.9%	-0.9%	-0.9%	n.a.	-0.9%	-0.9%
DEACS	MHEV	-0.9%	-0.9%	-0.9%	n.a.	-0.9%	n.a.
DEACS	ISG	-1.1%	-1.1%	-1.1%	n.a.	-1.1%	n.a.
ICP	6MAN	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%
ICP	IATC	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%
ICP	CVT	-0.8%	n.a.	-0.8%	-0.8%	-0.8%	n.a.
ICP	NAUTO	-0.4%	-0.4%	-0.4%	-0.4%	-0.4%	-0.4%
ICP	MHEV	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%	n.a.
ICP	ISG	-0.9%	-0.9%	-0.9%	-0.9%	-0.9%	n.a.
DCP	6MAN	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%
DCP	IATC	-0.4%	-0.4%	-0.4%	-0.4%	-0.4%	-0.4%
DCP	CVT	-1.3%	n.a.	-1.3%	-1.3%	-1.3%	n.a.
DCP	NAUTO	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%
DCP	MHEV	-0.8%	-0.8%	-0.8%	-0.8%	-0.8%	n.a.
DCP	ISG	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%	n.a.
DVVLD	6MAN	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%
DVVLD	IATC	-0.6%	-0.6%	-0.6%	-0.6%	-0.6%	-0.6%
DVVLD	CVT	-1.8%	n.a.	-1.8%	-1.8%	-1.8%	n.a.
DVVLD	NAUTO	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%
DVVLD	MHEV	-0.9%	-0.9%	-0.9%	-0.9%	-0.9%	n.a.
DVVLD	ISG	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%	n.a.
DEACD	6MAN	-0.2%	-0.2%	-0.2%	n.a.	-0.2%	-0.2%
DEACD	IATC	-0.6%	-0.6%	-0.6%	n.a.	-0.6%	-0.6%
DEACD	CVT	-1.8%	n.a.	-1.8%	n.a.	-1.8%	n.a.
DEACD	NAUTO	-1.0%	-1.0%	-1.0%	n.a.	-1.0%	-1.0%
DEACD	MHEV	-0.9%	-0.9%	-0.9%	n.a.	-0.9%	n.a.
DEACD	ISG	-1.1%	-1.1%	-1.1%	n.a.	-1.1%	n.a.
CVVL	6MAN	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%
CVVL	IATC	-0.6%	-0.6%	-0.6%	-0.6%	-0.6%	-0.6%
CVVL	CVT	-1.8%	n.a.	-1.8%	-1.8%	-1.8%	n.a.
CVVL	NAUTO	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%
CVVL	MHEV	-0.9%	-0.9%	-0.9%	-0.9%	-0.9%	n.a.
CVVL	ISG	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%	n.a.

Table IV-6d. Synergy pairings and values

Synergies		Fuel Consumption Improvement Synergy values by Vehicle Subclass Positive values are positive synergies, negative values are dissynergies.					
Technology A	**Technology B**	**Large PC**	**Large Perf. PC**	**Minivan LT**	**Small LT**	**Midsize LT**	**Large LT**
DEACO	6MAN	-0.1%	-0.1%	-0.1%	n.a.	-0.1%	-0.1%
DEACO	IATC	-0.5%	-0.5%	-0.5%	n.a.	-0.5%	-0.5%
DEACO	CVT	-1.4%	n.a.	-1.4%	n.a.	-1.4%	n.a.
DEACO	NAUTO	-0.8%	-0.8%	-0.8%	n.a.	-0.8%	-0.8%
DEACO	MHEV	-0.9%	-0.9%	-0.9%	n.a.	-0.9%	n.a.
DEACO	ISG	-1.2%	-1.2%	-1.2%	n.a.	-1.2%	n.a.
CCPO	6MAN	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%
CCPO	IATC	-0.6%	-0.6%	-0.6%	-0.6%	-0.6%	-0.6%
CCPO	CVT	-1.7%	n.a.	-1.7%	-1.7%	-1.7%	n.a.
CCPO	NAUTO	-0.9%	-0.9%	-0.9%	-0.9%	-0.9%	-0.9%
CCPO	MHEV	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%	n.a.
CCPO	ISG	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%	n.a.
DVVLO	6MAN	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%
DVVLO	IATC	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%
DVVLO	CVT	-2.0%	n.a.	-2.0%	-2.0%	-2.0%	n.a.
DVVLO	NAUTO	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%
DVVLO	MHEV	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%	n.a.
DVVLO	ISG	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%	n.a.
CDOHC	6MAN	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%
CDOHC	IATC	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%
CDOHC	CVT	-2.0%	n.a.	-2.0%	-2.0%	-2.0%	n.a.
CDOHC	NAUTO	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%
CDOHC	MHEV	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%	n.a.
CDOHC	ISG	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%	n.a.
CBRST	6MAN	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%
CBRST	IATC	-0.6%	-0.6%	-0.6%	-0.6%	-0.6%	-0.6%
CBRST	CVT	-1.8%	n.a.	-1.8%	-1.8%	-1.8%	n.a.
CBRST	NAUTO	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%
CBRST	MHEV	-2.1%	-2.1%	-2.1%	-2.1%	-2.1%	n.a.
CBRST	ISG	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%	n.a.
CBRST	EPS	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	n.a.
CBRST	IACC	-0.4%	-0.4%	-0.4%	-0.4%	n.a.	n.a.
CBRST	HVIA	-0.3%	-0.3%	-0.3%	-0.3%	-0.3%	n.a.
TRBDS	6MAN	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%
TRBDS	IATC	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%
TRBDS	CVT	-2.4%	n.a.	-2.4%	-2.4%	-2.4%	n.a.
TRBDS	NAUTO	-1.3%	-1.3%	-1.3%	-1.3%	-1.3%	-1.3%
TRBDS	MHEV	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%	n.a.
TRBDS	ISG	-1.3%	-1.3%	-1.3%	-1.3%	-1.3%	n.a.
DSLC	6MAN	-0.3%	-0.3%	-0.3%	-0.3%	-0.3%	-0.3%
DSLC	IATC	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
DSLC	CVT	-2.9%	n.a.	-2.9%	-2.9%	-2.9%	n.a.
DSLC	NAUTO	-1.7%	-1.7%	-1.7%	-1.7%	-1.7%	-1.7%
DSLC	MHEV	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%	n.a.
DSLC	ISG	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%	n.a.
DSLT	6MAN	-0.3%	-0.3%	-0.3%	-0.3%	-0.3%	-0.3%
DSLT	IATC	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
DSLT	CVT	-2.9%	n.a.	-2.9%	-2.9%	-2.9%	n.a.
DSLT	NAUTO	-1.7%	-1.7%	-1.7%	-1.7%	-1.7%	-1.7%
DSLT	MHEV	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%	n.a.
DSLT	ISG	-1.1%	-1.1%	-1.1%	-1.1%	-1.1%	n.a.

8. How does NHTSA use full vehicle simulation?

For regulatory purposes, the fuel economy of any given vehicle is determined by placing the vehicle on a chassis dynamometer (akin to a large treadmill that puts the vehicle's wheels in contact with one or more rollers, rather than with a belt stretched between rollers) in a controlled environment, driving the vehicle over a specific driving cycle (in which driving speed is specified for each second of operation), measuring the amount of carbon dioxide emitted from the vehicle's tailpipe, and calculating fuel consumption based on the density and carbon content of the fuel.

One means of determining the effectiveness of a given technology as applied to a given vehicle model would be to measure the vehicle's fuel economy on a chassis dynamometer, install the new technology, and then re-measure the vehicle's fuel economy. However, most technologies cannot simply be "swapped out," and even for those that can, simply doing so without additional engineering work may change other vehicle characteristics (*e.g.*, ride, handling, performance, etc.), producing an "apples to oranges" comparison.

Some technologies can also be more narrowly characterized through bench or engine dynamometer (*i.e.*, in which the engine drives a generator that is, in turn, used to apply a controlled load to the engine) testing. For example, engine dynamometer testing could be used to evaluate the brake-specific fuel consumption (*e.g.*, grams per kilowatt-hour) of a given engine before and after replacing the engine oil with a less viscous oil. However, such testing does not provide a direct measure of overall vehicle fuel economy or changes in overall vehicle fuel economy.

For a vehicle that does not yet exist, as in NHTSA's analysis of CAFE standards applicable to future model years, even physical testing can provide only an estimate of the vehicle's eventual fuel economy. Among the alternatives to physical testing, automotive engineers involved in vehicle design make use of computer-based analysis tools, including a powerful class of tools commonly referred to as "full vehicle simulation." Given highly detailed inputs regarding vehicle engineering characteristics, full vehicle simulation provides a means of estimating vehicle fuel consumption over a given drive cycle, based on the explicit representation of the physical laws governing vehicle propulsion and dynamics. Some vehicle simulation tools also incorporate combustion simulation tools that represent the combustion cycle in terms of governing physical and chemical processes. Although these tools are computationally intensive and required a great deal of input data, they provide engineers involved in vehicle development and design with an alternative that can be considerably faster and less expensive than physical experimentation and testing.

Properly executed, methods such as physical testing and full vehicle simulation can provide reasonably (though not absolutely) certain estimates of the vehicle fuel economy of specific vehicles to be produced in the future. However, when analyzing potential CAFE standards, NHTSA is not actually designing specific vehicles. The agency is considering implications of new standards that will apply to the average performance of manufacturers' entire production lines. For this type of analysis, precision in the estimation of the fuel economy of individual vehicle models is not essential; although it is important that the agency avoid systematic upward or downward bias, uncertainty at the level of individual models is mitigated by the fact that compliance with CAFE standards is based on average fleet performance (as opposed, for example, to model-by-model compliance required under EPA emissions standards).

As discussed above, the Volpe Model, which the agency has used to perform the analysis supporting today's final rule, applies an incrementally multiplicative approach to estimating the fuel savings achieved through the progressive addition of fuel-saving technologies. NAS' use of the same approach in its 2002 report was, at the time and henceforth, criticized by a small number of observers as being prone to systematic overestimation of available fuel savings. This assertion was based on the fact that, among the technologies present on any given vehicle, more than one may address the same energy loss mechanism (notably, pumping losses on throttled engines); once all energy losses of a given type are eliminated, even theoretical improvements attributable to that loss mechanism are no longer available.

The most direct critique of NAS' methods appeared in a 2002 SAE paper by four General Motors researchers (Patton, *et al.*), who compared some of NAS' calculations to fuel consumption estimates obtained through vehicle testing and simulation, and concluded that, as increasing numbers of technologies were applied, NAS' estimates became increasingly subject to overestimation of available fuel consumption reductions.[106]

In response to such concerns, which had also been raised as the NAS committee performed its analysis, the NAS report concluded that vehicle simulation performed for the committee indicated that the report's incremental fuel savings estimates were "quite reasonable" for the less aggressive two of the three product development paths it

[106] Patton, K.J., et al., General Motors Corporation, *"Aggregating Technologies for Reduced Fuel Consumption: A Review of the Technical Content in the 2002 National Research Council Report on CAFE",* 2002-01-0628, Society of Automotive Engineers, Inc., 2002.

evaluated. The report did, however, conclude that uncertainty increased with consideration of more technologies, especially under the more aggressive "path 3" evaluated by the committee. The report did not, however, mention any directional bias to this uncertainty.[107]

Notwithstanding this prior response to concerns about the possible overestimation of available fuel savings, and considering that analyses supporting the development of the NPRM, the Volpe model applies "synergy factors" that adjust fuel savings calculations when some pairs of technologies are applied to the same vehicle, as discussed above in Section IV.C.7. These factors reduce uncertainty and the potential for positive or negative biases in the Volpe model's estimates of the effects of technologies.

As an alternative to estimating fuel consumption through incremental multiplication and the application of "synergy" factors to address technology interactions, NHTSA considered basing its analysis of fuel economy standards on full vehicle simulation at every step. However, considering the nature of CAFE analysis (in particular, the analysis of fleets projected to be sold in the future by each manufacturer), as well as the quantity and availability of information required to perform vehicle simulation, the agency explained that it believed detailed simulation when analyzing the entire fleet of future vehicles is neither necessary nor feasible. Still, when estimating synergies between technologies, the agency did make use of vehicle simulation studies, as discussed above. The agency has also done so when re-estimating synergies before performing the analysis supporting today's final rule.

NHTSA also considered estimating changes in fuel consumption by explicitly accounting for each of several energy loss mechanisms—that is, physical mechanisms to

[107] NRC (2002), *op. cit.*, p. 151.

which the consumption of (chemical) energy in fuel may be attributed. This approach would be similar to that proposed in 2002 by Patton *et al*. The agency invited comment on this approach, requested that manufacturers submit product plans disaggregating fuel consumption into each of nine loss mechanisms, and sought estimates of the extent to which fuel-saving technologies affect each of these loss mechanisms.

In response to the NPRM, the Alliance presented a detailed analysis by Sierra Research, which used a modified version of VEHSIM (a vehicle simulation tool) to estimate the fuel consumption resulting from the application of various vehicle technologies to 25 vehicle categories intended to represent the fleet. The Alliance commented that this simulation-based approach is more accurate than that applied by NHTSA, and indicated that Sierra's ability to perform this analysis demonstrates that NHTSA should be able to do the same.

General Motors also raised questions regarding the multiplicative approach to fuel consumption estimation NHTSA has implemented using the Volpe model. GM indicated that the Volpe model should be enhanced with modifications to "take into account the basic physics of vehicles."[108] Although GM's comments did not explicitly mention vehicle simulation, GM did express full support for the Alliance's comments.

The California Air Resources Board (CARB) presented comparisons of different simulation studies, commenting that these demonstrate that the VEHSIM model used by Sierra Research "cannot accurately simulate vehicles that use advanced technologies such as variable valve timing and lift and advanced transmissions."[109] CARB also questioned

[108] GM comments at 2, Docket No. NHTSA-2008-0089-0162.
[109] CARB comments at 5, Docket No. NHTSA-2008-0089-0173. In developing potential greenhouse gas (GHG) emissions standards for light vehicles, CARB made significant use of vehicle simulation results presented in *"Reducing Greenhouse Gas Emissions from Light-Duty Motor Vehicles"*, which was

Sierra Research's simulation capabilities and suggested that, in support of actual product development, manufacturers neither contract with Sierra Research for such services nor make use of VEHSIM. CARB further commented that both AVL (which performed simulation studies supporting CARB's evaluation of potential greenhouse gas standards) and Ricardo (which has recently performed simulation studies and related analysis for both EPA and NHTSA) provide such services to manufacturers.[110]

However, the Alliance and GM have criticized technical aspects of the AVL and Ricardo vehicle simulation studies mentioned by CARB. Regarding the AVL vehicle simulations CARB utilized, GM raised concerns that, among other things, some of AVL's simulations assumed the use of premium-grade gasoline, and some effectively assume vehicle performance and utility would be compromised.[111] Similarly, the Alliance raised concerns that some of the simulations performed by Ricardo for EPA assumed the use of premium fuel, and that many of the simulations assumed vehicle performance would be reduced.[112] The Alliance also indicated that the five vehicles analyzed by Ricardo for EPA were not representative of all vehicles in the fleet, leading to overstatement of the degree of improvement potentially available to vehicles that already use technologies not present in the vehicles examined by EPA. The Alliance further argued that the report did not reveal sufficient detail regarding important simulation details (related, *e.g.*, to cylinder deactivation), that it failed to account for

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published in 2004 by the Northeast States Center for a Clean Air Future (NESCCAF). As NHTSA discussed in the NPRM, CARB's and NESCCAF's approach, which effectively reduces each manufacturer's fleet to five "representative" vehicles and two average vehicle weights, is too limited for purposes of CAFE analysis.

[110] California Air Resources Board, *"Air Resources Board Staff Comments on Sierra and Martec NRC Presentations"*, p. 2.

[111] Testimony of Kenneth Patton (GM); Testimony of Kevin McMahon (Martec); Plaintiffs' Proposed Findings of Fact, June 15, 2007, pp. 103 -113.

[112] Alliance of Automobile Manufacturers, *"Detailed Technical Comments on Ricardo 'Study of Potential Effectiveness of Carbon Dioxide Reducing Vehicle Technologies' Report"*, March 6, 2008.

some parasitic and accessory loads, and that EPA directed Ricardo to unrealistically assume universal improvements in aerodynamics, tire efficiency, and powertrain friction.[113]

Although submitted after the close of the comment period specified in the NPRM, comments by several state Attorneys General and other state and local official questioned the need and merits of full vehicle simulation within the context of CAFE analysis, stating that

> Computer simulation models such as VEHSIM are not practical except perhaps during vehicle development to determine the performance of specific vehicle models where all vehicle engineering parameters are known and can be accounted for in the inputs to the model. Such an exercise is extremely data intensive, and extending it to the entire fleet makes it subject to multiple errors unless the specific parameters for each vehicle model are known and accounted for in the model inputs.[114]

Considering the comments summarized above, the analyses to which they refer, and the nature of the analysis the agency performs when evaluating potential CAFE standards, NHTSA has concluded that full vehicle simulation, though useful to manufacturers' own product development efforts, remains neither necessary nor feasible for CAFE analysis. NHTSA's basis for this conclusion is as follows:

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[113] For the reader's reference, Ricardo's study for EPA was based on specific EPA-defined requirements, such as performing full vehicle simulations of 26 different technology packages on the EPA-specified 5 baseline vehicles. Thus, to the extent that Ricardo's numbers do not reflect specific differences in technology effectiveness by vehicle model, in conducting the analysis for NHTSA's final rule, NHTSA and Ricardo drew on Ricardo's knowledge to develop incremental benefits based in part on Ricardo's simulation work. Ricardo also noted differences between its report for EPA and the EPA Staff Technical Report in terms of the incremental benefits for individual technologies developed by EPA based on Ricardo's simulation.

[114] Attorneys General of the States of California, Arizona, Connecticut, Illinois, Maryland, Massachusetts, New Jersey, New Mexico, Oregon, and Vermont, the Executive Officer of the California Air Resources Board, the Commissioner of the New Jersey Department of Environmental Protection, the Secretary of the New Mexico Environment Department, the Secretary of the Commonwealth of Pennsylvania Department of Environmental Protection, and the Corporation Counsel of the City of New York, *Supplemental Comments Regarding Alliance of Automobile Manufacturers Comments*, Docket No. NHTSA-2008-0089-0495, October 8, 2008, p. 3.

Full vehicle simulation involves estimating the fuel consumption (and, typically, emissions) of a specific vehicle over a specific driving cycle. Many engineering characteristics of the vehicle must be specified, including, but not limited to weight, rolling resistance, tire radius, aerodynamic drag coefficient, frontal area, engine maps[115] and detailed transmission characteristics (gear ratios, shift logic, etc.), other drivetrain characteristics, and accessory loads. Additional engine test data would also be required in order to update engine maps when evaluating the application of advanced engine technologies. Driving cycles—vehicle speeds over time—are specified on a second-by-second (or more finely-grained) basis. Using full vehicle simulation to estimate average fuel consumption under the test procedures relevant to CAFE involves many simulations to capture all the potential combinations of technologies that could be used.

Given all of the requisite data representing a specific vehicle, full vehicle simulation can provide a powerful means of estimating vehicle performance while accounting for interactions between various vehicle components and systems. Full simulation can also provide a means of estimating vehicle performance under driving conditions not represented by certification test procedures. For an engineer involved in the design of a specific vehicle or vehicle component or system, or a manufacturer making specific decisions regarding the fleet of vehicles it will produce, vehicle simulation can be a powerful tool. However, even the most detailed simulation involving full combustion cycle simulation is not the "gold standard" for product design. Chrysler, for example, has portrayed simulation as one of several tools in its CAFE planning

[115] An engine map specifies the engine's efficiency under many different operating conditions, each of which is defined in terms of rotational speed (*i.e.*, revolutions per minute, or RPM) and load (*i.e.*, torque).

process, which also involves physical testing (*i.e.*, bench testing, chassis dynamometer testing) of actual components and assembled vehicles.[116]

In purpose and corresponding requirements, NHTSA's evaluation of regulatory options is fundamentally different from the type of product planning and development that a manufacturer conducts. A manufacturer must make specific decisions regarding every component that will be installed in every vehicle it plans to produce, and it must ultimately decide how many of each vehicle it will produce. Although manufacturers have some ability to make "mid-course adjustments," that ability is limited by a range of factors, such as contracts and tooling investments. By comparison, NHTSA attempts only to estimate how a given manufacturer *might* attempt to comply with a potential CAFE standard; given the range of options available to each manufacturer, NHTSA has little hope of predicting specifically what a given manufacturer *will* do. CAFE standards require average levels of performance, not specific technology outcomes. Therefore, while it is important that NHTSA avoid systematic bias when estimating the potential to increase the fuel economy of specific vehicle models, it is not important that the agency's estimates precisely forecast results for every future vehicle.

Furthermore, NHTSA evaluates the impact of CAFE standards on all manufacturers, based on a forecast of specific vehicle models each manufacturer will produce for sale in the U.S. in the future. Analyses spanning five model years can involve thousands of unique vehicle models, hundreds of unique engines, and hundreds of unique transmissions. The representation of the entire fleet on a model-by-model basis is essential to the analysis of attribute-based CAFE standards such as are mandated by

[116] Fodale, F., Chrysler LLC, *"Fuel Economy/Fuels—Presented to NRC Committee on Fuel Economy of Light-Duty Vehicles",* November 27, 2007.

EISA. This model-by-model representation allows the agency to, among other things, account for technologies expected to be present on each vehicle under "business as usual" conditions, thereby avoiding errors regarding the potential to add further technologies.

Because of the intense informational and computational requirements, industry-wide studies that rely on vehicle simulation reduce the fleet to a limited number of "representative" vehicles. This reduction limits the ability to account for technological and other heterogeneity of the fleet, virtually ensuring the overestimation of improvements available to some vehicles (*e.g.*, vehicles that begin with a great deal of technology) and some manufacturers (*e.g.*, manufacturers that sell many high-technology vehicles). AVL's analysis for NESCCAF and Ricardo's analysis for EPA, each of which considered only five vehicle models, are both, therefore, of severely limited use for fleetwide analysis, although both provide useful information regarding the range of fuel savings achieved by specific technologies and "packages" of technologies.

The analysis conducted by Sierra Research for the Alliance considers a significantly greater number (25) of "representative" vehicles, drawing important distinctions between similarly-sized cars based on performance. Sierra was able to do so in part because it analyzed historical vehicles. For example, Sierra indicates that model year 1998 engines were used to supply VEHSIM with baseline, "blended" engine maps applied universally (rather than specific maps for each manufacturer and vehicle model) for vehicle model years out to 2020. Considering that, even without increases in CAFE standards, many vehicles produced for sale in the U.S. during 2011-2015 are likely to have technologies such as VVLT and cylinder deactivation, NHTSA doubts "blended" 1998 engines are as representative as implied by Sierra's analysis.

Although NHTSA could, in principle, integrate full vehicle simulation into its analysis of the future fleet, the agency expects that manufacturers would be unable to provide much of the required information for future vehicles. Even if manufacturers were to provide such information, using full vehicle simulation to estimate the effect of further technological improvements to future vehicles would involve uncertain detailed estimates, such as valve timing, cylinder deactivation operating conditions, transmission shift points, and hybrid vehicle energy management strategies for each specific vehicle, engine, and transmission combination. Even setting aside the vast increases in computational demands that would accompany the use of full vehicle simulation in model-by-model analysis of the entire fleet, the agency remains convinced that the availability of underlying information and data would be too limited for this approach to be practical.

As a third alternative, one that might be more explicitly "physics-based" than the use of synergy factors and vastly more practical than full vehicle simulation, NHTSA requested comment on the use of partitioned fuel consumption accounting. Aside from GM's nonspecific recommendation that the Volpe model be modified to account for the "basic physics of vehicles," NHTSA did not receive comments regarding the relative merits of partitioning fuel consumption into several energy loss mechanisms for purposes of estimating the effects of fuel-saving technologies, even though the concept is similar to that proposed by Patton, *et al.* in 2002.[117] Some manufacturers provided some of the information that would have been necessary for the implementation of this approach.

[117] Patton, *et al.*, present an energy balance calculation that disaggregates fuel consumption into six energy loss categories, indicating that "an accounting of the effects of individual technologies on energy losses within these categories provides a practical, physically-based means to evaluate and compare the fuel consumption effects of the various technologies." (Patton, *et. al.*, (2002), *op. cit.*, p. 11.)

However, as a group, manufacturers that submitted product plan information to the agency provided far too little disaggregated fuel consumption information to support the development of this approach. Although NHTSA continues to believe that partitioning fuel consumption into various loss mechanisms could provide a practical and sound basis for future analysis, the information required to support this approach is not available at this time.

In conclusion, NHTSA observes that with respect to CAFE analysis, full vehicle simulation could theoretically be used at three different levels. First, full vehicle simulation could be used only to provide specific estimates, that, combined with other data (e.g., from bench testing) would provide a basis for estimates of the effectiveness of specific individual technologies. While NHTSA expects to continue this type of analysis, the agency anticipates that it will continue to be feasible and informative to make somewhat greater use of full vehicle simulation. Second, full vehicle simulation could be fully integrated into NHTSA's analysis of the entire fleet to be projected to be produced in future model years. NHTSA expects, however, that this level of integration will remain infeasible considering the size and complexity of the fleet. Also, considering the forward-looking nature of NHTSA's analysis, and the amount of information required to perform full vehicle simulation, NHTSA anticipates that this level of integration would involve misleadingly precise estimates of fuel consumption. Finally, full vehicle simulation can be used to develop less complex representations of interactions between technologies (such as was done using the lumped parameter model to develop the synergies for the final rule), and to perform reference points to which vehicle-specific estimates may be compared. NHTSA views this as a more practical and productive potential use of full vehicle simulation, and expects to continue to follow this approach in the future. NHTSA has contracted with NAS to, among other things, evaluate the potential use of full vehicle simulation and other fuel consumption estimation methodologies.

9. Refresh and redesign schedule

In addition to, and as discussed below, developing analytical methods that address limitations on overall rates at which new technologies can be expected to feasibly penetrate manufacturers' fleets, the agency has also developed methods to address the feasible scheduling of changes to specific vehicle models. In the Volpe model, which the agency has used to support the current rulemaking, these scheduling-related methods were first applied in 2003, in response to concerns that an early version of the model would sometimes add and then subsequently remove some technologies.[118] By 2006, these methods were integrated into a new version of the model, one which explicitly "carried forward" technologies added to one vehicle model to succeeding vehicle models in the next model year, and which timed the application of many technologies to coincide with the redesign or freshening of any given vehicle model.[119]

Even within the context of the phase-in caps discussed below, NHTSA considers these model-by-model scheduling constraints necessary in order to produce an analysis that reasonably accounts for the need for a period of stability following the redesign of any given vehicle model. If engineering, tooling, testing, and other redesign-related resources were free, every vehicle model could be redesigned every year. In reality, however, every vehicle redesign consumes resources simply to address the redesign.

[118] 68 FR 16874 (Apr. 7, 2003).
[119] 71 FR 17582 (Apr. 6, 2006).

Phase-in caps, which are applied at the level of manufacturer's entire fleet, do not constrain the scheduling of changes to any particular vehicle model. Conversely, scheduling constraints to address vehicle freshening and redesign do not necessarily yield realistic overall penetration rates (*e.g.*, for strong hybrids).

In the automobile industry there are two terms that describe when changes to vehicles occur: redesign and refresh (*i.e.*, freshening). Vehicle redesign usually encompasses changes to a vehicle's appearance, shape, dimensions, and powertrain, and is traditionally associated with the introduction of "new" vehicles into the market, which is often characterized as the next generation of a vehicle. In contrast, vehicle refresh usually encompasses only changes to a vehicle's appearance, and may include an upgraded powertrain. Refresh is traditionally associated with mid-cycle cosmetic changes to a vehicle, within its current generation, to make it appear "fresh." Vehicle refresh traditionally occurs no earlier than two years after a vehicle redesign or at least two years before a scheduled redesign. In the NPRM, NHTSA tied the application of the majority of the technologies to a vehicle's refresh/redesign cycle, because their application was significant enough that it could involve substantial engineering, testing, and calibration work.

NHTSA based the redesign and refresh schedules used in the NPRM as inputs to the Volpe model on a combination of manufacturers' confidential product plans and NHTSA's engineering judgment. In most instances, NHTSA reviewed manufacturers' planned redesign and refresh schedules and used them in the same manner it did in past rulemakings. However, in NHTSA's judgment, manufacturers' planned redesign and refresh schedules for some vehicle models were unrealistically slow considering overall market trends. In these cases, the agency reestimated redesign and refresh schedules more consistent with the agency's expectations, as discussed below. Also, if companies did not provide product plan data, NHTSA used publicly available data about vehicle redesigns to project the redesign and refresh schedules for the vehicles produced by these companies.[120]

Unless a manufacturer submitted plans for a more rapid redesign and refresh schedule, NHTSA assumed that passenger cars would normally be redesigned every 5 years, based on the trend over the last 10-15 years showing that passenger cars are typically redesigned every 5 years. These trends were reflected in the manufacturer product plans that NHTSA used in the NPRM analysis, and were also confirmed by many automakers in meetings held with NHTSA to discuss various general issues regarding the rulemaking.

NHTSA explained that it believes that the vehicle design process has progressed and improved rapidly over the last decade and that these improvements have made it possible for some manufacturers to shorten the design process for some vehicles in order to introduce vehicles more frequently in response to competitive market forces. Although manufacturers have likely already taken advantage of most available improvements, according to public and confidential data available to NHTSA, almost all passenger cars will be on a 5-year redesign cycle by the end of the decade, with the exception being some high performance vehicles and vehicles with specific market niches.

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[120] Sources included, but were not limited to manufacturers' web sites, industry trade publications (*e.g.*, Automotive News), and commercial data sources (*e.g.*, Wards Automotive, etc.).

NHTSA also stated in the NPRM that light trucks are currently redesigned every 5 to 7 years, with some vehicles (like full-size vans) having longer redesign periods. In the most competitive SUV and crossover vehicle segments, the redesign cycle currently averages slightly above 5 years. NHTSA explained that it is expected that the light truck redesign schedule will be shortened in the future due to competitive market forces Thus, for almost all light trucks scheduled for a redesign in model year 2014 and later, NHTSA projected a 5-year redesign cycle. Exceptions were made for high performance vehicles and other vehicles that traditionally had longer than average design cycles. For those vehicles, NHTSA attempted to preserve their historical redesign cycle rates.

NHTSA discussed these assumptions with several manufacturers at the NPRM stage, before the current economic crisis. Two manufacturers indicated at that time that their vehicle redesign cycles take at least five years for cars and 6 years and longer for trucks because they rely on those later years to earn a profit on the vehicles. They argued that they would not be able to sustain their business if forced by CAFE standards to a shorter redesign cycle. The agency recognizes that some manufacturers are severely stressed in the current economic environment, and that some manufacturers may be hoping to delay planned vehicle redesigns in order to conserve financial resources. However, consistent with its forecast of the overall size of the light vehicle market from MY 2011 on, the agency currently expects that the industry's status will improve, and that manufacturers will typically redesign both car and truck models every 5 years in order to compete in that market.

NHTSA received relatively few comments regarding its refresh/redesign schedule assumptions. UCS commented that redesign schedules should be shortened to 3 years, based on recent public statements by Ford that they intended to move to that cycle, and based on other recent manufacturer behavior.

Although NHTSA agrees with UCS that remarks by one Ford official at a January 2008 conference suggest that that company was then hoping to accelerate its vehicle "cycle time" to 3 years, the agency questions the context, intended meaning and scope, and representation of those remarks.[121] Further, the agency notes that the article referenced by UCS also indicates that "most manufacturers make changes to their vehicle lines every four years or more, depending on the segment of the market, with midcycle freshenings every two years or so."[122] Although some manufacturers have, in their product plans, indicated that they plan to redesign some vehicle models more frequently than has been the industry norm, all manufacturers have also indicated that they expect to redesign some other vehicle models considerably less frequently. The CAR report submitted by the Alliance, prepared by the Center for Automotive Research and EDF, states that "For a given vehicle line, the time from conception to first production may span two and one-half to five years," but that "The time from first production ("Job #1") to the last vehicle off the line ("Balance Out") may span from four to five years to eight to ten years or more, depending on the dynamics of the market segment." The CAR report then states that "At the point of final production of the current vehicle line, a new model with the same badge and similar characteristics may be ready to take its place, continuing the cycle, or the old model may be dropped in favor of a different product."[123]

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[121] Zoia, D.E. 2008. Ford to cut cycle times to three years. Online at http://www.wardsauto.com. January 24.
[122] *Id*.
[123] *See* NHTSA-2008-0089-0170.1, Attachment 16, at 8 (393 of pdf).

NHTSA believes that this description, which states that a vehicle model will be redesigned or dropped after 4-10 years, is consistent with other characterizations of the redesign and freshening process, and supports its 5-year redesign assumption and its 2-3 year refresh cycle assumptions.[124] Thus, for purposes of the final rule, NHTSA is retaining the 5-year redesign/2-3 year refresh assumptions employed in the NPRM. However, NHTSA will continue to monitor manufacturing trends and will reconsider these assumptions in subsequent rulemakings if warranted.

For purposes of the final rule, NHTSA has also considered confidential product plans where applicable and industry trends on refresh and redesign timing as discussed above, to apply specific technologies at redesign, refresh, or any model years as shown in Table IV-7 below.

[124] *See id.*, at 9 (394 of pdf).

Table IV-7. Technology Refresh and Redesign Application

Technology	Redesign only	Redesign or Refresh	Anytime
Low Friction Lubricants			X
Engine Friction Reduction		X	
VVT - Coupled Cam Phasing (CCP) on SOHC		X	
Discrete Variable Valve Lift (DVVL) on SOHC	X		
Cylinder Deactivation on SOHC		X	
VVT - Intake Cam Phasing (ICP)		X	
VVT – Dual Cam Phasing (DCP)		X	
Discrete Variable Valve Lift (DVVL) on DOHC	X		
Continuously Variable Valve Lift (CVVL)	X		
Cylinder Deactivation on DOHC		X	
Cylinder Deactivation on OHV		X	
VVT - Coupled Cam Phasing (CCP) on OHV		X	
Discrete Variable Valve Lift (DVVL) on OHV	X		
Conversion to DOHC with DCP	X		
Stoichiometric Gasoline Direct Injection (GDI)	X		
Combustion Restart		X	
Turbocharging and Downsizing	X		
Exhaust Gas Recirculation (EGR) Boost	X		
Conversion to Diesel following CBRST	X		
Conversion to Diesel following TRBDS	X		
Electric Power Steering		X	
Improved Accessories		X	
12V Micro-Hybrid	X		
Higher Voltage/Improved Alternator		X	
Integrated Starter Generator	X		
6-Speed Manual/Improved Internals	X		
Improved Auto. Trans. Controls/Externals		X	
Continuously Variable Transmission	X		
6/7/8-Speed Auto. Trans with Improved Internals	X		
Dual Clutch or Automated Manual Transmission	X		
Power Split Hybrid	X		
2-Mode Hybrid	X		
Plug-in Hybrid	X		
Material Substitution (1%)		X	
Material Substitution (2%)	X		
Material Substitution (5%)	X		
Low Rolling Resistance Tires		X	
Low Drag Brakes		X	
Secondary Axle Disconnect		X	
Aero Drag Reduction		X	

As the table shows, most technologies are applied by the Volpe model when a specific vehicle is due for a redesign or refresh. However, for low friction lubricants, the model is not restricted to applying it during a refresh/redesign year and thus it was made available for application at any time. Low friction lubricants are very cost-effective, can apply to multiple vehicle models/platforms and can be applied across multiple vehicle models/platforms in one year. Although they can also be applied during a refresh/redesign year, they are not restricted to that timeframe because their application is not viewed as necessitating a major engineering redesign and associated testing/calibration.

For several technologies estimated in the NPRM to be available for application during any model year, NHTSA now estimates that these technologies will be available only at refresh or redesign. Those technologies include aggressive shift logic, improved accessories, low rolling resistance tires and low drag brakes. Aggressive shift logic is now one of the technologies included under improved automatic transmission controls. This technology requires a recalibration specific to each vehicle, such that it can therefore be applied only at refresh or redesign model years. The "improved accessories" technology has been redefined to include intelligent engine cooling systems, which require a considerable change to the vehicle and engine cooling system; therefore, improved accessories also can be applied only at refresh or redesign model years. Also, NHTSA concurs with manufacturers' confidential statements that indicating that low drag brakes and low rolling resistance tires can be applied only at refresh or redesign model years due to the need for vehicle testing and calibration (*e.g.*, to ensure safe handling and braking) when these technologies are applied.

10. Phase-in caps

In 2002, NHTSA proposed the first increases in CAFE standards in six years due to a previous statutorily-imposed prohibition on setting new standards. That proposal, for MY 2005-2007 light truck standards, relied, in part, on a precursor to the current Volpe model. This earlier model used a "technology application algorithm" to estimate the technologies that manufacturers could apply in order to comply with new CAFE standards.

NHTSA received more than 65,000 comments on that proposal. Among those were many manufacturer comments concerning lead time and the potential for rapid widespread use of new technologies. The agency noted that DaimlerChrysler and Ford "argued that the agency had underestimated the lead time necessary to incorporate fuel economy improvements in vehicles, as well as the difficulties of introducing new technologies across a high volume fleet." Specific to Volpe's technology application algorithm, the agency noted that General Motors took issue with the algorithm's "application of technologies to all trucklines in a single model year."[125]

In response to those concerns, Volpe's algorithm was modified "to recognize that capital costs require employment of technologies for several years, rather than in a single year."[126] Those changes moderated the rates at which technologies were estimated to penetrate manufacturers' fleets in response to the new (MY 2005-MY 2007) CAFE standards. These changes produced more realistic estimates of the technologies manufacturers could apply in response to the new standards, and thereby produced more realistic estimates of the costs of those standards.

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[125] 68 FR 16874 (Apr. 7, 2003).
[126] *Id*., at 16885.

Prior to the next rulemaking, the Volpe model underwent significant integration and improvement, including the accommodation of explicit "phase-in caps" to constrain the rates at which each technology would be estimated to penetrate each manufacturer's fleet in response to new CAFE standards.[127] As documented in 2006, the agency's final standards for light trucks sold in MY 2008-MY 2011 were based on phase-in caps ranging from 17 percent to 25 percent (corresponding to full penetration of the fleet within 4 to 6 years) for most technologies, and from 3 percent to 10 percent (full penetration within 10 to 33 years) for more advanced technologies such as hybrid electric vehicles.[128] The agency based these rates on consideration of comments and on the 2002 NAS Committee's findings that "widespread penetration of even existing technologies will probably require 4 to 8 years" and that for emerging technologies "that require additional research and development, this time lag can be considerably longer".[129]

In its 2008 NPRM proposing new CAFE standards for passenger cars and light trucks sold during MY 2011-MY 2015, NHTSA considered manufacturers' planned product offerings and estimates of technology availability, cost, and effectiveness, as well as broader market conditions and technology developments. The agency concluded that many technologies could be deployed more rapidly than it had estimated during the prior rulemaking.[130] For most engine technologies, the agency increased these caps from 17 percent to 20 percent, equivalent to reducing the estimated time for potential fleet

[127] These caps constrain the extent to which additional technology is applied by the model, beyond the levels projected in each manufacturer's baseline fleet. Also, because manufacturers' fleets are comprised of vehicles, engines, and transmissions sold in discrete volumes, phase-in caps cannot be applied as precise limits. In some cases (when a phase-in cap is small or a manufacturer has a limited product line), doing so would prevent the technology from being applied at all. Therefore, the Volpe model enforces each phase-in cap constraint as soon as it has been exceeded by application of technologies to manufacturers.
[128] 71 FR 17572, 17679 (Apr. 6, 2006).
[129] *Id*. at. 17572. *See also* 2002 NAS Report, at 5.
[130] 73 FR 24387-88 (May 2, 2008).

penetration from 6 years to 5 years. For stoichiometric gasoline direct injection (GDI) engines, the agency increased the phase-in cap from 3 percent to 20 percent, equivalent to estimating that such engines could potentially penetrate a given manufacturer's fleet in 5 years rather than the previously-estimated 33 years. However, as in its earlier CAFE rulemakings, the agency continued to recognize that myriad constraints prohibit most technologies from being applied across an entire fleet of vehicles within a year, even if those technologies are available in the market.

In addition to requesting further explanation of NHTSA's use of phase-in caps, commenters addressing phase-in caps generally asserted one of three themes: (1) that hybrid phase-in caps were much lower than market trends or manufacturer announcements would otherwise suggest; (2) that the phase-in caps proposed in the NPRM were too high in the early years of the rulemaking and did not reflect the very small (from a manufacturing perspective) amount of lead-time between the final rule and the MY 2011 standards, and/or were too low in the later years of the rulemaking given the relatively-increased amount of lead-time for those model years; (3) that there are insufficient resources (either in terms of capital or engineering) to implement the number of technologies implied by the phase-in caps simultaneously.

Agency response: NHTSA continues to recognize that many factors constrain the rates at which manufacturers will be able to feasibly add fuel-saving technologies to the fleets they will sell in the United States. For a given technology, examples of these factors may include, but would not be limited to the following:

- Is the technology ready for commercial use? For example, can it operate safely and reliably under real-world driving conditions for several years and many miles?

- If the technology requires special infrastructure (*e.g.*, new electrical generation and charging facilities), how quickly will that be put in place?

- How quickly can suppliers ramp up to produce the technology in mass quantities? For example, how quickly can they obtain the materials, tooling, and engineering resources they will need?

- Are original equipment manufacturers (OEMs) ready to integrate the technology into vehicles? For example, how quickly can they obtain the necessary tooling (*e.g.*, retool factories), engineering, and financial resources?

- How long will it take to establish failure and warranty data, and to make sure dealers and maintenance and repair businesses have any new training and tooling required in order to work with the new technology?

- Will OEMs be able to reasonably recoup prior investments for tooling and other capital?

- To what extent are suppliers and OEMs constrained by preexisting contracts?

NHTSA cannot explicitly and quantitatively evaluate every one of these and other factors with respect to each manufacturer's potential deployment of each technology available during MY 2011-MY 2015. Attempting to do so would require an extraordinary effort by the agency, and would likely be subject to tremendous uncertainties. For example, in the current environment, in which there are well-reasoned concerns that one or more major manufacturers might soon cease to exist, the agency expects that it would be impossible to reliably predict specific characteristics of future supply chains. Therefore, the agency has concluded that it is appropriate to continue using phase-in caps to apply the agency's best judgment of the extent to which such factors combine to constrain the rates at which technologies may feasibly be deployed.

Considering the above-mentioned comments, NHTSA has concluded, most significantly, that the phase-in caps it applied during its analysis documented in the 2008 NPRM resulted in technology penetration rates that were unrealistically high in the earlier model years covered by its proposal. This was a significant basis for the proposed standards' "front loading" about which manufacturers, in particular, expressed serious concerns. Based on this conclusion, the Volpe model has been modified to use phase-in caps specified on a year-by-year basis, and the agency has applied phase-in caps that, in many cases, increase more rapidly in later years than in earlier years. In making these changes, the agency has been mindful of the need to provide manufacturers sufficient lead time to add technologies to their fleets. In the agency's judgment, its revised approach more realistically represents manufacturers' capabilities and therefore produces more realistic estimates of the costs of new CAFE standards.

For some technologies, NHTSA also concluded that slower overall rates of fleet penetration by MY 2015 are more likely than the rates shown in the NPRM. The agency estimates that cylinder deactivation, stoichiometric GDI, and turbocharging with downsizing will be able to potentially be added to 60-68 percent of the fleet, rather than the 100 percent of the fleet corresponding to the 20 percent phase-in caps used in the

NPRM for these technologies. Considering manufacturers' comments and some aspects of its reevaluation of the incremental benefits of available engine technologies, the agency has concluded that these technologies will, for some engines, require more significant hardware changes and certification burden than previously recognized, such that feasible deployment is likely to be somewhat slower than estimated in the NPRM.

NHTSA has also concluded, considering the complexities involved in deploying strongly hybridized vehicles (*i.e.*, power split, two mode, and plug-in hybrids), it is unrealistic to expect that, in response to new CAFE standards, manufacturers can produce more such vehicles in MY 2011 than they are already planning. Therefore, NHTSA has set the MY 2011 phase-in cap for strong hybrids to zero in MY 2011. Based on new information regarding engineering resources entailed in developing new power split and two-mode hybrid vehicles, the agency estimates that these technologies can be added to up to 11 percent and 8 percent, respectively, of a given manufacturer's MY 2015 fleet, rather than the 15 percent the agency estimated for the NPRM. The agency has also adopted a less aggressive 1 percent phase-in cap for plug-in hybrids during MY 2013-MY 2015, in part because although the agency expects that plug-in hybrids will rely on lithium-ion batteries, it is not clear whether and, if so, how the supply chain for large and robust lithium-ion batteries will develop.

On the other hand, NHTSA has also concluded that some technologies can potentially be deployed more widely than estimated in the NPRM. The agency estimates that 6/7/8-speed transmissions, dual clutch or automated manual transmissions, secondary axle disconnect, and aerodynamic improvements can potentially (notwithstanding engineering constraints that, for example, preclude the application of aerodynamic improvements to some performance vehicles) be added to all (100 percent) of a given manufacturer's fleet by MY 2015 rather than the 68-85 percent phase-in caps used in the NPRM for these technologies. In the agency's judgment, increased phase-in caps are appropriate for these transmission technologies, in part because the agency's review of confidential product plans which indicated a higher than anticipated application rate of these technologies than existed at the time of the NPRM. Additionally, several manufacturers indicated a high likelihood of significant usage of dual clutch transmissions across their fleet of vehicles. The secondary axle disconnect technology was redefined for the final rule to consist of a somewhat basic, existing technology applicable only to 4 wheel-drive vehicles (a smaller population) rather than the NPRM defined technology (which was applicable to both 4 and all wheel drive vehicles). The agency has also concluded that, because it has identified performance vehicles as such, and has estimated that aerodynamic improvements are not applicable to these vehicles, aerodynamic dynamic improvements can be applied more widely as long as they are applied consistent with vehicle redesign schedules. Furthermore, considering changes in manufacturers' stated expectations regarding prospects for diesel engines, the agency estimates that diesel engines could be added to as much as 20 percent of a manufacturer's MY 2015 light truck fleet by MY 2015, rather than the 15 percent estimated in the NPRM. These changes in NHTSA's estimates stem from the agency's reevaluation of the status of these technologies, as revealed by manufacturers' plans and confidential statements, as well as other related comments submitted in response to the NPRM.

Regarding comments that manufacturers' public statements reflect the ability to deploy technology more rapidly than reflected in the phase-in caps NHTSA applied in the

NPRM, NHTSA notes that it did consider such statements. Combined with other information, these led the agency to conclude that, as mentioned above, some technologies could, particularly by MY 2015, be applied more widely than the agency had previously estimated. However, in their confidential statements to NHTSA, manufacturers are typically more candid about factors—both positive and negative—that affects their ability to deploy new technologies than they are in public statements available to their competitors. Therefore, NHTSA places greater weight on manufacturers' confidential statements, especially when they are consistent with statements made by other manufacturers and/or suppliers. NHTSA also observes that some organizations have exhibited a tendency to take manufacturers' statements out of context, or overlook important caveats included in such statements, which are largely used for marketing purposes.

Table IV-8 below outlines the phase-in caps for each discrete technology for each model year under the rulemaking. These phase-in caps, along with the expanded number and types of vehicle subclasses, address the concerns raised by commenters and represent a substantial improvement in terms of consideration of the factors affecting technology penetration rates over those used in the NPRM. Additional considerations regarding specific phase-in caps, including nonlinear increases in these caps, are presented in the more detailed technology-by-technology analysis summarized below.

For some of the technologies applied in the final rule, primarily the valvetrain and diesel engine technologies, NHTSA has utilized combined phase-ins caps since the technologies are effectively the same from the standpoints of engineering and implementation. The final rule represented diesel engines as two technologies that both result in the conversion of gasoline engine vehicles. The phase-in caps for these two technologies, which are both set to a maximum of 15 percent for passenger cars (20 percent for light trucks) in the year 2015, have been combined so that the maximum total application of either or both technologies to any manufacturers' passenger car fleet is limited to 15 percent (not 30 percent). For example, if 15 percent of a manufacturers' passenger car fleet has received diesel following combustion restart by MY 2015, diesel following turbocharging and downsizing will not be applied because the phase-in cap for diesels would have been reached. These combined phase-in caps are discussed below where applicable to each technology.

Table IV-8a. Phase-in caps from 2006 rule, 2007 NPRM, and current rule

Technology	2006 Rule*	Current NPRM*	2008 Final Rule				
			2011	2012	2013	2014	2015
Low Friction Lubricants	25%	50%	50%	100%	100%	100%	100%
Engine Friction Reduction	17%	20%	20%	40%	60%	80%	100%
VVT – Coupled Cam Phasing (CCP) on SOHC	17%	20%	15%	35%	55%	75%	100%
Discrete Variable Valve Lift (DVVL) on SOHC	17%	20%	15%	35%	55%	75%	100%
Cylinder Deactivation on SOHC	17%	20%	9%	17%	34%	51%	68%
VVT - Intake Cam Phasing (ICP)	17%	20%	15%	35%	55%	75%	100%
VVT - Dual Cam Phasing (DCP)	17%	20%	15%	35%	55%	75%	100%
Discrete Variable Valve Lift (DVVL) on DOHC	17%	20%	15%	35%	55%	75%	100%
Continuously Variable Valve Lift (CVVL)	17%	20%	15%	35%	55%	75%	100%
Cylinder Deactivation on DOHC	17%	20%	9%	17%	34%	51%	68%
Cylinder Deactivation on OHV	17%	20%	9%	17%	34%	51%	68%
VVT – Coupled Cam Phasing (CCP) on OHV	17%	20%	15%	35%	55%	75%	100%
Discrete Variable Valve Lift (DVVL) on OHV	10%	20%	15%	35%	55%	75%	100%
Conversion to DOHC with DCP	n.a.	n.a.	9%	17%	34%	51%	68%
Stoichiometric Gasoline Direct Injection (GDI)	3%	20%	3%	6%	20%	40%	60%
Combustion Restart	n.a.	n.a.	0%	0%	0%	3%	6%
Turbocharging and Downsizing	17%	20%	9%	17%	34%	51%	68%
Exhaust Gas Recirculation (EGR) Boost	n.a.	n.a.	0%	0%	3%	6%	9%
Conversion to Diesel following CBRST	3%	3%	3%	6%	9%	12%	15%
Conversion to Diesel following TRBDS	3%	3%	3%	6%	9%	12%	15%

* Increased annually (in a linear manner) at the rate indicated

Table IV-8b. **Phase-in caps from 2006 rule, 2007 NPRM, and current rule**

Technology	2006 Rule*	Current NPRM*	2008 Final Rule				
			2011	2012	2013	2014	2015
Electric Power Steering	17%	25%	10%	35%	60%	85%	100%
Improved Accessories	25%	25%	10%	30%	50%	75%	100%
12V Micro-Hybrid	n.a.	n.a.	3%	6%	9%	12%	15%
Higher Voltage/Improved Alternator	17%	25%	10%	30%	50%	75%	100%
Integrated Starter Generator	5%	3%	3%	6%	9%	12%	15%
6-Speed Manual/Improved Internals	n.a.	17%	33%	67%	100%	100%	100%
Improved Auto. Trans. Controls/Externals	n.a.	25%	33%	67%	100%	100%	100%
Continuously Variable Transmission	17%	17%	5%	15%	30%	50%	80%
6/7/8-Speed Auto. Trans with Improved Internals	17%	17%	50%	75%	100%	100%	100%
Dual Clutch or Automated Manual Transmission	17%	17%	20%	50%	100%	100%	100%
Power Split Hybrid	5%	3%	0%	5%	7%	9%	11%
2-Mode Hybrid	5%	3%	0%	4%	6%	7%	8%
Plug-in Hybrid	n.a.	3%	0%	0%	1%	1%	1%
Material Substitution (1%)	0.17	0.17	5%	15%	30%	65%	80%
Material Substitution (2%)	17%	17%	5%	15%	30%	65%	80%
Material Substitution (5%)	0.17	0.17	5%	15%	30%	65%	80%
Low Rolling Resistance Tires	25%	25%	20%	40%	60%	80%	100%
Low Drag Brakes	0.17	0.25	20%	40%	60%	80%	100%
Secondary Axle Disconnect	17%	17%	17%	25%	42%	65%	100%
Aero Drag Reduction	17%	17%	17%	25%	42%	65%	100%

* Increased annually (in a linear manner) at the rate indicated

D. Specific technologies considered for application and NHTSA's estimates of their incremental costs and effectiveness

1. What data sources did NHTSA evaluate?

In developing the technology assumptions in the final rule, NHTSA, working with Ricardo, examined a wide range of data sources and comments. We reexamined the sources we relied on for the NPRM such as the 2002 NAS Report, the 2004 NESCCAF report developed for CARB by AVL and Martec, the 2006 EEA report and the EPA certification data. We also considered more recent and updated sources of information and reports submitted to the NPRM docket, including the (1) Sierra Research report submitted by the Alliance as an attachment to its comments as another set of estimates for fuel economy cost and effectiveness,[131] (2) CARB's response to aspects of that report, which was filed as supplemental comment on October 14, 2008, (3) the 2008 Martec Report,[132] which updated the Martec report on which the 2004 NESCCAF study was based, and the EPA Staff Technical Report,[133] which largely mirrored NHTSA's NPRM estimates.

The agency also evaluated confidential data from a number of vehicle manufacturers and technology component suppliers.[134] We note that vehicle

[131] Sierra Research, "Attachment to Comment Regarding the NHTSA Proposal for Average Fuel Economy Standards Passenger Cars and light Trucks Model Years 2011-2015," June 27, 2008. *Available at* Docket No. NHTSA-2008-0089-0179.1.

[132] Martec, "Variable Costs of Fuel Economy Technologies," June 1, 2008. *Available at* Docket No. NHTSA-2008-0089-0169.1.

[133] EPA Staff Technical Report: Cost and Effectiveness Estimates of Technologies Used to Reduce Light-Duty Vehicle Carbon Dioxide Emissions. EPA420-R-08-008, March 2008.

[134] The major suppliers that provided NHTSA with fuel economy cost and effectiveness estimates in response to our request for comments included Borg-Warner, Cummins, and Delphi, while Borg-Warner,

manufacturers updated their product plans in response to NHTSA's May 2008 Request for Comment.[135]

2. Individual technology descriptions and cost/effectiveness estimates

(a) Gasoline Engine Technologies

(i) Overview

Most passenger cars and light trucks in the U.S. have gasoline-fueled spark ignition internal combustion engines. These engines move the vehicle by converting the chemical energy in gasoline fuel to useful mechanical work output as shaft torque and power delivered to the transmission and to the vehicle's driving wheels. Vehicle fuel economy is directly proportional to the efficiency of the engine. Two common terms are used to define the efficiency of an engine are (1) Brake Specific Fuel Consumption (BSFC), which is the ratio of the mass of fuel used to the output mechanical energy; and (2) Brake Thermal Efficiency (BTE), which is the ratio of the fuel chemical energy, known as calorific value, to the output mechanical energy.

The efficiency of an automotive spark ignition engine varies considerably with the rotational speed and torque output demanded from the engine. The most efficient operating condition for most current engine designs occurs around medium speed (30-50 percent of the maximum allowable engine rpm) and typically between 70-85 percent of maximum torque output at that speed. At this operating condition, BTE is typically 33-36 percent. However, at lower engine speeds and torque outputs, at which the engine

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Bosch, Coring, Cummins, Delphi, and Siemens also provided NHTSA with fuel economy cost and effectiveness estimates during confidential meetings.

[135] Manufacturers that provided NHTSA with fuel economy cost and effectiveness estimates in response to our request for comments include BMW, Chrysler, Daimler, Ford, GM, Honda, Nissan, and Toyota.

operates in most consumer vehicle use and on standardized drive cycles, BTE typically drops to 20-25 percent.

Spark ignition engine efficiency can be improved by reducing the energy losses that occur between the point of combustion of the fuel in the cylinders to the point where that energy reaches the output crankshaft. Reduction in this energy loss results in a greater proportion of the chemical energy of the fuel being converted into useful work. For improving engine efficiency at lighter engine load demand points, which are most relevant for CAFE fuel economy, the technologies that can be added to a given engine may be characterized by which type of energy loss is reduced, as shown in Table IV-9 below.

Table IV-9. Technology Characterization by Type of Loss Reduced

Technology	Heat Loss Reduction	Exhaust Energy Reduction	Gas Exchange Reduction	Friction Reduction
Low Friction Lubricants				✓
Engine Friction Reduction				✓
VVT - Coupled Cam Phasing (CCP) on SOHC			✓	
Discrete Variable Valve Lift (DVVL) on SOHC			✓	
Cylinder Deactivation on SOHC			✓	
VVT - Intake Cam Phasing (ICP)			✓	
VVT - Dual Cam Phasing (DCP)			✓	
Discrete Variable Valve Lift (DVVL) on DOHC			✓	
Continuously Variable Valve Lift (CVVL)			✓	
Cylinder Deactivation on DOHC			✓	
Cylinder Deactivation on OHV			✓	
VVT - Coupled Cam Phasing (CCP) on OHV			✓	
Discrete Variable Valve Lift (DVVL) on OHV			✓	
Conversion to DOHC with DCP			✓	
Stoichiometric Gasoline Direct Injection (GDI)		✓		
Combustion Restart				✓
Turbocharging and Downsizing			✓	✓
Exhaust Gas Recirculation (EGR) Boost		✓	✓	✓
Conversion to Diesel	✓	✓	✓	

✓ Represents area of primary influence

As Table IV-9 shows, the main types of energy losses that can be reduced in gasoline engines to improve fuel economy are exhaust energy losses, engine friction losses, and gas exchange losses. Converting the gasoline engine to a diesel engine can also reduce heat losses.

Exhaust Energy Loss Reduction

Exhaust energy includes the kinematic and thermal energy of the exhaust gases, as well as the wasted chemical energy of unburned fuel. These losses represent approximately 32 percent of the initial fuel chemical energy and can be reduced in three ways: first, by recovering mechanical or electrical energy from the exhaust gases; second, by improving the hydrocarbon fuel conversion; and third, by improving the cycle thermodynamic efficiency. The thermodynamic efficiency can be improved by either increasing the engine's compression ratio or by operating with a lean air/fuel ratio. The latter is not likely possible in the MY 2011-2015 timeframe due to the non-availability of lean NO_x aftertreatment, as discussed below. However, the compression ratio may potentially be raised by 1 to 1.5 ratios using stoichiometric direct fuel injection.

Engine Friction Loss Reduction

Friction losses can represent a significant proportion of the global losses at low load. These losses are dissipated through the cooling system in the form of heat. Besides via direct reduction measures, friction can also be reduced through downsizing the engine by means of increasing the engine-specific power output.

Gas Exchange Loss Reduction

The energy expended while delivering the combustion air to the cylinders and expelling the combustion products is known as gas exchange loss, commonly referred to as pumping loss. The main source of pumping loss in a gasoline engine is the use of an inlet air throttle, which regulates engine output by controlling the pre-combustion cylinder air pressure, but is an inefficient way to achieve this pressure control. A more efficient way of controlling the cylinder air pressure is to modify the valve timing or lift. Another way to reduce the average pumping losses is to "downsize" the engine, making it run at higher loads or higher pressures.

As illustrated in Table IV-9, several different technologies target pumping loss reduction, but it is important to note that the fuel consumption reduction from these technologies is not necessarily cumulative. Once most of the pumping work has been eliminated, adding further technologies that also target reduced pumping loss will have little additional effectiveness. Thus, in the revised decision trees, the effectiveness value shown for additional technologies targeting pumping loss depends on the existing technology combination already present on the engine.

(ii) Low Friction Lubricants (LUB)

One of the most basic methods of reducing fuel consumption in gasoline engines is the use of lower viscosity engine lubricants. More advanced multi-viscosity engine oils are available today with improved performance in a wider temperature band and with better lubricating properties. CAFE standards notwithstanding, most MY 2011-2015 vehicles are likely to use 5W-30 motor oil, and some will use even less viscous oils, such as 5W-20 or possibly even 0W-20, to reduce cold start friction.

The NPRM reflected NHTSA's belief that manufacturer estimates are the most accurate, and it estimated that low friction lubricants could reduce fuel consumption by 0.5 percent for all vehicle types at an incremental cost of $3, which represented the midpoint of manufacturer estimates range, rounded up to the next dollar. For the final rule NHTSA used the $3 cost from the NPRM, updated it to 2007 dollars, and marked it up to a retail price equivalent (RPE) of $5. Several manufacturers commented confidentially that low friction lubricants could reduce fuel consumption by 0 to 1 percent, and the Alliance suggested 0.5 percent relative to the baseline fleet. These comments confirm NHTSA's NPRM effectiveness estimate, so NHTSA has retained it for the final rule.

Low friction lubricants may be applied to any class of vehicles. The phase-in for low friction lubricants is capped at 100 percent by the 2015 model year. Honda commented that low friction lubricants cannot be applied to engines that have not been developed specifically for them.[136] NHTSA understands that in some cases there could be a need for design changes and durability verification to implement low friction lubricants in existing engines. However, aftermarket low friction lubricant products already exist, and have been approved for use in existing engines.

(iii) Engine Friction Reduction (EFR)

Besides low friction lubricants, manufacturers can also reduce friction and improve fuel economy by improving the design of engine components and subsystems. Examples include improvements in low-tension piston rings, roller cam followers, improved crankshaft design and bearings, material coatings, material substitution, more optimal thermal management, and piston and cylinder surface treatments.

In the NPRM, based on confidential manufacturer data and the NAS, NESCCAF, and EEA reports, NHTSA estimated that friction reduction could incrementally reduce fuel consumption for all vehicles by 1 to 3 percent at a cost of $0 to $21 per cylinder resulting in cost estimates of $0-$84 for a 4-cylinder, $0-$126 for a V-6, and $0-$168 for

[136] Docket NHTSA-2008-0089-0191.1.

a V-8. For the final rule, NHTSA assumed there would be some cost associated with reducing engine friction, since at a minimum engineering and validation testing is required, in addition to any new components required such as roller followers or improved bearings. Additionally some revised components, such as improved surface materials/treatments, piston rings, etc., have costs that vary by component size which need to account for the full range of engines under consideration in the rulemaking, from small displacement gasoline to large displacement diesel engines.

Considering the above, NHTSA relied on confidential manufacturer comments in response to the NPRM to determine a lower technology cost bound of $35 for a 4-cylinder engine and an upper cost of $195 for a 6 cylinder engine. These costs were marked up by a 1.5 RPE factor to arrive at per-cylinder costs of $13 to $49 which were used to establish costs based on cylinder count. Costs of $52 to $196 for a 4-cylinder engine, $78 to $294 for a 6-cylinder engine, and $104 to $392 for an 8-cylinder engine were used in the final rule.

Confidential manufacturer comments submitted in response to the NPRM showed an effectiveness range of 0.3 to 2 percent for engine friction reduction. Besides the comments received another effectiveness estimate, a November 2007 press release from Renault, claimed a gain of 2 percent over the NEDC cycle[137] from engine friction

[137] Due to the advanced nature of many of the technologies discussed in the NPRM, and in an effort to find broad based rationale for the specific benefits of each technology type, reference data has been gathered that specifies fuel consumption benefits as measured on the NEDC test cycle. To make this conversion, data from the International Council on Clean Transportation (ICCT) showed excellent correlation between CAFE test cycle results and NEDC test cycle results. While there was an offset in the linear best fit, the slope was nearly equal to 1; therefore, for this report, any percentage improvement found on the NEDC cycle will be assumed to be equivalent to gains found on the CAFE test cycle.

reduction.[138] Based on the available sources, NHTSA established the fuel consumption effectiveness estimate for the final rule as 1 to 2 percent.

Engine friction-reducing technologies are available from model year 2011 and may be applied to all vehicle subclasses. No learning factors were applied to costs as the technology has a loosely defined BOM which may in part consist of materials (surface treatments, raw materials) that are commodity based. As was the case in the NPRM, a 20 percent year-over-year phase-in rate starting in 2011 was adopted; therefore the phase-in for the 2015 model year reaches 100 percent. As confirmed by manufacturers' comments, NHTSA has maintained the NPRM position that engine friction reduction may only be applied in conjunction with a refresh cycle.

(iv) Variable Valve Timing (VVT)

Variable valve timing (VVT) is a classification of valvetrain designs that alter the timing of the intake valve, exhaust valve, or both, primarily to reduce pumping losses, increase specific power, and control the level of residual gases in the cylinder. VVT reduces pumping losses when the engine is lightly loaded by positioning the valve at the optimum position needed to sustain horsepower and torque. VVT can also improve thermal efficiency at higher engine speeds and loads. Additionally, VVT can be used to alter (and optimize) the effective compression ratio where it is advantageous for certain engine operating modes.

VVT has now become a widely adopted technology: for the 2007 model year, over half of all new cars and light trucks have engines with some method of variable

[138] Renault press release, "Renault Introduces The Ecological, Economical Logan 'Renault Eco²' Concept At The Michelin Organized Challenge Bibendum, November 14, 2007. *Available at* http://www.renault.com/renault_com/en/images/15181%2015181_DP_logan_eco2_Shanghai_14_nov_DEF_GB_2_tcm1120-686305.pdf (last accessed October 27, 2008)

valve timing. Therefore, the degree of further improvement across the fleet is limited by the level of valvetrain technology already implemented on the vehicles. Comments from Ford received in response to the NPRM indicate that many of its new and upgraded engines during the specified time period will launch with or upgrade to advanced forms of VVT, which are discussed below.[139] Information found in the submitted product plans is used to determine the degree to which VVT technologies have already been applied to particular vehicles to ensure the proper level of VVT technology, if any, is applied.
There are three different implementation classifications of variable valve timing: ICP (Intake Cam Phasing), where a cam phaser is used to adjust the timing of the inlet valves only; CCP (Coupled Cam Phasing), where a cam phaser is used to adjust the timing of both the inlet and exhaust valves equally; and DCP (Dual Cam Phasing), where two cam phasers are used to control the inlet and exhaust valve timing independently.
Each of these three implementations of VVT uses a cam phaser to adjust the camshaft angular position relative to the crankshaft position, referred to as "camshaft phasing." This phase adjustment results in changes to the pumping work required by the engine to accomplish the gas exchange process. The majority of current cam phaser applications use hydraulically actuated units, powered by engine oil pressure and managed by a solenoid that controls the oil pressure supplied to the phaser. Electrically actuated cam phasers are relatively new, but are now in volume production with Toyota, which suggests that technical issues have been resolved.

Honda commented that VVT is not applicable on existing engine designs that do not already contain these technologies due to durability, noise-vibration-harshness (NVH), thermal, packaging, and other constraints that require engine redesign.

[139] Docket No. NHTSA-2008-0089-0202.1, at 4.

1. Intake Cam Phasing (ICP)

Valvetrains with ICP can modify the timing of the inlet valves by phasing the intake camshaft while the exhaust valve timing remains fixed. This requires the addition of a cam phaser on each bank of intake valves on the engine. An in-line 4-cylinder engine has one bank of intake valves, while V-configured engines have two banks of intake valves.

In the NPRM, NHTSA and EPA estimated that ICP would cost $59 per cam phaser or $59 for an in-line 4 cylinder engine and $119 for a V-type, for an overall cost estimate of $59 to $119, based on the NAS, NESCCAF, and EEA reports and confidential manufacturer data. NHTSA received several updated cost estimates confidentially from manufacturers for ICP costs in response to the NPRM that varied over a wide range from $35 to $300, and additionally looked to the 2008 Martec report for costing guidance. According to the 2008 Martec report, content assumptions for ICP costing include the addition of a cam phaser and oil control valves at $25 and $10 respectively, per bank, which agreed with confidential manufacturer data received in response to the NPRM. These figures were then adjusted to include an incremental camshaft sensor per bank at $4, and an additional $2 increase to account for an ECU upgrade as shown by confidential data. Using a markup of 1.5 to yield a RPE value, the incremental cost for ICP in the final rule is estimated to be $61 per bank, resulting in a $61 charge for in-line engine configurations and $122 for V-engine configurations.

For fuel economy effectiveness values, NHTSA tentatively concluded in the NPRM that the incremental gain in fuel consumption for ICP would be 1 to 2 percent depending on engine configuration, in agreement with the NESCCAF study.

Confidential manufacturer data submitted in response to the NPRM showed a larger effectiveness range of 1.0 to 3.4 percent, although the majority of those estimates fell at the lower end of that range. Based on the comments received, NHTSA retained the NPRM estimates of 1 to 2 percent incremental improvement in fuel consumption due to ICP.

ICP is applicable to all vehicle classes and can be applied at the refresh cycle. For the final rule, NHTSA has combined the phase-in caps for ICP, CCPS, CCPO and DCP and capped the joint penetration allowed at 100 percent by 2015 with time-based learning applied.

2. Coupled Cam Phasing (CCPS and CCPO)

Valvetrains with coupled (or coordinated) cam phasing can modify the timing of both the inlet valves and the exhaust valves an equal amount by phasing the camshaft of a single overhead cam (SOHC) engine or an overhead valve (OHV) engine.[140] For overhead cam engines, this requires the addition of a cam phaser on each bank of the engine. Thus, an in-line 4-cylinder engine has one cam phaser, while V-engines have two cam phasers. For overhead valve (OHV) engines, which have only one camshaft to actuate both inlet and exhaust valves, CCP is the only VVT implementation option available.[141]

[140] Although CCP appears only in the SOHC and OHV branches of the decision tree, it is noted that a single phaser with a secondary chain drive would allow CCP to be applied to DOHC engines. Since this would potentially be adopted on a limited number of DOHC engines NHTSA did not include it in that branch of the decision tree.

[141] It is also noted that coaxial camshaft developments would allow other VVT options to be applied to OHV engines. However, since they would potentially be adopted on a limited number of OHV engines NHTSA did not include them in the decision tree.

In the NPRM, NHTSA explained that for an OHV engine, the same phaser added for ICP would be used for CCP control, so the cost for CCP should be identical to that for ICP. For an OHV, since only one phaser would be required since only camshaft exists, NHTSA estimated the cost for CCP at $59 regardless of engine configuration, using the logic provided for ICP. For purposes of the final rule, the logic for ICP also carries over to the cost estimates for CCP. Cost assumptions for CCP are the same as ICP resulting in RPE-adjusted costs of $61 for in-line SOHC or OHV engines and $122 for SOHC V-engine configurations, incremental to an engine without VVT.

For fuel economy effectiveness, NHTSA estimated in the NPRM that the incremental gain in fuel consumption for CCP is 1 to 3 percent above that obtained by ICP, in agreement with the NESCCAF report and confidential manufacturer data. Confidential manufacturer data submitted in response to the NPRM also showed an effectiveness range of 1 to 3 percent for CCP, although Ford has publicly reported a 3.3 percent improvement for CCP when applied to its 5.4 liter 3-valve V8 engine (which has high EGR tolerance due to the valve-masking effect with the 3-valve design).[142] Most engines are not as EGR-tolerant and so will not achieve as much effectiveness from CCP as the Ford engine. For purposes of the final rule, NHTSA essentially carried over the NPRM incremental effectiveness of applying the CCP technologies to be 1 to 3 percent. CCP can be applied to any class of vehicles at refresh. For the final rule, NHTSA has combined the phase-in caps for ICP, CCPS, CCPO and DCP and capped the joint penetration allowed at 100% by 2015. Since these technologies are mature and in high volume, time-based learning factors are applied. CCP can be applied to any class of

[142] Robert Stein, Tachih Chou, and Jeffrey Lyjak, "The Combustion System Of The Ford 5.4 L 3 Valve Engine," Global Powertrain Congress 2003 - Advanced Engine Design & Performance, Sep 2003, Volume 24. *Available at* http://www.gpc-icpem.org/pages/publications.html (last accessed Nov. 8, 2008)

vehicles. For the final rule, NHTSA has combined the phase-in caps for ICP, CCPS, CCPO and DCP which reach 100 percent by 2015.

3. Dual Cam Phasing (DCP)

The most flexible VVT design is dual (independent) cam phasing, where the intake and exhaust valve opening and closing events are controlled independently. This option allows the option of controlling valve overlap, which can be used as an internal EGR strategy. At low engine loads, DCP creates a reduction in pumping losses, resulting in improved fuel consumption. Additionally, increased internal EGR results in lower engine-out NO_X emissions and improved fuel consumption. This fuel economy improvement depends on the residual tolerance of the combustion system, as noted in the CCP section above. Additional improvements are observed at idle, where low valve overlap can result in improved combustion stability, potentially reducing idle fuel consumption.

In the NPRM, NHTSA estimated costs for DCP by building upon the cost estimates for ICP, where an additional cam phaser is added to control each bank of exhaust valves less the cost of the EGR valve which can be deleted. This resulted in an NPRM cost range of $89 to $209. For purposes of the final rule, cost assumptions for DCP, which included inflation, were determined by essentially doubling the ICP hardware, yielding an incremental cost of $61 per engine cylinder bank, over ICP. This translates to a cost of $61 for in-line engines and $122 for V-engine configurations, incremental to ICP technology.

For fuel economy effectiveness, NHTSA estimated in the NPRM that the incremental gain in fuel consumption for DCP is 1 to 3 percent, in agreement with the

NESCCAF report and confidential manufacturer data. Confidential manufacturer data received in response to the NPRM showed an effectiveness range of 0.5 to 3.4 percent for DCP. Publicly available data from BMW[143] and Ford[144] show an effectiveness of 5 percent for DCP over engines without VVT, agreeing with the upper bounds for ICP and DCP combined. For purposes of the final rule, NHTSA concluded that the effectiveness for DCP should be at the upper end of the CCP range due to the additional flexibility gained through independent control of intake and exhaust valve timing, and therefore estimated an incremental fuel consumption reduction of 2 to 3 percent for DCP incremental to the 1 to 2 percent for ICP.

There are no class-specific applications of this technology and DCP can be applied at the refresh cycle. For the final rule, NHTSA has combined the phase-in caps for ICP, CCPS, CCPO and DCP and capped the joint penetration allowed at 100 percent by 2015. The DCP technology is assumed to be produced at high volume, thus time-based learning is applied.

(v) Discrete Variable Valve Lift (DVVLS, DVVLD, DVVLO)

DVVL systems allow the selection between two or three separate cam profiles by means of a hydraulically actuated mechanical system. By optimizing the cam profile for specific engine operating regions, the pumping losses can be reduced by reducing the amount of throttling required to produce the desired engine power output. This increases

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143 Meyer, BMW, "Turbo-Charging BMW's Spray-Guided DI Combustion System – Benefits and Challenges," Global Powertrain Congress, September, 2005, vol. 33. *Available at* http://www.gpc-icpem.org/pages/publications.html (last accessed Nov. 8, 2008)

144 Ulrich Kramer and Patrick Phlips, "Phasing Strategy For An Engine With Twin Variable Cam Timing," SAE Technical Paper 2002-01-1101, 2002. *Available at* http://www.sae.org/technical/papers/2002-01-1101. (last accessed Nov. 9, 2008)

the efficiency of the engine. DVVL is normally applied together with VVT control. DVVL is also known as Cam Profile Switching (CPS). DVVL is a mature technology with low technical risk.

In the NPRM, based on the NESCCAF report and confidential manufacturer data, NHTSA estimated the incremental cost for DVVL at \$169 to \$322 compared to VVT depending on engine size, which included \$25 for controls and associated oil supply needs. In response to the NPRM, confidential manufacturer comments noted a cost range of \$150 to \$600 for DVVL on OHC engines. Sierra Research has noted costs ranging from \$518 to \$656 for DVVL including dual cam phasers on a mid-size car and \$634 to \$802 on trucks.[145] For purposes of the final rule, NHTSA has changed the order of the technologies in the decision trees which has changed how the DVVL costs are handled.

For the overhead cam engines, SOHC and DOHC, the costs were derived by taking \$30 per cylinder for lost motion devices, adding a \$4 incremental cost for a camshaft position sensor upgrade and \$10 for an oil control valve on each engine cylinder bank, as indicated by the 2008 Martec report. This assumes that one lost motion device is used to control either a single intake valve on an SOHC engine or a pair of intake valves on a DOHC engine, as was done in the NPRM. NHTSA's independent review concurred with data in the 2008 Martec report because it contained the most complete published description of DVVL costs and it agreed with confidential manufacturer data received in response to the NPRM NHTSA adopted these cost estimates for the final rule, such that incremental costs for DVVLS and DVVLD, including a 1.5 RPE markup, are \$201 for an in-line 4-cylinder engine, \$306 for V-6 engines, and \$396 for V-8 engines. For overhead valve engines, OHV, the costs for V6 and V8 engines do not include the lost motion

[145] Docket no. NHTSA-2008-0089-0179.1, p 59 and Docket no. NHTSA-2008-0089-0046, p. 52.

devices and control hardware since DVVLO follows cylinder deactivation on the OHV decision tree path and employs similar lost motion devices. Rather, the DVVLO cost is for active engine mounts on V6 and V8 OHV engines which was based on $50 variable cost from Martec, adjusted to 2007 dollars and marked up with a 1.5 RPE factor to $76. For in-line 4-cylinder engines cylinder deactivation is not allowed so the cost for DVVLO is the same as for DVVLS and DVVLD at $201.

For fuel economy effectiveness, in the NPRM NHTSA estimated that DVVL could incrementally reduce fuel consumption by 0.5 to 3 percent compared to VVT. Confidential manufacturer comments received in response to the NPRM indicated a 2 percent effectiveness for DVVL, while the Alliance commented that a two-step system with dual cam phasing could reduce fuel consumption by 6.3 percent, with 1.3 percent attributable to DVVL. Publicly-available estimates suggest an improvement over the NEDC test cycle of 8 percent for DCP with 2 stage inlet DVVL applied to a 1.6 liter DOHC 4 cylinder engine in a 1500 kg vehicle.[146] With the DCP system expected to deliver 5 percent effectiveness, this suggests the DVVL system is giving approximately 3 percent. The comments received from manufacturers and publicly available data are in alignment with independent review suggesting a range of 1 to 3 percent for overhead cam engines with VVT. NHTSA has therefore estimated an incremental reduction in fuel consumption for DVVLS and DVVLD of 1 to 3 percent for purposes of the final rule. On OHV engines, DVVLO is applied following both VVT and cylinder deactivation, therefore the fuel consumption effectiveness has been reduced from 1 to 3 percent for OHC engines to 0.5 to 2.6 percent.

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[146] Mark Sellnau and Eric Rask, "Two-Step Variable Valve Actuation For Fuel Economy, Emissions, and Performance, Delphi Research Labs, SAE 2003-01-0029. *Available at* http://www.sae.org/technical/papers/2003-01-0029. (last accessed Nov. 9, 2008)

This technology may be applied to any class of vehicles with any kind of engine at the redesign cycle. For the final rule, NHTSA has combined the phase-in caps for DVVLS, DVVLD, DVVLO and CVVL and capped the joint penetration allowed at 100 percent by 2015 with time-based learning applied. Other technologies, such as continuously variable valve lift (CVVL), described below, will be implemented in place of DVVL in some applications where the fuel economy requirements dictate further optimization of the engine's breathing characteristics to improve efficiency.

(vi) Continuously Variable Valve Lift (CVVL)

In CVVL systems, maximum valve lift is varied by means of a mechanical linkage, driven by an actuator controlled by the engine control unit. The valve opening and phasing vary as the maximum lift is changed; the relation depends on the geometry of the mechanical system. BMW has the most production experience with CVVL systems and has sold port-injected "Valvetronic" engines since 2001. CVVL allows the airflow into the engine to be regulated by means of inlet valve opening reduction, which improves engine efficiency by reducing pumping losses from throttling the intake system further upstream as with a normally throttled engine.

Variable valve lift gives a further reduction in pumping losses compared to that which can be obtained with cam phase control only, with CVVL providing greater effectiveness than DVVL, since it can be fully optimized for all engine speeds and loads, and is not limited to a two or three step compromise. There may also be a small reduction in valvetrain friction when operating at low valve lift. This results in improved low load fuel consumption for cam phase control with variable valve lift as compared to cam phase control only. Most of the fuel economy effectiveness is achieved with variable valve lift on the inlet valves only.

It is generally more difficult to achieve good cylinder-to-cylinder airflow balance at low load with a CVVL valve-throttled engine due to the sensitivity of airflow to small differences in lift caused by manufacturing tolerances. BMW has reported mixture quality issues with CVVL and port fuel injection, requiring a compromise on pumping work reduction to ensure good mixture quality. In addition, a small amount of throttling is necessary with CVVL to maintain the vacuum required for power brake assist, unless a separate vacuum pump is used. BMW calibrations maintain a small amount of inlet manifold depression on their "Valvetronic" engines to allow the brake servo to function, which reduces the efficiency gain from the system somewhat. Tumble air motion generated by the inlet port is not available in the cylinder at low valve lift, which has an effect on combustion characteristics. The high gas velocities at the valve seat generate high turbulence levels, but most of this has decayed by the time of ignition. This phenomenon could potentially lead to sub-optimal combustion characteristics, which would reduce the fuel consumption effectiveness of the technology.

In the NPRM, NHTSA estimated the cost for CVVL of \$254 to \$508 compared to VVT, with cost estimates varying from \$254 for a 4-cylinder engine, \$466 for a 6-cylinder engine, and \$508 for an 8-cylinder engine, based on confidential manufacturer data and the NESCCAF report, with more weight given to the manufacturer data. As for DVVL, for purposes of the final rule, NHTSA relied primarily on the 2008 Martec report, because it contained the most complete published description of CVVL costs and agreed with confidential manufacturer data received in response to the NPRM. The system consists of 1 stepper motor per bank to control an eccentric shaft and the costs as described by Martec include dual cam phasing are $285 for an in-line 4-cylinder engine, $450 for a V-6 engine, and $550 for a V-8 engine. Applying a 1.5 RPE markup factor to these variable costs, and then deducting $122 for the incremental cost of both ICP and DCP per bank, the incremental RPE cost is $306 for a 4-cylinder engine, $432 for a 6-cylinder engine and $582 for an 8-cylinder engine.

For fuel economy effectiveness, in the NPRM NHTSA estimated that CVVL could incrementally reduce fuel consumption by 1.5 to 4 percent compared to VVT, based on confidential manufacturer data and the NESCCAF report. Confidential manufacturer comments received in response to the NPRM suggested a range of 3 to 7.4 percent incremental fuel consumption savings. NHTSA also found several sources reporting a 5 percent additional fuel consumption effectiveness over the NEDC cycle when applying CVVL to an engine with dual cam phasers.[147] For purposes of the final rule, NHTSA has estimated the reduction in fuel consumption for CVVL at 1.5 to 3.5 percent over an engine with DCP. This estimate is lower that the effectiveness reported by BMW and allows the application of CVVL without the need for the high level of manufacturing complexity inherent in BMW's "Valvetronic" engines.

There are no class specific applications of this technology, although it appears in only the DOHC portion of the decision tree. Due to the changes required to implement DVVL on an engine the Volpe model allows it to be applied at redesign model years only

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[147] *See* Johannes Liebl, Manfred Kluting, Jurgen Poggel, and Stephen Missy, BMW, "The New BMW 4-Cylinder Engine with Valvetronic Part 2: Thermodynamics and Functional Features," MTZ Worldwide, July/Aug 2001, pp 26-29. *See also* Meyer, BMW, "Turbo-Charging BMW's Spray-Guided DI Combustion System – Benefits and Challenges," Global Powertrain Congress, Sept. 2005, vol. 33. *Available at* http://www.gpc-icpem.org/pages/publications.html (last accessed Nov. 8, 2008). *See also* Rainer Wurms, Philipp Lobbert, Stefan Dengler, Ralf Budack, and Axel Eiser, Audi, "How Much VVT Makes Sense?" Haus der Technik Conference on Variable Valve Control, Essen, Feb. 2007.

with time-based learning applied. For the final rule, NHTSA has combined the phase-in caps for DVVLS, DVVLD, DVVLO and CVVL and capped the joint penetration allowed at 100% by 2015. There is no technical reason this technology could not be applied to all DOHC engines, but due to engineering resource limitations it is unlikely that CVVL will be applied to all engines, and that other technologies such as DVVL will be used in some instances.

(vii) Cylinder Deactivation (DEACS, DEACD, DEACO)

In conventional spark-ignited engines, combustion occurs in all cylinders of the engine (*i.e.*, the engine is "firing on all cylinders"), and throttling the airflow controls the engine output, or load. This is an inefficient method of operating the engine at low loads as pumping losses result from throttling. Cylinder deactivation (DEAC) can improve engine efficiency by disabling or deactivating half of the cylinders when the load is less than half of the engine's total torque capability, allowing the active cylinders to operate at roughly twice the load level, and thereby incur roughly half the pumping losses.

Simplistically, cylinder deactivation control strategy relies on setting maximum and minimum manifold absolute pressures (which are directly proportional to load) within which it can deactivate the cylinders. The engine operating range over which cylinder deactivation may be enabled is restricted by other factors as well, with noise, vibration, and harshness (NVH) being the primary concern; these restrictions all reduce the fuel economy effectiveness achievable with cylinder deactivation. In general, DEAC has very high sensitivity of efficiency gain relative to vehicle application, according to comments from Ford, Chrysler, the Alliance, and in confidential comments submitted in response to the NPRM.

Manufacturers have stated that use of DEAC on 4 cylinder engines would cause unacceptable NVH; therefore NHTSA has not applied cylinder deactivation to 4-cylinder engines. In addition, to address NVH issues for V6 and V8 engines, active engine mounts are included in the content list. Noise quality from both intake and exhaust systems has been problematic on some vehicle applications, and in some cases, has resulted in active exhaust systems solutions with an ECU-controlled valve.

The NPRM reported an incremental cost range for DEAC at $203 to $229, citing manufacturer data as the most credible, with the bill of materials including lost motion devices for each cylinder. The 2008 Martec report estimated the additional hardware necessary for cylinder deactivation ranging between $50 for the addition of two active engine mounts ($75 RPE using 1.5 RPE factor) where DVVL already exists. This value has been adopted by NHTSA in the final rule so DEACS and DEACD costs are $75. For OHV engines NHTSA estimates the costs for DEACO as being $306 for V6 engines and $400 for V8 engines that are not already equipped with DVVL using assumptions for lost motion devices plus incremental costs for oil control valves and camshaft position sensors as noted in the DVVL section.

For fuel economy effectiveness, in the NPRM NHTSA estimated that cylinder deactivation could reduce fuel consumption by 4.5 to 6 percent. As noted, DEAC has very high sensitivity of efficiency gain relative to vehicle application. Chrysler, for example, stated that the effectivenesss could range from 3 to 10 percent on the same engine depending on the specific vehicle application.[148] Confidential manufacturer comments received in response to the NPRM reported a range of 3 to 7.5 percent. For the final rule, the incremental fuel consumption effectiveness varies depending on which branch of the decision tree it is on: for DOHC engines which are already equipped with DCP and DVVLD there is little benefit that can be achieved since the pumping work has already been minimized and internal EGR rates are maximized, so the effectiveness ranges from 0 to 0.5 percent for DEACD; for SOHC engines which have CCP and DVVLS applied, NHTSA estimates a 2.5 to 3 percent effectiveness for DEACS; and for OHV engines, which do not have VVT or VVL technologies, the effectiveness for DEACO ranges from 3.9 to 5.5 percent.

This technology may be applied only to V-6 and V-8 engines, as discussed above, and so does not apply to vehicle classes with I-4 engines. DEAC can be applied during a redesign or refresh model year with time-based learning. NHTSA proposed to raise the phase-in cap for this technology to 20 percent per year in the NPRM. For the final rule, NHTSA has combined the phase-in caps for DEACS, DEACD and DEACO and capped the joint penetration allowed at 68 percent by 2015.

(viii) Conversion to Double Overhead Camshaft Engine with Dual Cam Phasing (CDOHC)

This technology was named "Multi-valve Overhead Camshaft Engine" in the NPRM. Engines with overhead cams (OHC) and more than two valves per cylinder achieve increased airflow at high engine speeds and reductions of the valvetrain's moving mass and enable central positioning of the spark plug. Such engines typically develop higher power at high engine speeds. In the NPRM, the model was generally not allowed

[148] Docket No. NHTSA-2008-0089-0215.1.

to apply multivalve OHC technology to OHV engine, except where continuous variable valve timing and lift (CVVL) is applied to OHV engine. In that case, the model assumed conversion to a DOHC valvetrain, because a DOHC valvetrain is a prerequisite for the application of any advanced engine technology over and above CVVL. Since applying CVVL to an OHV engine is the last improvement that could be made, it was assumed that manufacturers would redesign that engine as a DOHC and include CVVL as part of that redesign.

However, it appears likely that vehicles will still use overhead valve (OHV) engine with pushrods and one intake and one exhaust valve per cylinder into the next decade. For the final rule, NHTSA assumed that conversion of an OHV engine to a DOHC engine would more likely be accompanied by dual cam phasing (DCP) than by CVVL, since DCP application rates are higher than CVVL rates.

For V8 engines, the incremental cost to redesign an OHV engine as a DOHC with DCP was estimated as $746 which includes $415 for the engine conversion to DOHC per the 2008 Martec report and a 1.5RPE factor, plus $122 for an incremental cam phasing system (reflecting the doubling of cam shafts). For a V6 engine we estimated 75 percent of the V8 engine cost to convert to DOHC plus the same incremental coupled cam phasing cost to arrive at $590. For inline 4-cylinder engines, 50 percent of the V8 engine conversion costs were assumed and one additional cam phasing system yielding an incremental cost including a 1.5 RPE factor of $373.

For fuel economy effectiveness, NHTSA estimated in the NPRM that the incremental gain in fuel consumption for conversion of an OHV engine with cylinder deactivation and CCP to a DOHC engine with CVVL at 1 to 4 percent, in agreement with the NESCCAF report and confidential manufacturer data. The fuel consumption benefit for converting an OHV engine to a DOHC engine with DCP is due largely to friction reduction according to a confidential manufacturer comment. For the final rule the upper bound stated in the NPRM was reduced because DCP will give less improvement than CVVL compared to an engine that already has cylinder deactivation and CCP applied. NHTSA estimates the incremental fuel consumption effectiveness at 1 to 2.6 percent independent of the number of engine cylinders.

There are no class-specific applications of this technology. In the NPRM, NHTSA proposed raising the phase-in cap to 20 percent per year, but has concluded for the final rule that a 9 percent phase-in cap in model year 2011 followed by 17 percent increases for model years 2012 through 2015 is more consistent with manufacturers' comments. No comments were received regarding phase-in rates of converting OHV engines to DOHC. The conversion from OHV to DOHC engine architecture with DCP is a major engine redesign that can be applied at redesign model years only with time-based learning applied.

(ix) Stoichiometric Gasoline Direct Injection (SGDI)

In gasoline direct injection (GDI) engines, fuel is injected into the cylinder rather than into the inlet manifold or inlet port. GDI allows for the compression ratio of the engine to be increased by up to 1.5 units higher than a port-injected engine at the same fuel octane level. As a result of the higher compression ratio, the thermodynamic efficiency is improved, which is the primary reason for the fuel economy effectiveness with stoichiometric DI systems. The compression ratio increase comes about as a result of the in-cylinder air charge cooling that occurs as the fuel, which is sprayed directly into the combustion chamber, evaporates.

Volumetric efficiency in naturally-aspirated GDI engines can also be improved by up to 2 percent, due to charge cooling, which improves the full load torque. The improved full load torque capability of GDI engines can have a secondary effect on fuel economy by enabling engine downsizing, thereby reducing fuel consumption.

Two operating strategies can be used in gasoline DI engines, characterized by the mixture preparation strategy. One strategy is to use homogenous charge where fuel is injected during the intake stroke with a single injection. The aim is to produce a homogeneous air-fuel-residual mixture by the time of ignition. In this mode, a stoichiometric air/fuel ratio can be used and the exhaust aftertreatment system can be a relatively low cost, conventional three-way catalyst. Another strategy is to use stratified charge where fuel is injected late in the compression stroke with single or multiple injections. The aim here is to produce an overall lean, stratified mixture, with a rich area in the region of the spark plug to enable stable ignition. Multiple injections can be used per cycle to control the degree of stratification. Use of lean mixtures significantly improves efficiency by reducing pumping work, but requires a relatively high cost lean NO_x trap in the exhaust aftertreatment system.

For purposes of this rulemaking, only homogeneous charge stoichiometric DI systems were considered, due to the anticipated unavailability of low sulfur gasoline during the MY 2011-2015 time period. This decision was supported by comments from Mercedes, which sells lean burn DI engines in other world markets, stating that lean burn DI engines cannot function in the absence of ultra-low sulfur gasoline. Lean NO_x trap technologies require ultra-low sulfur gasoline to function at high conversion efficiency over the entire life cycle of a vehicle.

Gasoline DI systems effectiveness from the increased efficiency of the thermodynamic cycle. The fuel consumption effectiveness from DI technology is therefore cumulative to technologies that target pumping losses, such as the VVT and VVLT technologies. The Sierra Research report stated that Sierra Research could not determine from the NPRM decision trees if VVLT technologies were retained when SGDI was applied. To clarify, as the model progresses through the decision trees, technologies preceding SGDI are retained in the cumulative effectiveness and cost.

In the NPRM, NHTSA estimated the incremental fuel consumption effectiveness for naturally aspirated SGDI[149] to be 1 to 2 percent. The Alliance commented that it estimated 3 percent gains in fuel efficiency, as well as a 7 percent improvement in torque, which can be used to mildly downsize the engine and give up to a 5.8 percent increase in efficiency. Other published literature reports a 3 percent effectiveness for SGDI,[150] and another source reports a 5 percent improvement on the NEDC drive cycle.[151] Confidential manufacturer data submitted in response to the NPRM reported an efficiency effectiveness range of 1 to 2 percent. For the final rule NHTSA has estimated, following independent review of all the sources referenced above, the incremental gain in fuel consumption for SGDI to be approximately 2 to 3 percent.

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[149] SGDI was referred to as GDI or SIDI in the NPRM.

[150] Paul Whitaker, Ricardo, Inc., "Gasoline Engine Performance And Emissions – Future Technologies and Optimization," ERC Symposium, Low Emission Combustion Technologies for Future IC Engines, Madison, WI, June 8-9, 2005. *Available at* http://www.erc.wisc.edu/symposiums/2005_Symposium/June%208%20PM/Whitaker_Ricardo.pdf (last accessed Nov. 9, 2008).

[151] Stefan Trampert, FEV Motorentechnik GmbH, "Engine and Transmission Development Trends - Rising Fuel Cost Pushes Technology," Symposium on International Automotive Technology, Pune, India, January 2007.

Content assumptions for cost estimating of SGDI include no major changes to engine architecture compared to a port fuel injection engine, although cylinder head casting changes are required to incorporate the fuel injection system and the piston must change as well to suit the revised combustion chamber geometry. The fuel injection system utilizes an electrically-driven low pressure fuel pump to feed a high pressure mechanical pump, supplying fuel at pressures up to 200 Bar. A common fuel rail supplies the injectors, which produce a highly atomized spray with a Sauter Mean Diameter (SMD) of 15-20 microns, which compares to approximately 50 microns for a port injector.

In the NPRM, NHTSA estimated the following incremental cost ranges for applying SGDI: $122 to $420 for an inline 4-cylinder engine, $204 to $525 for a V6 engine, and $228 to $525 for a V8 engine. The Alliance commented that NHTSA had not accounted for the costs required to address NVH concerns associated with the implementation of SGDI. For purposes of the final rule, all costs have been based upon side mount DI technology as these costs were determined in the 2008 Martec Report to be lower than center mount DI systems. An applied RPE factor of 1.5 was used in all cases, providing incremental costs that ranged from $293 to $440 for an I4 engine with no NVH package required, to $384 to $558 for a V6 engine and $512 to $744 for a V8 engine with an added NVH package, in response to the Alliance comment.

Homogeneous, stoichiometric DI systems are regarded as mature technology with minimal technical risk and are expected to be increasingly incorporated into manufacturers' product lineups. Time-based learning has been applied to this technology due to the fact that over 1.5 million vehicles containing this technology are now produced annually. Due to the changes to the cylinder head and combustion system and the control system development required to adopt SGDI technology, which are fairly extensive, SGDI can be applied only at redesign model years. There are no limitations on applying SGDI to any vehicle class. The phase-in cap for SGDI is applied at a 3 percent rate for the first two model years of the rule period in order to account for the lead time required to incorporate SGDI engines. The third year rate is increased to 14 percent and the fourth and fifth years increase further to 20 percent, as was proposed in the NPRM.

(x) Combustion Restart (CBRST)

Combustion restart allows "start-stop" functionality of DI engines through the implementation of an upgraded starter with bi-directional rotation to allow precise crankshaft positioning prior to subsequent fuel injection and spark ignition, allowing engine restart. This method of implementing engine stop/start functionality allows not only the fuel savings from not idling the engine, but also reduces fuel consumption as the engine speeds up to its operational speed. A Direct Injection (DI) fuel system is required for implementation of this technology.

NHTSA has determined, upon independent review, combustion restart to be a high technical risk due to the following unresolved issues. First, very high or very low ambient air temperatures may limit the ability to start the engine in the described manner. Although the starter motor can provide fail-safe starting capability in these temperature limited areas, strategies must be developed to manage the transitions. Additionally, a fail-safe start strategy that recognizes failed attempts and responds quickly enough has yet to be demonstrated. The risk of missed start events is currently relatively high, which is unacceptable from a production implementation perspective. As a result, availability of this technology was assessed as beyond the 2015 model year for purposes of this rulemaking. However, the agency notes that one manufacturer submitted confidential product plans with combustion restart at sufficient volumes that it was allowed in the model for 2014 and 2015 model years with a 3 percent per year phase-in cap for the whole industry.

Additional hardware required to implement combustion restart, beyond SGDI, includes a battery sensor, incremental wiring and high current switching, an incremental crank position sensor, and, in the case of an automatic transmission applications, a transmission oil pump to allow for torque converter continuity. For purposes of the final rule, NHTSA relied on independent source data, which aligned with the 2008 Martec Report cost estimates for individual pieces. The total RPE cost (excluding transmission pump) is $141 at high volumes, which indicates the costs for this technology would include a $70 starter upgrade, $10 battery sensor and wiring, $10 high current switch and $4 crank sensor a totalling $94 cost and $141 at 1.5 RPE.

Combustion restart was a technology that was not described in the NPRM, and no other comments were received by NHTSA. BMW has published a 3.5 percent fuel consumption effectiveness over the NEDC drive cycle for combustion restart,[152] and AVL a 4.8 percent effectiveness.[153] However, these reported effectiveness levels could potentially be reduced significantly on the EPA combined drive cycle, as combustion

[152] Stefan Wolff, Dirk Abendroth, Werner Weigl, Claus-Peter Linner, Rupert Neudecker, Michael Schneider, Wolfgang Huber, and Andreas Rau, BMW, "Introducing The Automatic Start-Stop (ASS) Function In Series Models," 7th Stuttgart Automotive Vehicle and Engine Symposium, Organised by FKFS, Mar 2007, Vol. 1.

[153] G.K. Fraidl, P.E. Kapus, and H. Friedl, AVL List GmbH, "Future Gasoline Engine Technologies for 130 g/Km CO_2," VKM-THD 11th Symposium on the Working Process of Combustion Engines, TU Graz, Sept. 2007.

restart does not save fuel on the highway drive cycle. Therefore, NHTSA estimates the fuel consumption effectiveness for CBRST to be from 1.8 to 2.4 percent.

CBRST is first available in MY 2014 and is applicable to all vehicle classes. Confidential product plan data indicates CBRST to be at high volume by 2014 so time-based volume is applied. CBRST can be applied a vehicle refresh with a phase-in cap of 3 percent per year.

(xi) Turbocharging and Downsizing (TRBDS)

Forced induction in the form of turbocharging and supercharging has been used on internal combustion engines for many years. Their traditional role has been to provide enhanced performance for high-end or sports car applications. However, turbocharging and downsizing can also be used to improve fuel economy. There is a natural friction reduction with a boosted downsized engine, because engine friction torque is primarily a function of engine displacement. When comparing FMEP (Friction Mean Effective Pressure – friction torque normalized by displacement) there is very little difference between the full size naturally-aspirated engine and the boosted downsized engine despite the higher cylinder pressure associated with higher BMEP. Turbocharging and downsizing can also reduce pumping losses (PMEP), because a turbocharged downsized engine runs at higher BMEP (Brake Mean Effective Pressure) levels, and therefore higher manifold pressures, than a naturally aspirated engine. The upper limit of BMEP level that can be expected from a naturally aspirated engine is approximately 13.5 Bar, whereas a turbocharged engine can produce BMEP levels in excess of 20 Bar. Engines that are not downsized and boosted use a throttle to regulate load, but this causes pumping losses as discussed previously. Thus, by using a small displacement engine with a turbocharger, the smaller engine works harder (higher cylinder load), which results in lower pumping loss since the throttle must be further open to produce the same road power output.

Due to the incremental nature of the decision tree, engines having turbocharging and downsizing applied are assumed to have SGDI already applied. In boosted engines, SGDI allows improved scavenging of the cylinder, which reduces the internal exhaust gas residual level and the charge temperature. This in turn allows a higher compression ratio to be used for a given fuel octane rating and can therefore improve the fuel consumption of boosted SGDI engines.

In most cases, a boosted downsized engine can replace a conventional naturally aspirated engine and achieve equivalent or greater (albeit at the expense of fuel economy) power and torque. However, there are some challenges associated with acceptance of a down sized boosted engine, including:

- Achievement of “seamless” power delivery compared to the naturally aspirated engine (no perceptible turbo lag);
- A complication in emissions regulatory compliance, because the addition of a turbocharger causes additional difficulty with catalyst light off due to the thermal inertia of the turbo itself;
- Potential issue with customer acceptance of smaller-displacement engines, given a common perception that only larger-displacement engines can be high-powered; and
- Additional base engine cost and vehicle integration costs.

Manufacturers' structural changes to the base engine are generally focused on increasing the structure's capacity to tolerate higher cylinder pressures. NHTSA believes that it is reasonable to expect that the maximum cylinder pressure would increase by 25 to 30 percent over those typical of a naturally aspirated engine. Another consideration is that higher pressures lead to higher thermal loads.

One potential disadvantage of downsized and boosted engines is cost. Turbocharging systems can be expensive and are best combined with direct injection and other engine technologies. The Alliance expressed a related concern that the fuel economy effectiveness was based on the use of premium grade fuel in direct injection turbocharged engines, and argued that as the baseline vehicles were not fueled with premium gasoline, this gave the direct injection turbocharged engines an unrealistic advantage.[154] However, CARB stated in its comments that premium fuel is not necessary for use with turbocharged downsized engines and that substantial effectiveness are still available with regular fuel.[155] In fact, most turbocharged direct injection engines will have a compression ratio and calibration designed to give best performance on premium fuel, although they are safe to operate on regular fuel. On regular fuel, the knock sensor output is used to allow the ECU to keep the engine safe by controlling boost and ignition timing. Maximum torque is reduced on the lower octane fuel due to the ECU intervention strategy, but at part load, where knock is not an issue, the fuel economy will not be affected adversely relative to the estimated effectiveness. Additionally, the driver retains the choice of obtaining more performance by paying more for premium fuel and will still obtain stated fuel consumption effectiveness.

[154] Docket No. NHTSA-2008-0089-0179.1.
[155] Docket No. NHTSA-2008-0089-0173.

Nevertheless, the case for using downsized boosted engines has strengthened with the wider introduction of direct injection gasoline engines. Downsized boosted engines with stoichiometric direct injection present minimal technical risk, although there have been only limited demonstrations of this technology achieving SULEV emission levels.

In the NPRM, NHTSA estimated that downsized and turbocharged engines could incrementally reduce fuel consumption from 5 to 7.5 percent. CARB commented that Sierra Research in its presentation to the NAS committee on January 24, 2008, suggested there is no carbon dioxide reduction potential for turbocharging and downsizing, but argued that this is not supported by other vehicle simulation efforts nor by manufacturer plans to release systems such as the Ford EcoBoost.[156] The Alliance and Sierra Research, in contrast, commented that turbocharged and downsized engines do not improve fuel economy unless they are also equipped with DI fuel systems and using premium fuel.[157] NHTSA believes that turbocharging and downsizing, when combined with SGDI, offers benefits without the use of premium fuel as noted above. Confidential manufacturer data suggests an incremental range of fuel consumption reduction of 4.8 to 7.5 percent for turbocharging and downsizing. Other publicly-available sources suggest a fuel consumption benefit of 8 to 13 percent compared to current-production naturally-aspirated engines without friction reduction or other fuel economy technologies: a joint technical paper by Bosch and Ricardo suggesting an EPA fuel economy gain of 8 to 10 percent for downsizing from a 5.7 liter port injection V8 to a 3.6 liter V6 with direct

[156] Docket no. NHTSA-2008-0089-0173.4.
[157] Docket no. NHTSA-2008-0089-0046, Docket no. NHTSA-2008-0089-0179.1.

injection;[158] a Renault report suggesting a 11.9 percent NEDC fuel consumption gain for downsizing from a 1.4 liter port injection in-line 4-cylinder engine to a 1.0 liter in-line 4-cylinder engine with direct injection;[159] and a Robert Bosch paper suggesting a 13 percent NEDC gain for downsizing to a turbocharged DI engine.[160] These reported fuel economy benefits show a wide range in large part due to the degree of vehicle attribute matching (such as acceleration performance) that was achieved.

For purposes of the final rule, NHTSA estimated a net fuel consumption reduction of approximately 14 percent for a turbocharged downsized DOHC engine with direct injection and DCP over a baseline fixed-valve engine that does not incorporate friction reducing technologies. This equates to an incremental fuel consumption reduction of 2.1 to 5.2 percent for TRBDS, which is incremental to an engine with SGDI and previously applied technologies (*e.g.*, VVT and VVL) as defined by the decision tree. This wide range is dependent upon the decision tree path that is followed or the configuration of the engine prior to conversion to TRBDS. The incremental fuel consumption benefit for TRBDS is estimated to range from 2.1 to 2.2 percent for V6 and V8 engines and from 4.5 to 5.2 percent for inline 4-cylinder engines. As explained, the incremental improvement from TRBDS must be added to the previous technology point on the decision tree. In the case of SOHC and OHV engines, for example, moving to the TRBDS technology also assumes implementation of DOHC engine architecture in addition to DCP and SGDI.

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158 David Woldring and Tilo Landenfeld of Bosch, and Mark J. Christie of Ricardo, "DI Boost: Application of a High Performance Gasoline Direct Injection Concept," SAE 2007-01-1410. *Available at* http://www.sae.org/technical/papers/2007-01-1410 (last accessed Nov. 9, 2008)
159 Yves Boccadoro, Loïc Kermanac'h, Laurent Siauve, and Jean-Michel Vincent, Renault Powertrain Division, "The New Renault TCE 1.2L Turbocharged Gasoline Engine," 28th Vienna Motor Symposium, April 2007.
160 Tobias Heiter, Matthias Philipp, Robert Bosch, "Gasoline Direct Injection: Is There a Simplified, Cost-Optimal System Approach for an Attractive Future of Gasoline Engines?" AVL Engine & Environment Conference, September 2005.

In the NPRM, NHTSA estimated that the cost for a boosted/downsized engine system would be $690 for small cars, $810 for large trucks, and $120 for all other vehicle classes, based on the NAS report, the EEA report, and confidential manufacturer data, which assumed downsizing allowed the removal to two cylinders in most cases, except for small cars and large trucks. CARB questioned Martec's cost estimates for turbocharging and downsizing, specifically the credit for downsizing a V6 engine to an in-line 4 cylinder dropped from their estimate used in the NESCCAF report of $700 to $310 and the use of more expensive hardware than some manufacturers use. In response, NHTSA's independent review of the cost to downsize a V6 DOHC engine to a I4 DOHC engine closely aligned with the 2008 Martec credit of $310, while the report for NESCCAF was not specific with regard to the assumptions used to construct that estimate. Additionally, confidential manufacturer data submitted in response to the NPRM provided a range for TRBDS with SGDI of $600 to $1400 variable cost or $900 to $2100 RPE assuming a 1.5 markup factor. When comparing the confidential manufacturer cost range and the incremental RPE cost estimates for the final rule, it is important to realize the incremental cost for TRBDS does not include SGDI since it is considered a separate technology.[161]

Some of the costs included in turbocharging and downsizing come from structural changes due to the higher cylinder pressures and increased cylinder temperatures, which also drive additional cooling requirements (*e.g.* water-cooled charge air cooler,

[161] NHTSA also examined the Jetta TDI as an example of a current vehicle model that comes in both diesel and gasoline-engine form, but in attempting to do an apples-to-apples comparison with the non-turbocharged/downsized version , the SE, found indications that VW appears to be keeping the cost of the TDI down by removing other content (*e.g.*, the SE has a sunroof, which normally costs around $1,000, while the TDI does not). Thus, NHTSA did not find VW's price differential for the two versions of the Jetta to be convincing evidence of the actual cost of turbocharging and downsizing an engine.

circulation pump, and thermostats) and require improved exhaust valve materials. High austenitic stainless steel exhaust manifolds and upgraded main bearings are some of the other hardware upgrades required. For purposes of the final rule, NHTSA used cost data from the 2008 Martec report, but constructed a bill of materials consistent with the incremental TRBDS technology as shown in the decision trees and based on confidential manufacturer data. For the vehicle subclasses which have a baseline gasoline V8 engine, two turbochargers rated for 1050° C at $250 each were added, $270 was deducted for downsizing to a V6 from a V8 engine, $217 was added for engine upgrades to handle higher operating pressures and temperatures at, and a water-cooled charge air cooler was added at $280. The baseline SOHC engine was converted to a DOHC engine with 4 valves per cylinder at a variable incremental cost of $92. The total variable costs summed to $819 and a 1.5 RPE factor was applied to arrive at $1229 incremental cost to turbocharging and downsizing.

For the vehicle subclasses which have a baseline gasoline V6 engine, a twin-scroll turbocharger rated for 1050° C was added at a cost of $350, $310 was deducted for downsizing to an I4 from a V6 engine, $160 was added for engine upgrades to handle higher operating pressures and temperatures, and a water-cooled charge air cooler was added at $259. The baseline SOHC engine was converted to a DOHC engine with 4 valves per cylinder at a variable incremental cost of $87. The total variable costs summed to $548 and a 1.5 RPE factor was applied to arrive at $822 incremental cost to turbocharging and downsizing.

For the vehicle subclasses which have a baseline gasoline I4 engine, a twin-scroll turbocharger rated for 1050° C was added at a cost of $350, $160 was added for engine upgrades to handle higher operating pressures and temperatures, and a water-cooled charge air cooler was added at $259. The baseline SOHC engine was converted to a DOHC engine with 4 valves per cylinder at a variable incremental cost of $46. The total variable costs summed to $815 and a 1.5 RPE factor was applied to arrive at $1223 incremental cost for turbocharging and downsizing.

In summary, for the final rule NHTSA estimated TRBDS to have an incremental RPE cost of $1223 for vehicle classes with a baseline in-line 4-cylinder engine downsized to a smaller I-4 engine which are: Subcompact, Performance Subcompact, Compact and Midsize Car, and Small Truck. For vehicle classes with a baseline V6 engine that was downsized to an I4 engine the RPE cost is estimated at $822; these classes are the Performance Compact, Performance Midsize and Large Car, Minivan and Midsize Truck. The two vehicle classes with baseline V8 engines, Performance Large Car and Large Truck, were downsized to V6 turbocharged engines at an incremental RPE cost of $1229.

Time-based learning has been applied to TRBDS because submitted product plan data indicated turbocharging and downsizing would already be at high volume in 2011. Due to the fact that a turbocharged and downsized engine is entirely different than the baseline engine it can be applied only at redesign model years. The phase-in cap for TRBDS is applied at a 9 percent rate for the first two model years of the rule period in order to account for the lead time required to incorporate TRBDS engines. The third through fifth year rates are increased to 17 percent, as was done for the 2006 light truck final rule.

(xii) Cooled Exhaust Gas Recirculation Boost (EGRB)

EGR Boost is a combustion concept that involves utilizing EGR as a charge dilutant for controlling combustion temperatures. Fuel economy is therefore increased by operating the engine at or near the stoichiometric air/fuel ratio over the entire speed and load range and using higher exhaust gas residual levels at part load conditions. Further fuel economy increases can be achieved by increased compression ratio enabled by reduced knock sensitivity, which enables higher thermal efficiency from more advanced spark timing. Currently available turbo, charge air cooler, and EGR cooler technologies are sufficient to demonstrate the feasibility of this concept.

However, this remains a technology with a number of issues that still need to be addressed and for which there is no production experience. EGR system fouling characteristics could be potentially worse than diesel EGR system fouling, due to the higher HC levels found in gasoline exhaust. Turbocharger compressor contamination may also be an issue for low pressure EGR systems. Additionally, transient controls of boost pressure, EGR rate, cam phasers and intake charge temperature to exploit the cooled EGR combustion concept fully will require development beyond what has already been accomplished by the automotive industry. These are all "implementation readiness" issues that must be resolved prior to putting EGR Boost into volume production.

Because of these issues NHTSA did not consider EGR Boost in the NPRM, and consequently had no tentative conclusions with regard to its cost or fuel economy effectiveness. For purposes of the final rule, however, and given the need of the nation to conserve energy, NHTSA with independent review has concluded that these implementation issues could be resolved and this technology brought to production by MY 2013. Supporting this conclusion, MEMA has suggested a 5 to 7 percent effectiveness for cooled EGR systems, although without boosting.[162] Two public sources suggest a 10 to 20 percent fuel consumption effectiveness for a downsized DI engine with cooled EGR compared to a naturally aspirated baseline engine[163] and a 4 percent fuel consumption effectiveness for cooled EGR compared to a conventional downsized DI turbocharged engine.[164] Based on the data from these reports, NHTSA estimates the incremental reduction in fuel consumption for EGR Boost to be 4 percent over a turbocharged and downsized DI engine. As with all the other technologies considered in this analysis, it must be understood that a 4 percent fuel consumption reduction is incremental to the improvements from the preceding technologies. Since TRBDS precedes EGRB in the decision tree, adding the 12 percent gain from TRBDS to the 4 percent gain from EGRB results in a total fuel consumption reduction of 16 percent which is in agreement with range suggested in the Lotus report.[25]

For purposes of the final rule, NHTSA relied on independent source data, which aligned with the 2008 Martec Report cost estimates for individual pieces. The addition of EGR cooler and EGR valve are estimated to have an incremental cost impact of approximately $173 based on confidential data describing EGR cooler costs of $75, EGR

[162] Docket No. NHTSA-2008-0089-0193.1
[163] Cairns *et al.*, Lotus, "Low Cost Solutions for Improved Fuel Economy in Gasoline Engines," Global Powertrain Congress September 27-29, 2005, vol. 33. *Available at* http://www.gpc-icpem.org/pages/publications.html (last accessed Nov. 9, 2008).
[164] Tim Lake, John Stokes, Richard Murphy, and Richard Osborne of Ricardo and Andreas Schamel of Ford-Werke, "Turbocharging Concepts for Downsized DI Gasoline Engines," VKA/ika Aachen Colloquium 2003. *Available at* http://cat.inist.fr/?aModele=afficheN&cpsidt=16973598 (last accessed Nov. 9, 2008)
[25] *See supra* note 162.

valve costs of $20 and associated piping costs of $20, totalling $115 which applying a 1.5 RPE markup gives $173 over a turbocharged downsized DI engine.

EGRB can be applied to all vehicle classes starting in 2013. Phase-in caps are limited to 3 percent per year with time-based learning applied. NHTSA considered the complexity and high technical risk of implementing this technology and determined that this technology can be applied at redesign only.

(b) Diesel Engine Technologies

Diesel engines, which currently make up about 0.27 percent of engines in the MY 2008 U.S. fleet, have several characteristics that give them superior fuel efficiency compared to conventional gasoline, spark-ignited engines. Pumping losses are much lower due to lack of (or greatly reduced) throttling. The diesel combustion cycle operates at a higher compression ratio, with a very lean air/fuel mixture, and turbocharged light-duty diesels typically achieve much higher torque levels at lower engine speeds than equivalent-displacement naturally-aspirated gasoline engines. Additionally, diesel fuel has higher energy content per gallon.[165]

However, diesel engines, including those on the many diesel vehicles sold in Europe, have emissions characteristics that present challenges to meeting federal Tier 2 emissions standards. It is a significant systems-engineering challenge to maintain the fuel consumption advantage of the diesel engine while meeting U.S. emissions regulations, since fuel consumption is negatively impacted by emissions reduction strategies. Emission compliance strategies for diesel vehicles sold in the U.S. are expected to include a combination of combustion improvements and aftertreatment.

[165] Burning one gallon of diesel fuel produces about 11 percent more carbon dioxide than gasoline due to the higher density and carbon to hydrogen ratio.

These emission control strategies are currently widely used in Europe, but will have to be modified due to the fact that U.S. emission standards, especially for NO_x, are much tighter than corresponding European standards. To achieve U.S. Tier 2 emissions limits, roughly 45 to 65 percent more NO_x reduction is required compared to the Euro VI standards. Additionally, as discussed below, there may be a fuel consumption penalty associated with diesel aftertreatment since extra fuel is needed for the aftertreatment, subsequently this extra fuel is not used in the combustion process of the engine that provides torque to propel the vehicle.

Nevertheless, emissions control technologies do exist, and will enable diesel engines to make considerable headway in the U.S. fleet in MYs 2011-2015. Several key advances in diesel technology have made it possible to reduce emissions coming from the engine prior to aftertreatment. These technologies include improved fuel systems (higher pressures and more responsive injectors), advanced controls and sensors to optimize combustion and emissions performance, higher EGR levels and EGR cooling to reduce NO_x, lower compression ratios, and advanced turbocharging systems.

The fuel systems on advanced diesel engines are anticipated to be of a High-Pressure Common Rail (HPCR) type with piezoelectric injectors that operate at pressures up to 1800 Bar or greater and provide fast response to allow multiple injections per cycle. The air systems will include a variable geometry turbocharger for 4-cylinder inline engines with charge-air cooling and high-pressure and low-pressure EGR loops with EGR coolers. For V-6 or V-8 engines the air systems will employ series sequential turbo-charging with one variable geometry turbocharger and one fixed geometry turbocharger.

As suggested above, the traditional 3-way catalyst aftertreatment found on gasoline-powered vehicles is ineffective due to the lean-burn combustion of a diesel. All diesels will require a diesel particulate filter (DPF), a diesel oxidation catalyst (DOC), and a NO_x reduction strategy to comply with Tier 2 emissions standards. The most common NO_x reduction strategies include the use of lean NO_x traps (LNT) or selective catalytic reduction (SCR), which are outlined below.

(i) Diesel Engine with Lean NO_x Trap (LNT) Catalyst After-Treatment

A lean NO_x trap operates, in principle, by storing NO_x (NO and NO_2) when the engine is running in its normal (lean) state. When the control system determines (via mathematical model or a NO_x sensor) that the trap is saturated with NO_x, it switches the engine into a rich operating mode or may in some cases inject fuel directly into the exhaust stream to produce excess hydrocarbons that act as a reducing agent to convert the stored NO_x to N_2 and water, thereby "regenerating" the LNT and opening up more locations for NO_x to be stored. LNTs are sensitive to sulfur deposits that can reduce catalytic performance, but periodically undergo a desulfurization engine-operating mode to clean it of sulfur buildup.

The fuel consumption penalty associated with aftertreatment systems, including both DPF and LNT, is taken into account in the reported values. In the case of the DPF, extra fuel is needed to raise the temperature of the DPF above approximately 550°C to enable active regeneration. A similar process is needed to regenerate the LNT, but instead of being used to remove particulates and raise the temperature, the excess fuel is used to provide a fuel-rich condition at the LNT to convert the trapped NO_x on the LNT to nitrogen gas. The estimated fuel consumption penalty on the CAFE test cycle associated with the LNT aftertreatment system is 5 percent on the EPA city cycle and 3 percent on the highway cycle, as described in the report to the EPA.[166]

In order to maintain equivalent performance to comparable gasoline-engine vehicles, an inline 4-cylinder (I-4) diesel engine with displacement varying around 2 liters to meet vehicle performance requirements was assumed for Subcompact, Performance Subcompact, Compact, and Midsize Passenger Car and Small Truck vehicle subclasses, and it was also assumed that these vehicles would utilize LNT aftertreatment systems.

In the NPRM, NHTSA estimated that LNT-based diesels could incrementally reduce fuel consumption by 8 to 15 percent at an incremental RPE cost of $1,500 to $1,600 compared to a direct injected turbocharged and downsized spark-ignition engine, in agreement with confidential manufacturer data. These costs were based on a "bottom up" cost analysis that was performed with EPA, which then subtracted the costs of all previous steps on the decision tree prior to diesel engines.

Comments submitted in response to the NPRM including both manufacturers' confidential data and non-confidential data sources for diesel engines was in the range of 16.7 percent to 26.7[167] percent fuel consumption benefit over a baseline gasoline engine at a variable cost of $2000 to $11200. Confidentially submitted diesel cost and effectiveness estimates generally did not differentiate between car and truck applications,

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166 Ricardo, "A Study of Potential Effectiveness of Carbon Dioxide Reducing Vehicle Technologies, Revised Final Report," at 62. *Available at* http://www.epa.gov/otaq/technology/420r08004a.pdf (last accessed Oct. 4, 2008).

167 The 26.7 percent fuel consumption reduction is a maximum estimate cited in a June 2008 Sierra Research report (Docket No. NHTSA-2008-089-0179.1) for a CAFE estimate in a midsize car, whereas an April 2008 Sierra report (Docket No. NHTSA-2008-089-0046) cites a maximum estimate of 22.4 percent for the same vehicle class; NHTSA was unable to discern why the estimates differed.

engine size and aftertreatement systems leading to large ranges for both cost and effectiveness estimates. Additionally, most of the costs appeared to be stated as variable costs not RPE but this was not always completely discernible.

For purposes of the final rule, NHTSA estimated the net fuel consumption benefit for an I-4 diesel engine with LNT aftertreatment to be approximately 20 to 26 percent improvement over a baseline gasoline engine. This equates to a 5.3 to 7.7 percent improvement for DSLT, which is incremental to a turbocharged downsized gasoline engine (TRBDS) with EGRB, and a 15.0 to 15.3 percent incremental improvement for DSLC, which is incremental to a gasoline engine with combustion restart (CBRST.) The 2008 Martec report was relied upon for cost estimates and the diesel cost was adjusted by removing the downsizing credit and applying a 1.5 RPE marked up factor to arrive at a cost of $4007 compared to a baseline gasoline engine. This results in an incremental RPE cost of $1567 to $1858 for DSLT and $2963 to $3254 for DSLC. NHTSA's independent review concurred with all the costs in this bill-of-material-based cost analysis.

A large part of the explanation for the cost increase since the NPRM is the dramatic increase in commodity costs for the aftertreatment systems, namely the platinum group metals. The updated cost estimates of Martec 2008 and others reflect the rise of global costs for raw materials since Martec 2004 and other prior referenced cost estimates were conducted. As described in Martec 2008, engine technologies employing high temperature steels or catalysts with considerable platinum group metals usage have experienced tremendous inflation of raw material prices. These updated estimates account for current spot prices of platinum and rhodium which have demonstrated cost inflation amounting to between 300 and 750 percent of global prices.[168]

(ii) Diesel Engine with Selective Catalytic Reduction (SCR) After-Treatment

An SCR aftertreatment system uses a reductant (typically, ammonia derived from urea) that is continuously injected into the exhaust stream ahead of the SCR catalyst. Ammonia combines with NO_x in the SCR catalyst to form N_2 and water. The hardware configuration for an SCR system is more complicated than that of an LNT, due to the onboard urea storage and delivery system (which requires a urea pump and injector into the exhaust stream). While a rich engine-operating mode is not required for NO_x reduction, the urea is typically injected at a rate of 3 to 4 percent of the fuel consumed. Manufacturers designing SCR systems intend to align urea tank refills with standard maintenance practices such as oil changes.

The fuel consumption penalty associated with the SCR aftertreatment system is taken into account in the values reported here. Similar to the LNT system, extra fuel is needed to warm up the SCR system to an effective operating temperature. The estimated fuel consumption penalty on the CAFE test cycle associated with the SCR aftertreatment system is 5 percent on the EPA city cycle and none on the highway cycle, as described in the report to the EPA.[169] A recent report, however, suggests a fuel economy benefit associated with the use of a SCR system, based on the supposition that the engine calibration is shifted towards improved fuel consumption and more of the NO_x reduction

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[168] Martec, "Variable Costs of Fuel Economy Technologies," June 1, 2008, at 13-20. Docket No. NHTSA-2008-0089-0169.1.

[169] Ricardo, "A Study of Potential Effectiveness of Carbon Dioxide Reducing Vehicle Technologies, Revised Final Report," at 62. *Available at* http://www.epa.gov/otaq/technology/420r08004a.pdf (last accessed Oct. 4, 2008).

is being handled by the SCR system.[170] Nevertheless, since this benefit is not yet proven for high-volume production, it has not been applied for purposes of the final rule.

In order to maintain equivalent performance to comparable gasoline-engine vehicles, a V-6 diesel engine, with displacement varying around 3 liters was assumed for Performance Compact, Performance Midsize, Large Passenger Car, Minivan, and Midsize Truck. A V-8 diesel engine, with displacement varying around 4.5 liters to meet vehicle performance requirements, was assumed for Large Truck and Performance Large Car vehicle classes. It was also assumed that these classes with V-6 and V-8 diesel engines utilize SCR aftertreatment systems instead of LNT.

In the NPRM, NHTSA estimated incremental fuel consumption reduction for diesel engines with an SCR system to range from 11 to 20 percent at an incremental RPE cost of $2,051 to $2,411 compared to a direct injected turbocharged and downsized spark-ignition engine. These costs were based on a "bottom up" cost analysis that was performed with EPA, which then subtracted the costs of all previous steps on the decision tree prior to diesel engines.

As explained above for LNT, confidential manufacturer and non-confidential comment data submitted in response to the NPRM for diesel engines was in the range of 16.7 percent to 26.7 percent fuel consumption benefit over a baseline gasoline engine at variable cost of $2000 to $11200 with no detail about the aftertreatment, engine size or application. Additionally, Ricardo's vehicle simulation work for EPA found an

[170] Timothy V. Johnson, "Diesel Emission Control in Review," Society of Automotive Engineers Technical Series, 2008-01-0069, 2008. Available at http://www.sae.org/technical/papers/2008-01-0069 (last accessed Nov. 9, 2008).

incremental *fuel economy* benefit of 19 percent for a 4.8L diesel in a Large Truck.[171] However, when the baseline 4-speed automatic transmission shift and torque converter lockup scheduling was optimized for the diesel engine, an additional 5 percent fuel economy benefit was obtained to yield an incremental benefit for a diesel of 24 percent. As noted in the report on page 84, however, this does not represent an optimized result, as only the final packages complete with all technologies were optimized. Nevertheless, this is a reasonable estimate for diesel engine fuel economy benefit over a baseline gasoline engine with coordinated cam phasing (CCP). This estimate did not have the aftertreatment penalty, however, so applying the 5 percent penalty associated with diesel oxidation catalyst, diesel particulate filter, and SCR aftertreatment brings the fuel economy benefit for diesel engine with aftertreatment down to 19 percent, which is equal to a 16 percent *fuel consumption* benefit.

For purposes of the final rule, NHTSA estimated the net fuel consumption benefit for a V-6 diesel engine with SCR aftertreatment to be approximately 20 to 26 percent improvement over a baseline gasoline engine. This equates to a 4.0 to 7.7 percent improvement for DSLT, which is incremental to a turbocharged downsized gasoline engine (TRBDS) with EGRB, and a 9.9 to 13.1 percent incremental improvement for DSLC, which is incremental to a gasoline engine with combustion restart (CBRST.) The 2008 Martec report was relied upon for cost estimates and the diesel cost was adjusted by removing the downsizing credit and applying a 1.5 RPE marked up factor to arrive at a cost of $5603 compared to a baseline gasoline engine. This results in an incremental

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[171] Ricardo, "A Study of Potential Effectiveness of Carbon Dioxide Reducing Vehicle Technologies, Revised Final Report," Table 7-9 shows incremental fuel economy and CO2 benfits for Truck with technology package 11, p. 87. *Available at* http://www.epa.gov/otaq/technology/420r08004a.pdf (last accessed Oct. 4, 2008).

RPE cost of $3110 to $3495 for DSLT and $4105 to $4490 for DSLC. NHTSA's independent review concurred with all the costs in this bill-of-material-based cost analysis for V-6 engines.

NHTSA estimated the net fuel consumption benefit for a V-8 diesel engine with SCR aftertreatment to be approximately 19 to 25 percent improvement over a baseline gasoline engine. This equates to a 4.0 to 6.5 percent improvement for DSLT, which is incremental to a turbocharged downsized gasoline engine (TRBDS) with EGRB, and a 10.0 to 12.0 percent incremental improvement for DSLC, which is incremental to CBRST. The 2008 Martec report was relied upon for cost estimates and the diesel cost was adjusted by removing the downsizing credit and applying a 1.5 RPE marked up factor to arrive at a cost of $7002 compared to a baseline gasoline engine. This results in an incremental RPE cost of $3723 to $4215 for DSLT and $5125 to $5617 for DSLC. NHTSA's independent review concurred with all the costs in this bill-of-material-based cost analysis for V-8 engines.

The diesel engine with SCR has an incremental cost that is significantly higher for the final rule than the NPRM. NHTSA believes the increase is explained by the improved accuracy of the final rule analysis which relied on the updated cost estimates from the 2008 Martec Report as described previously[172]. In addition, comments from the Alliance suggested that the incremental diesel cost for a midsize car was $6198 and $7581[173] for a pickup truck.

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[172] Martec, "Variable Costs of Fuel Economy Technologies," June 1, 2008, at 13-20. Docket No. NHTSA-2008-0089-0169.1.

[173] These cost estimates are taken from the April 2008 Sierra Research report (Docket No. NHTSA-2008-089-0046). A June 2008 Sierra Research report (Docket No. NHTSA-2008-089-0179.1) contained lower estimates of $5,947 and $7,271 for the same vehicles; NHTSA was unable to discern the reason for the difference.

The economic breakeven point for diesel engine aftertreatment options is based on public information[174] and on recent discussions that NHTSA and EPA have had with auto manufacturers and aftertreatment device manufacturers. NHTSA explained in the NPRM that it had received strong indications that LNT systems would probably be used on smaller vehicles while the SCR systems would be used on larger vehicles and trucks. The economic break-even point between LNT and SCR is dependent on the quantity of catalyst used, the market price for the metals in those catalysts, and the cost of the urea injection system. The NPRM estimated that the breakeven point would occur around 3 liters engine displacement, based on discussions with auto manufacturers and aftertreatment device manufacturers. Thus, NHTSA tentatively concluded that it would be cheaper to manufacturer diesel engines smaller than 3 liters with an LNT system, and that conversely, it would be cheaper to manufacturer diesel engines larger than 3.0 liters with a SCR system. No comments were submitted to NHTSA regarding the breakeven point between a LNT and SCR system. However, according to one source of recently published data the breakeven point occurs between 2.0 to 2.5L.[175] Considering that continuing developments are being made in this area and the wide range of precious metal content required, NHTSA believes that an economic breakeven point of 2 to 3 liters is reasonable and that other factors will strongly influence which system is chosen by any given vehicle manufacturer.

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[174] Timothy V. Johnson, "Diesel Emission Control in Review," Diesel Engine-Efficiency and Emissions Research (DEER) Conference, Detroit, MI, August 20-24, 2006. *Available at* http://www1.eere.energy.gov/vehiclesandfuels/pdfs/deer_2006/session2/2006_deer_johnson.pdf (last accessed Nov. 9, 2008). *See also* Tim Johnson, "Diesel Engine Emissions and Their Control," Platinum Metals Review, 52, at 23-37 (2008). *Available at* http://www.platinummetalsreview.com/dynamic/article/view/52-1-23-37 (last accessed Nov. 9, 2008)

[175] *Id*.

Cummins commented that LNT systems should be considered for more than just the compact and subcompact vehicles, and stated that a number of large vehicles and trucks currently use LNT. Cummins argued that a LNT aftertreatment system can be a cost-effective technology on both small and larger engines. For the final rule, NHTSA assumed the use of a LNT aftertreatment system for three additional vehicle subclasses compared to the NPRM. However, following the rationale explained in the preceding paragraph, the SCR type aftertreatment system is assumed for larger vehicle subclasses. As is the case with all technologies in the analysis, technology application assumptions are based on the general understanding of what a manufacturer could do in response to meeting emissions compliance but other manufacturer specific factors will dictate the actual technology applications.

In the NPRM, NHTSA assumed a 3 percent phase in rate per year for diesel technologies. For the final rule, passenger cars, as defined by the technology class, retained the 3 percent combined (for DSLT and DSLC) phase-in cap per year. However, diesel technologies for truck technology classes were allowed to be applied at a 4 percent combined (for DSLT and DSLC) phase-in cap per year to account for the higher application rates observed in the submitted product plans and diesel's favorable characteristics in truck applications. Volume-based learning was assumed for the NPRM, however, confidential product plans indicated that this technology would be in high-volume in 2011 timeframe thus time-based learning was assumed for the final rule. For the final rule, diesel technologies can only be applied at redesign, which is consistent with the NPRM.

(c) Transmission Technologies

NHTSA has also reconsidered the way it applies transmission technologies in the Volpe model to obtain increased fuel savings. The revised decision tree for transmission technologies reflects the fact that baseline vehicles now include either 4- or 5-speed automatic transmissions, given that many manufacturers are already employing 5-speed automatic transmissions or are going directly to 6-speed automatics.[176] The decision tree in the final rule also combines “aggressive shift logic” and “early torque converter lockup,” although the NPRM considered them separately, because NHTSA concluded upon further review that the two technologies could be optimized simultaneously due to the fact that adding both of them primarily required only minor modifications to the transmission or calibration software. Cost and effectiveness numbers have also been thoroughly reexamined, as have learning rates and phase-in caps, based on comments received. The section below describes each of the transmission technologies considered.

(i) Improved Transmission Controls and Externals (IATC)

During operation, an automatic transmission’s controller manages the operation of the transmission by scheduling the upshift or downshift, and locking or allowing the torque converter to slip based on a preprogrammed shift schedule. The shift schedule contains a number of lookup table functions, which define the shift points and torque converter lockup based on vehicle speed and throttle position, and other parameters such as temperature. Aggressive shift logic (ASL) can be employed in such a way as to maximize fuel efficiency by modifying the shift schedule to upshift earlier and inhibit downshifts under some conditions, which reduces engine pumping losses and engine

[176] Confidential product plans indicate that future products manufactured within the rulemaking period may not go from 4- or 5-speed transmission, but will instead introduce 6- or 7-speed automatic transmissions as replacements.

friction as noted in the gas engine section. Early torque converter lockup[177] in conjunction with ASL can further improve fuel economy by locking the torque converter sooner, thus reducing inherent torque converter slippage or losses. As discussed above, the NPRM separated these two technologies, but they are combined for purposes of the final rule since the calibration software can be optimized for both functions simultaneously.

Calibrating the transmission shift schedule to improve fuel consumption reduces the average engine speed and increases the average engine load, which can lead to a perceptible increase in engine harshness. The degree to which the engine harshness can be increased before it becomes noticeable to the driver is strongly influenced by characteristics of the vehicle, and although it is somewhat subjective, it always places a limit on how much fuel consumption can be improved by transmission control changes. The Alliance agreed in its comments that ASL can be used effectively to reduce throttling losses, but at the expense of noise-vibration-harshness (NVH) and drivability concerns. The Alliance also commented that losses in the torque converter typically make automatic transmissions less efficient than manual transmissions, and suggested that efficiency can be improved by mechanically "locking up" the torque converter earlier or replacing the torque converter with a friction clutch of the type used on a manual transmission. Simply replacing a torque converter with a friction clutch, however, ignores the torque multiplication that torque converters provide at vehicle launch.

[177] Although only modifications to the transmission calibration software are considered as part of this technology, very aggressive early torque converter lock up may require an adjustment to damper stiffness and hysteresis inside the torque converter. Internal transmission hardware changes associated with this technology are addressed in 6/7/8-Speed Automatic Transmission with Improved Internals section.

In the NPRM, NHTSA estimated that aggressive shift logic could incrementally reduce fuel consumption by 1 to 2 percent at an incremental cost of $38 and early torque converter lockup could incrementally reduce fuel consumption by 0.5 percent at a $30 cost for the calibration effort. Confidential manufacturer comments suggested that less aggressive shift logic must be employed on vehicles with low acceleration reserve, but that a 1-3 percent improvement in fuel economy was attainable on vehicles with adequate acceleration reserve.

For the final rule, NHTSA combined aggressive shift logic and early torque converter lockup into the IATC technology with an effectiveness estimate of 1.5 to 2.5 percent in agreement with most confidential manufacturer estimates. As aggressive shift logic and early torque converter lockup are both achievable with a similar calibration effort, the incremental cost for improved automatic transmission controls used the higher value of $38, converted this value to 2007 dollars, and applied a 1.5 RPE markup factor to arrive at an incremental cost estimate of $59 for the final rule.

The IATC technology is considered to be available at the start of the 2011 model year, and as was the case in the NPRM, NHTSA considers that it can be applied during a refresh model year since NVH concerns must be addressed. The technology is applicable to all vehicle subclasses and NHTSA determined IATC type technologies will be high volume within the 2011 timeframe so time-based learning is assumed and a 100 percent phase-in cap is estimated for 2013 and subsequent model years.

(ii) Automatic 6-, 7- and 8-Speed Transmissions (NAUTO)

Having more "speeds" on a transmission (*i.e.*, having more gear ratios on the transmission) gives three effects in terms of vehicle performance and fuel economy. First, more gear ratios allow deeper 1st and 2nd gear ratios for improved launch performance, or increased acceleration. Second, a wider ratio spread also offers the ability to reduce the steps between gear ratios, which allows the engine to operate closer to optimum speed and load efficiency region. And third, a reduction in gear ratio step size improves internal transmission losses by reducing the sliding speeds across the clutches, thus reducing the viscous drag loss generated between two surfaces rotating at different speeds. Bearing spin losses are also reduced as the differential speed across the two bearing surfaces is reduced. This allows the engine to operate at a reduced load level to improve fuel economy.

Although the additional gear ratios improve shift feel, they also introduce more frequent shifting between gears, which can be perceived by consumers as bothersome. Additionally, package space limitations prevent 7- and 8-speed automatics from being applicable to front wheel drive vehicles.

Comparison between NPRM and final rule cost and effectiveness estimates are somewhat complicated by the revisions in the decision trees and technology assumptions. In the NPRM, NHTSA estimated that 6-, 7- and 8-speed transmissions could incrementally reduce fuel consumption by 0.5 to 2.5 percent at an incremental cost of $76 to $187, relative to a 5-speed automatic transmission, a technology not used in the final rule decision tree, and the incremental cost for a 4-speed to a 5-speed automatic transmission (again no longer considered in the final rule) was estimated to be $76 to $167.

In response to NHTSA's request for information, confidential manufacturer data projected that 6-speed transmissions could incrementally reduce fuel consumption by 0 to 5 percent from a baseline 4-speed automatic transmission, while an 8-speed transmission could incrementally reduce fuel consumption by up to 6 percent from a baseline 4-speed automatic transmission. The 2008 Martec report estimated a cost of $323 (RPE adjusted) for converting a 4-speed to a 6-speed transmission and a cost of $638 (RPE adjusted) for converting a 4-speed to an 8-speed transmission. GM has publicly claimed a fuel economy improvement of up to 4 percent for its new 6-speed automatic transmissions.[178] The 2008 EPA Staff Technical Report found a 4.5 to 6.5 percent fuel consumption improvement for a 6-speed over a 4-speed automatic transmission.[179]

For the final rule, NHTSA estimated that the conversion to a 6-,7- and 8-speed transmission (NAUTO) from a 4 or 5-speed automatic transmission with IATC would have an incremental fuel consumption benefit of 1.4 percent to 3.4 percent, for all vehicle subclasses. The 2008 Martec report, which quoted high volume, fully learned costs, was relied on to develop the final rule cost estimates. Subcompact, Compact, Midsize, Large Car and Minivan subclasses, which are typically considered normal performance passenger cars, are assumed to utilize a 6-speed automatic transmission only (as opposed to 7 or 8 speeds) resulting in an incremental RPE cost of $323 from Martec 2008. For Performance Subcompact, Performance Compact, Performance Midsize, Performance Large car and Small, Midsize and Large truck, where performance and or payload/towing

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[178] General Motors, news release, "From Hybrids to Six-Speeds, Direct Injection And More, GM's 2008 Global Powertrain Lineup Provides More Miles with Less Fuel" (released Mar. 6, 2007). *Available at http://www.gm.com/experience/fuel_economy/news/2007/adv_engines/2008-powertrain-lineup-082707.jsp* (last accessed Sept. 18, 2008).

[179] Page 17, "EPA Staff Technical Report: Cost and Effectiveness Estimates of Technologies Used to Reduce Light-duty Vehicle Carbon Dioxide Emissions" Environmental Protection Agency, EPA420-R-08-008, March 2008.

may be a larger factor, NHTSA assumed that 6-, 7- or 8-speed transmissions are applicable thus the incremental RPE cost range of \$323-\$638 was established which used the Martec 2008 six speed cost and 8-speed costs for the estimates.

This technology will be available from the start of the rulemaking period. Confidential manufacturer data indicates the widespread use of 6-speed or greater automatic transmissions and introductions into the fleet occur primarily at vehicle redesign cycles. This prompted NHTSA to increase the phase-in rates allowing 100 percent application by 2013 but also to consider that the technology can only be applied at a redesign cycle, as opposed to the refresh cycle application of the NPRM. The technology is determined to be at high volume in the 2011 timeframe, and since these are mature and stable technologies, time-based learning factors are applied.

(iii) Dual Clutch Transmissions / Automated Manual Transmissions (DCTAM)

An automated manual transmission (AMT) is similar in architecture to a conventional manual transmission, but shifting and launch functions are performed through hydraulic or electric actuation. There are two basic types of AMTs, single-clutch and dual-clutch transmission (DCT), both of which were considered in the NPRM. Upon further consideration and in response to manufacturer comments to only include dual-clutch AMTs, single-clutch AMTs are not applied in the analysis for the final rule.

Single clutch transmissions exhibit a torque interruption when changing gears because the clutch has to be disengaged. In a conventional manual transmission vehicle, the driver has initiated the gear change, and so expects to feel the resulting torque interruption. With an AMT, in contrast, a control system initiates the shift, which is unexpected and can be disconcerting to the driver. Comments from Ford in response to the NPRM indicated that the acceptability of this torque interruption among U.S. drivers is poor, although Ford also commented that DCTs do not have the risk of customer acceptance that AMTs do. BorgWarner, a DCT supplier, echoed these comments. DCTs do not display the torque interrupt characteristic due to their use of two clutch mechanisms which allow for uninterrupted power transmission. To assist with launch of a DCT equipped vehicle, the first gear ratio can be deepened to gain back some of the performance advantage an automatic transmission possesses due to the torque converter's torque multiplication factor.

There are two types of DCT systems, wet clutch and dry clutch, which are used for different types of vehicles. Wet clutch DCTs offer a higher torque capacity that comes from the use of a hydraulic system that cools the clutches, but that are less efficient than the dry clutch type due to the losses associated with hydraulic pumping. Additionally, wet DCTs have a higher cost due to the additional hydraulic hardware required. Wet clutch DCT systems have been available in the U.S. market on imported products since 2005, and Chrysler has publicly stated that it will have a DCT transmission in its 2010 model year vehicle line-up.[180]

Consistent with manufacturers' confidential comments and based on its own analysis, NHTSA determined that dry clutch DCTs are applicable to smaller front wheel drive cars, due to their lower vehicle weight and torque production, and wet clutch DCTs are more applicable to higher torque applications with higher power requirements. Therefore lower cost, higher efficiency dry clutch DCTs are specified for the Subcompact

[180] Chrysler blog, "Dual-Clutch Transmissions Explained" (released October 3, 2007) available at http://blog.chryslerllc.com/blog.do?p=entry&id=113, last accessed September 18, 2008.

and Compact Car vehicle classes, while all other classes required wet clutch DCTs.

In the NPRM, NHTSA estimated that the incremental cost for DCTs was $141, independent of vehicle class, which was the midpoint of the NESCCAF estimates and within the range provided confidential manufacturer data. CARB commented that NHTSA had incorrectly cited the cost of AMTs from the NESCCAF study in the NPRM, stating that AMTs had been determined to be cost neutral (zero cost) relative to baseline transmission, as opposed to a $0-$240 cost justification. Confidential manufacturer data suggest additional DCT costs from $80 to $740, with dry clutch DCT costs being approximately $100 less due to reduced hydraulic system content. The 2008 Martec study also reported variable costs for AMTs.

In the NPRM, NHTSA cited the NESCCAF study as projecting that AMTs could incrementally reduce fuel consumption by 5 to 8 percent and confidential manufacturer data projected that AMTs could incrementally reduce fuel consumption by 2 to 5 percent. On the basis of these estimates, NHTSA concluded in the NPRM that AMTs could incrementally reduce fuel consumption by 4.5 to 7.5 percent. Confidential manufacturer data received in response to the NPRM suggest a benefit of 2 to 12 percent for DCTs over a 6-speed planetary automatic, and one confidential manufacturer estimates a benefit of 1 to 2 percent for a dry clutch DCT over a wet clutch DCT. The 2008 EPA Staff Technical Report also indicates a benefit of 9.5 to 14.5 percent for a DCT (wet or dry was not specified) over a 4-speed planetary automatic transmission.

For the final rule, NHTSA estimated a 5.5 to 9.5 percent improvement in fuel consumption over a baseline 4/5-speed automatic transmission for a wet clutch DCT, which was assumed for all vehicle subclasses except Subcompact and Compact Car. This results in an incremental effectiveness estimate of 2.7 to 4.1 percent over the NAUTO technology. For Subcompact and Compact Cars, which were assumed to use a dry clutch DCT, NHTSA estimated an 8 to 13 percent fuel consumption improvement over a baseline 4/5-speed automatic transmission, which equates to a 5.5 to 7.5 percent incremental improvement over the NAUTO technology.

The 2008 Martec report was utilized to develop the cost estimates for the final rule; it estimated an RPE cost of $450 for a dry clutch DCT, and $600 for a wet clutch DCT, both relative to a baseline 4/5-speed. In the transmission decision tree for the final rule, this yielded a dry clutch DCT incremental cost estimate of $68 for the Subcompact and Compact Cars relative to the NAUTO technology. For Midsize, Large Car and Minivan classes the wet clutch DCT incremental cost over NAUTO is $218, which reflects the lower, 6-speed only cost of the NAUTO technology applied to these vehicles. The average incremental cost for wet DCT for the four Performance classes and the Small, Midsize and Larger truck is $61, which is lower than the other vehicle subclasses due to the higher cost NAUTO technology (up to 8-speeds) that the DCTAM technology supersedes.

NHTSA relied upon confidential manufacturer product plans showing DCT production will be readily available and at high volume by 2011. Therefore volume-based learning is not applicable, and since this is a mature and stable technology, time-based learning is applied. As production facility conversion or construction may be required to facilitate required capacity, NHTSA limited production phase-in caps in 2011 and 2012 to 20 and 50 percent, respectively, with a phase-in cap of 100 percent by 2013.

As with other transmission technologies, application was allowed at redesign only due to the vehicle changes required to adapt a new type transmission.

(iv) Continuously Variable Transmission (CVT)

A continuously variable transmission (CVT) is unique in that it does not use gears to provide ratios for operation. Most CVTs use either a belt or chain on a system of two pulleys (the less common toroidal CVTs replace belts and pulleys with discs and rollers) that progressively vary the ratio, thus permitting an infinite number of effective gear ratios between a maximum and minimum value, and often a wider range of ratios than conventional automatic transmissions. This enables even finer optimization of the transmission ratio under different operating conditions and, therefore, some reduction of engine pumping and friction losses. In theory, the CVT has the ability to be the most fuel-efficient kind of transmission due to the infinite ability to optimize the ratio and operate the engine at its most efficient point. However, this effectiveness is reduced by the significant internal losses from high-pressure, high-flow-rate hydraulic pump, churning, friction loss, and bearing losses required to generate the high forces needed for traction.[181]

Some U.S. car manufacturers have abandoned CVT applications because they failed to deliver fuel economy improvements over automatic transmissions. GM abandoned the use of CVT before 2006.[182] Ford offered a CVT in the Five Hundred and Freestyle from MYs 2005-2007 and discontinued it thereafter. However, Chrysler offers

[181] "Transmission and Driveline – Major contributors to FUEL efficiency, safety, fun to drive and brand differentiation", Car Training Institute Symposium, May 6-7, 2008- Plenary Speech, Robert Lee, Vice President, Mircea Gradu, Director Transmission and Driveline, Chrysler LLC, USA. Available from the Car Training Institute, for contact information *see* http://www.car-training-institute.com/cti_en/html/kontakt.html (last accessed Nov. 9, 2008).

[182] *See* http://car-reviews.automobile.com/news/general-motors-to-kill-continually-variable-transmission/166/ (last accessed Oct. 23, 2008).

CVTs in the Dodge Caliber, the Jeep Compass, and the Jeep Patriot. Nissan was using CVTs in many vehicles, but appears to be restricting the use of this technology to passenger cars only.

In the NPRM, NHTSA estimated a CVT effectiveness of approximately 6 percent over a 4-speed automatic, which was above the NESCCAF value but in the range of NAS. For costs, NHTSA concluded in the NPRM that the adjusted costs presented in the 2002 NESCCAF study represent the best available estimates, and thus estimated that CVTs could incrementally reduce fuel consumption by 3.5 percent when compared to a conventional 5-speed automatic transmission (which cost an incremental \$76 - \$167), a technology which is considered a baseline transmission option on the final rule decision tree, at an incremental cost of \$100 to \$139. After reviewing confidential manufacturer data and the Martec report, for the final rule NHTSA is now estimating the incremental cost of CVTs to be \$300 for all vehicle subclasses, except for large performance cars, midsize light trucks and large light trucks for which the technology is incompatible.

Confidential manufacturer data in response to the NPRM suggested that the incremental effectiveness estimate from CVTs may be 2 to 8 percent over 4-speed planetary transmissions in simulation (however one commenter reported a zero percent improvement in dynamometer testing) at a cost of \$140 to \$800. Considering the NPRM conclusion and confidential data together with independent review, NHTSA has estimated the fuel consumption effectiveness for CVTs at 2.2 to 4.5 percent over a 4/5-speed automatic transmission, which translates into a 0.7 to 2.0 incremental effectiveness improvement over the IATC technology. NHTSA estimated the CVT incremental cost to be \$300 for the final rule, noting that the NPRM costs were incremental to a 5-speed technology that is no longer represented in the decision tree, hence the higher final rule cost.[183]

CVTs are currently available, but due to their limited torque-carrying capability, they are not applied to Performance Large cars and Midsize and Large trucks. There is limited production capability for CVTs, so phase-in caps are limited through the 2011-2015 timeframe to account for new plants and tooling to be prepared. CVTs reach a phase-in cap of 80 percent by 2015. CVTs can be introduced at product redesign intervals only based on confidential manufacturer data and consistent with the NPRM approach (since it requires vehicle attribute prove-out, test and certification prior to introduction). Confidential manufacturer data indicates that CVTs will be at high volumes by 2011, and this is a mature and stable technology, therefore NHTSA applied time-based learning factors.

(v) 6-Speed Manual Transmissions (6MAN)

Manual transmissions are entirely dependent upon driver input to change gear ratio: the driver selects when to perform the shift and which gear ratio to select. This is the most efficient transfer of energy of all transmission layouts, because it has the lowest internal gear losses, with a minimal hydraulic system, and the driver provides the energy to actuate the clutch. From a systems viewpoint, however, vehicles with manual transmissions have the drawback that the driver may not always select the optimum gear ratio for fuel economy. Nonetheless, increasing the number of available ratios in a manual transmission can improve fuel economy by allowing the driver to select a ratio that optimizes engine operation more often. Typically, this is achieved through adding

[183] Since the decision trees are configured differently, the net cost to CVT in the NPRM included 5-speed automatic transmission technology costs that are not applied in the final rule.

overdrive ratios to reduce engine speed at cruising velocities (which saves fuel through reduced pumping losses) and pushing the torque required of the engine towards the optimum level. However, if the gear ratio steps are not properly designed, this may require the driver to change gears more often in city driving resulting in customer dissatisfaction. Additionally, if gear ratios are selected to achieve improved launch performance instead of to improve fuel economy, then no fuel saving effectiveness is realized.

NHTSA recognizes that while the manual transmission is very efficient, its effect on fuel consumption relies heavily upon driver input. In driving environments where little shifting is required, the manual transmission is the most efficient because it has the lowest internal losses of all transmissions. However, the manual transmission may have lower fuel efficiency on a drive cycle when drivers shift at non-optimum points.

In the NPRM, NHTSA estimated that a 6-speed manual transmission could incrementally reduce fuel consumption by 0.5 percent when compared to a 5-speed manual transmission, at an incremental cost of $107. Confidential manufacturer data received in response to the NPRM suggests that manual transmissions could incrementally reduce fuel consumption by 0 to 1 percent over a base 5-speed manual transmission at an incremental cost of $40 to $900. Most confidential comments suggested that the incremental cost was within the lower quartile of the full range, thus $225 (the lower quartile upper-bound) was multiplied by the 1.5 RPE markup factor for a total of $338. Therefore, the final rule states that the incremental fuel consumption effectiveness for a 6-speed manual transmission over a 5-speed manual transmission is 0.5 percent at a RPE cost of $338.

This technology is applicable to all vehicle classes considered and can be introduced at product redesign intervals, consistent with the NPRM and other final rule transmission technologies. Six-speed manuals are already in production at stable and mature high volumes so time-based learning is applied with a phase-in cap of 100 percent by 2013.

(d) Hybrid and Electrification/Accessory Technologies

(i) Overview

A hybrid describes a vehicle that combines two or more sources of energy, where one is a consumable energy source (like gasoline) and one is rechargeable (during operation, or by another energy source). Hybrids reduce fuel consumption through three major mechanisms: (1) by turning off the engine when it is not needed, such as when the vehicle is coasting or when stopped; (2) by recapturing lost braking energy and storing it for later use; and by (3) optimizing the operation of the internal combustion engine to operate at or near its most efficient point more of the time. A fourth mechanism to reduce fuel consumption, available only to plug-in hybrids, is by substituting the fuel energy with energy from another source, such as the electric grid.

Engine start/stop is the most basic of hybrid functions, and as the name suggests, the engine is shut off when the vehicle is not moving or when it is coasting, and restarted when needed. This saves the fuel that would normally be utilized to spin the engine when it is not needed. Regenerative braking is another hybrid function which allows some of the vehicle’s kinetic energy to be recovered and later reused, as opposed to being wasted as heat in the brakes. The reused energy displaces some of the fuel that would normally be used to drive the vehicle, and thus results in reduced fuel consumption.

Operating the engine at its most efficient operating region more of the time is made possible by adding electric motor power to the engine's power so that the engine has a degree of independence from the power required to drive the vehicle. Fuel consumption is reduced by more efficient engine operation, the degree of which depends heavily on the amount of power the electric motor can provide. Hybrid vehicles with large electric motors and battery packs can take this to an extreme and drive the wheels with electric power only and the engine consuming no fuel. Plug-in hybrid vehicles can substitute fuel energy with electrical energy, further reducing the fuel consumption.[184]

Hybrid vehicles utilize some combination of the above mechanisms to reduce fuel consumption. The effectiveness of a hybrid, and generally the complexity and cost, depends on the utilization of the above mechanisms and how aggressively they are pursued.

In addition to the purely hybrid technologies, which decrease the proportion of propulsion energy coming from the fuel by increasing the proportion of that energy coming from electricity, there are other steps that can be taken to improve the efficiency of auxiliary functions (*e.g.*, power-assisted steering or air-conditioning) which also reduce fuel consumption. These steps, together with the hybrid technologies, are collectively referred to as "vehicle electrification" because they generally use electricity instead of engine power. Three "electrification" technologies are considered in this analysis along with the hybrid technologies: electrical power steering (EPS), improved accessories (IACC), and high voltage or improved efficiency alternator (HVIA).

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[184] Substituting fuel energy with electrical energy may not actually save total overall energy used, when considering the inefficiencies of creating the electricity at a power plant and storing it in a battery pack, but it does enable use of other primary energy sources, and reduces the vehicle's fuel consumption. Plug-in hybrids are also receiving increasing attention because of their ability to use "clean energy" from the electric grid, such as that solar or wind, which can reduce the overall greenhouse gas output.

(ii) Hybrid System Sizing and Cost Estimating Methodology

Estimates of cost and effectiveness for hybrid and related electrical technologies have been adjusted from those described in the NPRM to address commenters' concerns that NHTSA considered technologies not likely to be adopted by automakers (*e.g.*, 42V electrical systems) or did not scale the costs for likely technologies across the range of vehicle subclasses considered. To address these concerns, the portfolio of vehicle electrification technologies has been refined based on commenter data as described below in the individual hybrid technologies sections. Ricardo and NHTSA have also developed a "ground-up" hybrid technology cost estimating methodology and, where possible, validated it to confidential manufacturer data. The hybrid technology cost method accounts for variation in component sizing across both the hybrid type and the vehicle platform. The method utilizes four pieces of data: (1) key component sizes for a midsize car by hybrid system type; (2) normalized costs for each key component; (3) component scaling factors that are applied to each vehicle subclass by hybrid system type; and (4) vehicle characteristics for the subclasses which are used as the basis for the scaling factors.

Component sizes were estimated for a midsize car using publicly available vehicle specification data and commenter data for each type of hybrid system as shown in Table IV-10.

Table IV-10. Component Sizes by Hybrid Type for a Midsize Car

Component	Hybrid Type				
	MHEV	ISG	PSHEV	2MHEV	PHEV
Primary Motor power, continuous (kW)	3	11	45	45	45
Secondary Motor power, continuous (kW)	na	na	30	45	30
Primary Inverter power, continuous (kW)	3	11	45	45	45
Secondary Inverter power, continuous (kW)	na	na	30	45	30
Controls complexity (relative to strong hybrid)	25%	50%	100%	100%	100%
NiMH Battery Pack capacity (kW-hr)	na	1	2	2	na
Li-Ion Battery Pack capacity (kW-hr)	na	na	na	na	15
DC/DC Converter power (kW)	0.7	3	3	3	3
High Voltage Wiring (relative to strong hybrid)	na	50%	100%	100%	100%
Supplemental heating	Yes	Yes	Yes	Yes	Yes
Mechanical Transmission (relative to baseline vehicle)	100%	100%	50%	100%	25%
Electric AC	No	No	Yes	Yes	Yes
Blended Brakes	No	No	Yes	Yes	Yes
Charger power, continuous (kW)	na	na	na	na	3

In developing Table IV-10, NHTSA made several assumptions:

1) Hybrid controls hardware varies with the level of functionality offered by the hybrid technology. Assumed hybrid controls complexity for a 12V micro hybrid (MHEV) was 25 percent of a strong hybrid controls system and the complexity for an Integrated Starter Generator (ISG) was 50 percent. These ratios were estimates based on the directional need for increased functionality as system complexity increases.

2) In the MY 2011-2015 time frame, Li-ion battery packs will have limited market penetration, with a majority of hybrid vehicles using NiMH batteries. One estimate from Anderman indicates that Li-ion market penetration will achieve 35 percent by 2015.[185] For the purposes of this analysis, it was assumed that mild and strong hybrids will use NiMH batteries and plug-in hybrids will use Li-ion batteries.

3) The plug-in hybrid battery pack was sized for a mid-sized car by assuming: the vehicle has a 20 mile all electric range and consumes an average of 300

[185] Anderman, Advanced Automotive Battery Conference, May 2008. Proceedings available for purchase at http://www.advancedautobat.com/Proceedings/index.html (last accessed October 17, 2008).

W-hr per mile; the battery pack can be discharged down to 50 percent depth of discharge; and the capacity of a new battery pack is 20 percent greater than at end of life (i.e. range on a new battery pack is 24 miles).

4) All hybrid systems included a DC/DC converter which was sized to accommodate vehicle electrical loads appropriate for increased vehicle electrification in the 2011 to 2015 time frame.
5) High voltage wiring scaled with hybrid vehicle functionality and could be represented as a fraction of strong hybrid wiring. These ratios were estimates based on the directional need for increased functionality as system complexity increases.
6) All hybrid systems included a supplemental heater to provide vehicle heating when the engine is stopped, however, only stronger hybrids included electric air conditioning to enable engine stop/start when vehicle air conditioning was requested by the operator.

In the hybrid technology cost methodology developed for cost-scaling purposes, several strong hybrid systems replaced a conventional transmission with a hybrid-specific transmission, resulting in a cost offset for the removal of a portion of the clutches and gear sets within the transmission. The transmission cost in Table IV-11 below expresses hybrid transmission costs as a percentage of traditional automatic transmission cost, as described in the 2008 Martec Report, at $850. The method assumed that the mechanical aspect of a power-split transmission with a reduced number of gear sets and clutches resulted in a cost savings of 50 percent of a conventional transmission with torque converter. For a 2-mode hybrid, the mechanical aspects of the transmission are similar in complexity to a conventional transmission with a torque converter, thus no mechanical cost savings was appropriate. The plug-in hybrid assumed a highly simplified transmission for electric motor drive, thus 25 percent of the base vehicle transmission cost was applied.

Estimates for the cost basis of each key component are shown in Table IV-11 below along with the sources of those estimates. The cost basis estimates assume fully learned, high-volume (greater than 1.2 million units per annum) production. The costs shown are variable costs that are not RPE adjusted.

Table IV-11. Component Cost Basis at High Volumes and Data Sources

Component	Cost Basis	Data Source
Primary Motor ($/kW)	$ 15	Martec 2008
Secondary Motor ($/kW)	$ 15	
Primary Inverter ($/kW)	$ 10	Confidential business information
Secondary Inverter ($/kW)	$ 10	
Controls	$ 100	
NiMH Battery Pack ($/kW-hr.)	$ 50	Attorneys General/Anderman comments (NHTSA-2008-089-0199.5)
Li-Ion Battery Pack ($/kW-hr.)	$ 600	Anderman, AABC 2008 ($900/kW-hr @ 2000 units/yr learned and rounded)
DC/DC Converter	$ 100	Confidential business information
High Voltage Wiring	$ 250	Martec 2008
Supplemental heating	$ 84	
Mechanical Transmission	$ 850	Martec 2008 (to 4-spd. Auto.)
Electric AC	$ 450	Confidential business information
Blended Brakes	$ 400	Martec 2008
Charger	$ 100	Confidential business information
Automatic Transmission pump	$ 75	Martec 2008

Component scaling factors were determined based on vehicle characteristics for each type of hybrid system as shown in Table IV-12 below.

Table IV-12. Component Scaling Factors applied to Vehicle Class for each Hybrid System Type

<table>
<tr><th rowspan="2">Component</th><th colspan="5">Hybrid Type</th></tr>
<tr><th>MHEV</th><th>ISG</th><th>PSHEV</th><th>2MHEV</th><th>PHEV</th></tr>
<tr><td>Primary Motor</td><td>Engine displacement</td><td>Curb weight</td><td colspan="2">Curb weight[1]</td><td>Engine power</td></tr>
<tr><td>Secondary Motor</td><td>na</td><td>na</td><td colspan="2">Engine displacement</td><td>Vehicle mass[2]</td></tr>
<tr><td>Primary Inverter</td><td colspan="5">Primary motor power</td></tr>
<tr><td>Secondary Inverter</td><td>na</td><td>na</td><td colspan="3">Secondary motor power</td></tr>
<tr><td>Controls</td><td colspan="5">Complexity</td></tr>
<tr><td>NiMH Battery Pack</td><td>na</td><td colspan="3">Vehicle mass</td><td>na</td></tr>
<tr><td>Li-Ion Battery Pack</td><td>na</td><td>na</td><td>na</td><td>na</td><td>Vehicle mass</td></tr>
<tr><td>DC/DC Converter</td><td colspan="5">Vehicle mass[3]</td></tr>
<tr><td>High Voltage Wiring</td><td>na</td><td colspan="4">Vehicle footprint</td></tr>
<tr><td>Supplemental heating</td><td colspan="5">Vehicle footprint</td></tr>
<tr><td>Mechanical Transmission</td><td colspan="5">Same for all vehicle classes</td></tr>
<tr><td>Electric AC</td><td>na</td><td>na</td><td colspan="3">Vehicle footprint</td></tr>
<tr><td>Blended Brakes</td><td>na</td><td>na</td><td colspan="3">Same for all vehicle classes</td></tr>
<tr><td>Charger</td><td>na</td><td>na</td><td>na</td><td>na</td><td>Same for all vehicle classes</td></tr>
</table>

(1) For all vehicle classes except for performance classes which use Engine Torque

(2) Vehicle mass used as surrogate for vehicle road load

(3) Vehicle mass used as surrogate for vehicle electrical load

NHTSA’s CAFE database was used to define the average vehicle characteristics for each vehicle subclass as shown in Table IV-13 below, and these attributes were used as the basis of the scaling factors.

Table IV-13. Key Vehicle Characteristics For Each Vehicle Class

Vehicle Subclass	Curb Weight (lbs)	Footprint (ft2)	Engine Disp. (L)	Power (hp)	Torque (ft-lb)
Subcompact Car	2795	41	1.9	134	133
Compact Car	3359	44	2.2	166	167
Midsize Car	3725	47	2.9	205	206
Large Car	4110	50	3.4	258	248
Performance Subcompact Car	3054	40	2.7	260	260
Performance Compact Car	3516	44	3.0	269	260
Performance Midsize Car	3822	47	3.9	337	318
Performance Large Car	4189	51	4.8	394	388
Minivan	4090	50	3.3	247	242
Small Truck	3413	45	2.6	178	185
Medium Truck	4260	50	3.6	250	256
Large Truck	5366	63	5.0	323	352

Table IV-14 shows the costs for the different types of hybrid systems on a midsize vehicle. The individual component costs were scaled from the normalized costs shown in Table IV-11 according to the component size shown in Table IV-10 and adjusted to a low volume cost by backing out volume-based learning reductions.[186] These component costs were summed to get the total low volume cost for each hybrid type, and a 1.5 RPE adjustment was applied. The ISG technology replaces the MHEV technology on the Electrification/Accessory technology decision tree, therefore the MHEV technology costs must be subtracted to reflect true costs ($2,898 - $707 = $2,191 in this example).

Wherever possible, the results of the hybrid technology cost method were compared with values as previously described in the NPRM and the results generally matched prior estimates. Additionally, the results from the hybrid technology cost method were validated with public literature and confidential manufactures test data as

[186] High volume costs are multiplied by a factor of 1.56, which represents two cycles of 20 percent reverse learning, to determine the appropriate low volume, or unlearned costs.

allowed. Elements of the 2008 Martec report identified cost data and a detailed bill of materials for several comparable hybrid technologies (Micro-hybrid systems and Full Hybrid systems), and the hybrid technology cost model agreed well with this data. The scalable bill of material based methodology described above was determined to offer the best solution for estimating component sizes and costs across a range of hybrid systems and vehicle platforms and the validation of these cost outputs with other data sources suggests that this approach is a reasonable approach.

Table IV-14. Hybrid System - Midsize Vehicle Low Volume Costs

Component	Hybrid Type Low Volume (Unlearned) Costs				
	MHEV	**ISG***	**PSHEV**	**2MHEV**	**PHEV**
Primary Motor [Example: MHEV = 3KW * 15$/KW * 1.56 (vol uplift)]	$ 70	$ 263	$ 1,053	$ 1,053	$ 1,755
Secondary Motor	$ -	$ -	$ 702	$ 1,053	$ 702
Primary Inverter	$ 47	$ 176	$ 702	$ 702	$ 1,170
Secondary Inverter	$ -	$ -	$ 468	$ 702	$ 468
Controls	$ 39	$ 78	$ 156	$ 156	$ 156
NiMH Battery Pack	$ -	$ 546	$ 1,092	$ 1,092	$ -
Li-Ion Battery Pack	$ -	$ -	$ -	$ -	$ 14,040
DC/DC Converter	$ 109	$ 468	$ 468	$ 468	$ 468
High Voltage Wiring	$ -	$ 195	$ 390	$ 390	$ 390
Supplemental heating	$ 131	$ 131	$ 131	$ 131	$ 131
Mechanical Transmission	$ -	$ -	$ (663)	$ -	$ (995)
Electric AC	$ -	$ -	$ 702	$ 702	$ 702
Blended Brakes	$ -	$ -	$ 624	$ 624	$ 624
Charger	$ -	$ -	$ -	$ -	$ 468
Automatic transmission pump	$ 75	$ 75	$ -	$ -	$ -
Total Hybrid System Cost @ Low Volume	$ 471	$ 1,932	$ 5,825	$ 7,073	$ 20,080
RPE (1.5) System Cost @ Low Volume	***$ 707***	***$ 2,898***	***$ 8,738***	***$ 10,610***	***$ 30,119***

* ISG replaces the MHEV technology on the Accessory/Electrification Decision Tree

(iii) Electrical Power Steering (EPS)

Electrical Power Steering (EPS) is advantageous over conventional hydraulic power-assisted steering in that it only draws power when the vehicle is being steered, which is typically a small percentage of the time a vehicle is operating. In fact, on the EPA test cycle no steering is done, so the CAFE fuel consumption effectiveness comes about by eliminating the losses from driving the hydraulic steering pump at engine speed. EPS systems use either an electric motor driving a hydraulic pump (this is a subset of EPS systems known as electro-hydraulic power steering) or an electric motor directly assisting in turning the steering column. EPS is seen as an enabler for all vehicle hybridization technologies, since it provides power steering when the engine is off. This was a primary consideration in placing EPS at the top of the Electrification/Accessory decision tree.

In the NPRM, NHTSA estimated the fuel consumption effectiveness for EPS at 1.5 to 2 percent at an incremental cost of $118 to $197, believing confidential manufacturer data most accurate. In response to the NPRM Sierra Research suggested EPS and high efficiency alternators combined is worth 1 to 1.8 percent on the CAFE test cycle,[187] and confidential manufacturer data indicated a 0.7 to 2.9 percent fuel consumption reduction. The cost range from confidential manufacturer data was $70 to $300. Sierra estimated EPS for cars at $82 and $150 for trucks.[188] A market study by Frost & Sullivan indicated the cost of an EPS system at roughly $65 more than a conventional hydraulic (HPS) system.[189] Because there is a wide range in the effectiveness for EPS depending on the vehicle size, NHTSA has increased the range from the NPRM to incorporate the lower ranges suggested by most manufacturers and estimates the fuel consumption effectiveness for EPS at 1 to 2 percent for the purpose of the final rule. The incremental costs are also estimated on range below the Sierra value for cars but above the Frost & Sullivan estimate at a piece cost range of $70 to $80 and included a 1.5 RPE uplift to $105 to $120 for the final rule.

EPS is currently in volume production in small to mid-sized vehicles with a standard 12V electrical system; however, heavier vehicles may require a higher voltage system, which adds cost and complexity. The Chevy Tahoe Hybrid, for example, uses a

[187] Docket No. NHTSA-2008-0089-0179.1, Attachment 2, at 53.
[188] Docket No. NHTSA-2008-0089-0179.1, Attachment 2, at 59.
[189] Cost for EPS quoted at 48 Euros, at $1.35 per Euro exchange rate (Oct. 7, 2008) equates to $65, from Frost & Sullivan, Feb. 9, 2006 "Japanese Steering System Market Moves Into High Gear," http://www.theautochannel.com/news/2006/02/09/210036.html (last accessed Nov. 2, 2008).

higher voltage EPS system. For purposes of the final rule, NHTSA has applied EPS to all vehicle subclasses except for Large trucks.

In the NPRM, NHTSA assumed a 25 percent phase in rate of EPS technologies. For the purposes of the final rule, EPS phase-in caps were limited to 10 percent in MY 2011 to address confidential manufacturer concerns over lead time and increased to 25 percent in MY 2012 and following until 100 percent is reached. In the NPRM, NHTSA assumed a volume-based learning effect for EPS. For the final rule, however, NHTSA applied time-based learning for EPS since NHTSA's analysis indicated that this technology would be in high-volume use at the beginning of its first year of availability. NHTSA also assumed in the NPRM that EPS could be applied during refresh model years, which was consistent with information provided in confidential product plans, therefore for the purpose of the final rule, NHTSA again applied EPS at refresh timing.

(iv) Improved Accessories (IACC)

Improved accessories (IACC) was defined in the NPRM as improvements in accessories such as the alternator, coolant and oil pumps that are traditionally driven by the engine. Improving the efficiency or outright electrification of these accessories would provide opportunity to reduce the accessory loads on the engine. However, as the oil pump provides lubrication to the engine's sliding surfaces such as bearings pistons, and camshafts and oil flow is always required when the engine is spinning, and it is only supplied when the engine is spinning, there is no efficiency to be gained by electrifying the oil pump.[190]

[190] Oil pump electrification comes with an additional potential technical and financial risk (to warranty and consumer), in that significant engine damage can occur should the system fail to provide engine lubrication, even on a momentary basis.

Electrical air conditioning (EAC) could reduce fuel consumption by allowing the engine to be shut off when it is not needed to drive the vehicle. For this reason EAC is often used on hybrid vehicles. In highway driving, however, there is little opportunity to shut the engine off; furthermore EAC is less efficient when the engine is running because it requires mechanical energy from the engine to be converted to electrical energy and then back again to mechanical. Since air conditioning is not required on the EPA city or highway test cycles, there is no CAFE fuel consumption effectiveness from EAC. Therefore, EAC does not improve accessory efficiency apart from the hybrid technologies. For the purposes of the final rule, IACC refers strictly to improved engine cooling, since electrical lubrication and air conditioning are not effective stand-alone fuel saving technologies and improved alternator is considered as a separate technology given its importance to vehicle electrification.

Improved engine cooling, or intelligent cooling, can save fuel through two mechanisms: by reducing engine friction as the engine warms up faster; and by operating an electric coolant pump at a lower speed than the engine would (*i.e.*, independent of engine speed). Intelligent cooling can be applied to vehicles that do not typically carry heavy payloads. Larger vehicles with towing capacity present a challenge for electrical intelligent cooling systems, as these vehicles have high cooling fan loads. Therefore NHTSA did not apply IACC to the Large Truck and SUV class.

In the NPRM, NHTSA estimated the fuel consumption effectiveness for improved accessories at 1 to 2 percent at an incremental cost of $124 to $166 based on the 2002 NAS Report and confidential manufacturer data. Confidential manufacturer data received in response to the NPRM and Sierra Research both suggested a range for fuel consumption effectiveness from 0.5 to 2 percent. A comment from MEMA suggested that improved thermal control of the engine could produce between 4 and 8 percent fuel economy improvement;[191] however, NHTSA's independent review of intelligent cooling suggests this estimate is high and concurs with the estimates from NAS. Independent review found the cost for IACC at low volumes, assuming the base vehicle already has an electric fan, to be $180 to $220. These costs were adjusted to account for volume-based learning and then marked up to account for the 1.5 RPE factor. For the purposes of the final rule, NHTSA retained the fuel consumption effectiveness at 1 to 2 percent and estimated the incremental costs to be $173 to $211.

MEMA also suggested that NHTSA consider solar glass technology to reduce cabin thermal loading; however, air conditioning technologies were not considered as part of this technology.

In the NPRM, NHTSA proposed a 25 percent phase-in cap for Improved Accessories. To address manufacturer concerns over lead time in the early years, IACC phase-in cap was limited to 10 percent in MY 2011 and increased to 20 percent in MYs 2012 and 2013, then 25 percent in MYs 2014 and 2015 for the final rule. In the NPRM, NHTSA assumed for improved accessories a volume-based learning curve. For the final rule, however, NHTSA applied time-based learning for IACC since NHTSA's analysis indicated that this technology would be in high-volume use at the beginning of its first year of availability. NHTSA assumed in the NPRM that improved accessories could be applied during any model year. For the purpose of the final rule, NHTSA applied intelligent cooling at refresh model years due to the significant changes required to the vehicle cooling system that necessitate recertification testing.

[191] Docket No. NHTSA-2008-0089-0193.1.

(v) 12V Micro Hybrid (MHEV)

12V Micro-Hybrid (MHEV) systems are the most basic of hybrid systems and offer mainly idle-stop capability. Their low cost and easy adaptability to existing powertrains and platforms can make them attractive for some applications. The conventional belt-driven alternator is replaced with a belt-driven, enhanced power starter-alternator and a redesigned front-end accessory drive system that facilitates bi-directional torque application. Also, during idle-stop, some functions such as power steering and automatic transmission hydraulic pressure are lost with conventional arrangements; so electric power steering and an auxiliary transmission pump are needed. These components are similar to those that would be used in other hybrid designs. Also included in this technology is the Smart Starter Motor. This system is comprised of an enhanced starter motor, along with some electronic control that monitors the accelerator, brake, clutch positions, and the battery voltage as well as low-noise gears to provide fast and quiet engine starts. Despite its extended capabilities, the starter is compact and thus relatively easy to integrate in the vehicle.

12V micro hybrid was added to the technology list to address concerns from CARB and Delphi that the hybrid classifications used in the NPRM did not adequately represent these technologies.[192]

The effectiveness estimates by NHTSA for this technology are based on confidential manufacturer data and independent source data. For the vehicles equipped with (baseline) inline 4, those with smaller displacements, the effectiveness is between 1 and 2.9 percent, and for those equipped with V-6 or V-8, the effectiveness is between 3.4 and 4 percent. The 1 to 2.9 percent incremental fuel consumption savings applies to the

[192] Docket Nos. NHTSA-2008-0089-0173 and -0144.1, respectively.

Sub-Compact Car, Performance Sub-Compact Car, Compact Car, Midsized Car, and Small Truck/SUV variants. The 3.4 to 4 percent incremental fuel consumption applies to the remaining classes with the exception of Large Truck/SUV where MHEV is not applied due to payload and towing requirements for this class.

Confidential manufacturer comments submitted in response to the NPRM indicated a $200 to $1000 cost for the MHEV. The 12V micro-hybrid does not have a high voltage battery, and thus does not have a high-voltage wire cost. The 12V micro-hybrid system for the midsize vehicle has a 3kW electric motor. This agrees well with two commercially available systems used on smaller engines.[193] The value used for the DC/DC converter represents the cost for a 12V power conditioning circuit to allow uninterrupted power to the radio and a limited number of other accessories when the engine starter is engaged. The sizing for the rest of the components is shown in Table IV-9.

The MHEV technology, which will be available from the 2011 model year, is projected to be in high volume use at the beginning of its first year of availability according to NHTSA's analysis, therefore volume based learning reductions (two cycles at 20 percent) were applied to "learn" the hybrid method costs and time based learning factors were applied throughout the remaining years. For the final rule, NHTSA established incremental costs ranging from $372 to $549 with the highest cost applying to the Performance Large Car class.

The 12V micro hybrid technology is applicable across all the vehicle segments except for the Large Truck/SUV class. Although this technology was not specifically

[193] Citroen uses a 2kW system for a 1.4L diesel engine, and Valeo has a 1.6kW system applicable for engines up to 2L in displacement. The midsize vehicle class has an average engine size of 2.9L, and thus a 3kW starter is appropriate.

stated in the NPRM, a phase-in cap of 3 percent was assumed for hybrid technologies. For the final rule, this figure was retained since it is generally supportable within the industry as expressed at the SAE HEV Symposium in San Diego in Feb 2008.

The NPRM proposed that all of the hybrid technologies could be introduced during the redesign model year only. This view is consistent with manufacturer's views, therefore, for this rule making, NHTSA has assumed that 12V micro hybrids can only be introduced at the redesign model years.

(vi) High Voltage / Improved Alternator (HVIA)

In the NPRM, a 42V accessory technology was identified in the decision tree for Other Technologies. Several confidential manufacturer comments received by NHTSA related to 42V technology, and indicated that the effectiveness of 42V system were not realized when electrical conversion efficiencies were considered, and the cost of transitioning the industry from a 12V to 42V system made the technology unreasonable for deployment in the 2011 to 2015 timeframe. As a result of these comments, NHTSA revised the technology from 42V technology to High Voltage / Improved Alternator (HVIA).

The "High Voltage/Improved Efficiency Alternator" technology block represents technologies associated with increased alternator efficiency. As most alternators in production vehicles today are optimized for cost and the process for increasing the efficiency of an alternator is well understood by the industry, this technology is applicable to all vehicle subclasses except Midsize and Large Truck and SUV where it is not considered applicable due to the high utility of these classes.

The NPRM identified fuel economy effectiveness that were based on 42V accessory systems, and are not directly applicable for this current technology definition. Confidential manufacturer data indicates that a midsized car with an improved efficiency alternator provided 0.2 to 0.9 percent fuel consumption effectiveness over the CAFE drive cycles, and a pickup truck provided 0.6 percent fuel consumption effectiveness over the same cycles. As this technology can be applied over a range of vehicles, NHTSA believes the fuel consumption effectiveness for larger vehicles will be biased downward. For purposes of this final rule, NHTSA estimates the fuel consumption effectiveness for High Voltage/Improved Efficiency Alternator" technology at 0.2 to 0.9 percent.

The NPRM identified several sources for high voltage / improved efficiency alternators incremental costs, but focused this technology on 42V systems, thus making some of these references not representative of the current technology description. The NPRM "Engine accessory improvement" technology discussion, however, did quote the NESCCAF study that indicated a $56 cost for a high efficiency generator. An independent confidential study estimated that the incremental cost increase for a high efficiency generator at high volume was similar to the NESCCAF quoted cost, thus NHTSA concludes that the NESCCAF study cost of $56 is still a representative cost for this technology. At a 1.5 RPE value, this cost equates to $84.

As the definition of the technology has been revised from the NPRM, phase-in rates identified in the NPRM are not applicable. NHTSA believes the High voltage / Improved Efficiency Alternator technology represents an adjustment to the alternator manufacturing industry infrastructure, so for purposes of this final rule, phase-in caps for this technology were estimated at 10 percent per year starting in MY 2011 and increased to 20 percent in MYs 2012 and 2013, then 25 percent in MYs 2014 and 2015.

As the definition of the technology has been revised from the NPRM, learning curve assumptions from the NPRM are not applicable. The high voltage / improved alternator technology costs were based on high volume estimates, thus, for purposes of the final rule, NHTSA assumed time-based learning (3 percent YOY) for High Voltage Systems / Improved Alternator technology. For purposes of the final rule, NHTSA assumed the technology can be introduced during refresh or redesign model changes only.

(vii) Integrated Starter Generator (ISG)

The next hybrid technology that is considered is the Integrated Starter Generator (ISG) technology. There are 2 types of integrated starter generator hybrids that are considered: the belt mounted type and the crank mounted type.

A Belt Mounted Integrated Starter Generator (BISG) system is similar to a micro-hybrid system, except that here it is defined as a system with a 110 to 144V battery pack which thus can perform some regenerative braking, whereas the 12V micro-hybrid system cannot. The larger electric machine and battery enables additional hybrid functions of regenerative braking and a very limited degree of operating the engine independently of vehicle load. While having a larger electric machine and more battery capacity than a MHEV, this system has a smaller electric machine than stronger hybrid systems because of the limited torque capacity of the belt driven design.

BISG systems replace the conventional belt-driven alternator with a belt-driven, enhanced power starter-alternator and a redesigned front-end accessory drive system that facilitates bi-directional torque application utilizing a common electric machine. Also, during idle-stop, some functions such as power steering and automatic transmission hydraulic pressure are lost with conventional arrangements; so electric power steering and an auxiliary transmission pump need to be added. These components are similar to those that would be used in other hybrid designs.

A Crank Mounted Integrated Starter Generator (CISG) hybrid system, also called an Integrated Motor Assist (IMA) system, utilizes a thin axial electric motor (100-144V) bolted to the engine's crankshaft. The electric machine acts as both a motor for helping to launch the vehicle and a generator for recovering energy while slowing down. It also acts as the starter for the engine and is a higher efficiency generator. An example of this type of a system is found in the Honda Civic Hybrid. For purposes of the final rule, NHTSA assumed the electric machine is rigidly fixed to the engine crankshaft, thus making electric-only drive not practical.[194]

The fuel consumption effectivenesss of the ISG systems are greater than those of micro-hybrids, because they are able to perform the additional hybrid function of regenerative braking and able to utilize the engine more efficiently because some transient power demands from the driver can be separated from the engine operation. Their transient performance can be better as well, because the larger electric machine can provide torque boost. The ISG systems are more expensive than the micro hybrids, but have lower cost than the strong hybrids described below because the electrical component sizes (batteries, electric machines, power electronics, etc.) are sized in between the micro-

[194] A clutch between the engine and the electric motor would enable pure electric drive, but the Porsche Cayenne is the only example of such a system that is planned in MY 2011-2015 time frame. Because of limited expected volumes of this type of system, and in the interest of reducing complexity, that variant is not included here.

hybrid and the strong hybrid components. The engineering effort required to adapt conventional powertrains to these configurations is also in between that required for micro-hybrid and strong hybrid configurations. Packaging is a greater concern due to the fact that the engine-motor-transmission assembly is physically longer, and the battery pack, high voltage cabling and power electronics are larger.

The hybrid decision tree was modified to address several manufacturer comments and comments from CARB and Delphi asking for more appropriate separation of hybrid technology classifications (*i.e.*, 12V versus higher voltage Integrated Starter Generators, etc.). The inclusion of the ISG technology in the final rule is in response to these comments and those from subject matter experts.

The NPRM had proposed a fuel consumption savings of between 5 and 10 percent for ISG systems, and between 3.5 and 8.5 percent for the Honda IMA system, both of which fall in the ISG category described above. Confidential manufacturer comments submitted in response to the NPRM indicated an incremental 3.8 to 7.4 percent fuel consumption effectiveness and a $1,500 to $2,400 cost as compared to the baseline vehicle.

The incremental fuel consumption savings for the Compact Car variant for ISG over a 12V Micro-hybrid with start/stop was calculated using published data and confidential manufacturer data, while published Honda Civic Hybrid data was used to calculate the fuel consumption gains due to the hybrid system. For the final rule, gains for the other technologies also included on this vehicle were subtracted out to give an incremental effectiveness of 5.7 to 6.5 percent for ISG. Data for these individual gains was taken from confidential manufacturer data. The 5.7 to 6.5 percent incremental fuel consumption savings was carried over from the Compact Car to all other vehicle subclasses. A 2 percent incremental effectiveness was subtracted from the Performance subclasses to allow for the improved baseline performance

The NPRM proposed a cost of $1636 to $2274 for these systems. For the final rule, NHTSA determined the cost for the ISG system using system sizing data for different available ISG hybrids. The 2006 Honda Civic has a Crank Mounted ISG and uses a 0.87 kW-hr battery pack. In light of the potential growth of vehicle electrification, a 1 kW-hr pack size was chosen for both the belt and crank mounted ISG systems. The crank mounted ISG was sized as 11kW continuous (15kW peak). This is an average of the 10kW system on the 2003 Honda Civic and the 12kW system on the 2005 Honda Accord. The 2006 Civic has a 15kW system. The belt mounted ISG has a slightly smaller electric machine (7.5kW continuous and 10kW peak) due to power transmission limitations of the belt.

For the final rule, the hybrid technology cost method projected costs ranging from $2,475 to $3,290 for the Sub-Compact car class through the Midsize Truck classes as compared to the conventional baseline vehicle and the incremental costs of $1,713 to $2,457 were calculated by backing out the prior hybrid technology costs. The ISG technology is projected to be in low volume use at the beginning of the rulemaking period therefore low volume costs are used and volume-based learning factors are applied.

Integrated starter generator systems are applicable to all vehicle subclasses except Large Truck. In the NPRM, a phase-in cap of 3 percent was assumed for both the "ISG with idle off" and "IMA" technologies. For the final rule, NHTSA has retained the phase-in cap of 3 percent. These values are generally supportable within the industry as expressed at the SAE HEV Symposium in San Diego in February 2008.

The NPRM proposed that all of the hybrid technologies could be introduced during the redesign model year only. This view is consistent with manufacturer's views as well, because all of the hybrid technologies under consideration require redesign of the powertrain (ranging from engine accessory drive to transmission redesign) and vehicle redesign to package the hybrid components (from high voltage cabling to the addition of large battery packs). Given this, for purposes of the final rule, they can only be introduced in redesign model years.

(viii) Power Split Hybrid

The Power Split hybrid (PSHEV) is described as a full or a strong hybrid since it has the ability to move the vehicle on electric power only. It replaces the vehicle's transmission with a single planetary gear and a motor/generator. A second, more powerful motor/generator is directly connected to the vehicle's final drive. The planetary gear splits the engine's torque between the first motor/generator and the final drive. The first motor/generator uses power from the engine to either charge the battery or supply power to the wheels. The speed of the first motor/generator determines the relative speed of the engine to the wheels. In this way, the planetary gear allows the engine to operate independently of vehicle speed, much like a CVT. The Toyota Prius and the Ford Hybrid Escape are two examples of power split hybrid vehicles.

In addition to providing the functions of idle engine stop and subsequent restart, regenerative braking, this hybrid system allows for pure EV operation. The two motor/generators are bigger and more powerful than those in an ISG hybrid, allowing the engine to be run in efficient operating zones more often. For these reasons, the power split system provides very good fuel consumption in city driving. During highway cycles, the hybrid functions of regenerative braking, engine start/stop and optimal engine operation cannot be applied as often as in city driving, and so the effectiveness in fuel consumption are less. Additionally, it is less efficient at highway speeds due to the fact that the first motor/generator must be spinning at a relatively high speed and therefore incurs losses.

The battery pack for PSHEV is assumed to be 300V NiMH for MYs 2011-2015, as is used in current PSHEV systems today. Their reliability is proven (having been in hybrids for over 10 years) and their cost is lower than Li Ion, so it is likely that the battery technology used in HEVs will continue to be NiMH through the 2015 model year for hybrids that do not require high energy storage capability like a plug-in hybrid does.

The Power Split hybrid also reduces the cost of the transmission, replacing a conventional multi-speed unit with a single planetary gear. The electric components are bigger than those in an ISG configuration so the costs are correspondingly higher.

However, the Power Split system is not planned for use on full-size trucks and SUVs due to its limited ability to efficiently provide the torque needed by these vehicles. The drive torque is limited to the first motor/generator's capacity to resist the torque of the engine. It is anticipated that Large Trucks would use the 2-mode hybrid system.

The NPRM estimated that Power Split hybrids could achieve fuel consumption reductions of 25 to 35 percent over conventionally powered vehicles. NHTSA received confidential manufacturer data of absolute fuel consumption effectiveness for the compact car class. This indicated a fuel consumption improvement of approximately 23 to 28 percent over the base conventional vehicle. For the final rule, NHTSA carried the 23 to 28 percent absolute from the Compact Car class and applied it to all other applicable vehicle subclasses. The effectiveness for the performance car classes was lowered by 2 percent to allow for the improved baseline performance of these vehicles. This resulted in an approximate 21 to 26 percent overall fuel consumption savings for the Performance car classes. The incremental effectiveness stated in the input sheets were calculated from the absolute values for the Power Split hybrid by subtracting the previously applied technologies in the electrification and transmission trees.

In the NPRM, the cost of the power split system was proposed to be an incremental $3,700-$3,850. The power-split transmission has a much simpler mechanical design when compared to the baseline 4-speed automatic transmission, resulting in a savings of approximately 50 percent of the cost. Several vehicles were benchmarked to determine the battery pack size for the power-split system.[195] In light of the potential growth of vehicle electrification, a 2 kW-hr battery pack size was chosen for both the power-split and 2-mode technologies in a midsize car. The power split hybrid was sized with one 45kW continuous (60kW peak) electric motor and one 30kW continuous (40kW peak) electric motor. These sizes are sufficient for recovering significant regenerative braking and for providing an appropriate amount of torque boost in a midsize vehicle.[196] The 2-mode electric motors were both sized at 45kW continuous (60kW peak) which is again sufficient to capture significant regenerative braking in a midsize vehicle, as well as provide an appropriate amount of torque boost.

[195] The 2004 Toyota Prius has a 1.3 kW-hr pack, the 2007 Toyota Camry and 2007 Nissan Altima have a 1.6 kW-hr packs, and the 2008 Chevy Tahoe has a 1.66 kW-hr pack.
[196] For comparison, the 2004 Toyota Prius' traction electric motor is rated at 50kW.

Confidential manufacturer comments submitted in response to the NPRM indicated a $6,500 to $10,500 cost as compared to the baseline vehicle. The PSHEV technology is projected to be in high volume use at the beginning of its first year of availability according to NHTSA's analysis, therefore learning reductions (two cycles at 20 percent) were applied to the hybrid method costs and time based learning factors were applied. For the final rule, NHTSA assumes a net cost of approximately $4,300 - $8,800 for subclasses ranging from the Sub-Compact class through Midsize Tuck/SUV class when compared to the conventional baseline vehicle, which results in incremental costs ranging from $1,436 to $5,494.

This technology is applicable to the passenger car, Small and Medium light truck subclasses, but was not applied to the Large Truck subclass given its towing requirements. In the NPRM, a phase-in rate of 3 percent was assumed for the power split technology. Although this system has been engineered for some vehicles by a couple of manufacturers, the required engineering resources both at OEMs and Tier 1 suppliers are high. For the final rule, NHTSA limited the volumes of power split hybrids to 11 percent in 2015.

The NPRM proposed that all of the hybrid technologies could be introduced during the redesign model year only, consistent with manufacturer's views. Given this, for this final rule NHTSA has retained the redesign application timing.

(ix) 2-Mode Hybrid

The 2-mode hybrid (2MHEV) is another strong hybrid system that has all-electric drive capability. The 2MHEV uses an adaptation of a conventional stepped-ratio automatic transmission by replacing some of the transmission clutches with two electric motors, which makes the transmission act like a CVT. Like the Power Split hybrid, these motors control the ratio of engine speed to vehicle speed. But unlike the Power Split system, clutches allow the motors to be bypassed, which improves both the transmission's torque capacity and efficiency for improved fuel economy at highway speeds. This type of system is used in the Chevy Tahoe Hybrid.

In addition to providing the hybrid functions of engine stop and subsequent restart and regenerative braking, the 2MHEV allows for pure EV operation. The two motor/generators are bigger and more powerful than those in an ISG hybrid, allowing the engine to be run in efficient operating zones more often. For these reasons, the 2-mode system also provides very good fuel economy in city driving. The primary motor/generator is comparable in size to that in the PSHEV system, but the secondary motor/generator is larger. The 2-mode system cost is greater than that for the power split system due to the additional transmission complexity and secondary motor sizing.

The battery pack for 2MHEV is assumed to be 300V NiMH for MYs 2011-2015, as is used in current 2MHEV systems today. Their reliability is proven (having been in hybrids for over 10 years) and their cost is lower than Li Ion, so it is likely that the batteries will continue to be NiMH through the 2015 model year for hybrids that do not require high energy storage capability like a plug-in hybrid does.

The NPRM estimated that that 2MHEV could achieve fuel consumption reductions of 25 to 40 percent, but actually should have estimated 25 to 40 percent improvement in *fuel economy*. GM comments received in response to the NPRM indicated that unadjusted fuel economy gains for the 2008 Chevrolet Tahoe Hybrid 2-Mode are 16 to 18 percent for 4WD or 2WD, respectively. Using estimates for other vehicle and engine technologies included elsewhere in the final rule decision trees, the remaining 2-mode hybrid technology accounts for 86 percent of the total vehicle effectiveness. This 14 to 16 percent fuel economy effectiveness translates to a 12 to 14 percent fuel consumption effectiveness. Thus, for purposes of the final rule, NHTSA estimated effectiveness at 15 percent for 2MHEV on a Large Truck, slightly higher than the Tahoe Hybrid figures as calculated above but lower than the Sierra estimate of 22 percent for strong hybrids. A Medium Truck 2MHEV was estimated for the final rule to have 19 percent fuel consumption effectiveness compared to a baseline vehicle. The incremental effectiveness was calculated by subtracting the previously applied effectiveness from these absolute values.

In the NPRM, the incremental cost of the 2-mode hybrid was proposed as $4,340 to $5,600. Using the hybrid technology cost method described previously, an absolute cost of approximately $9,800-$15,300 for the Small through Large Truck/SUV classes was derived for the final rule resulting in incremental costs of $6,403 - $14,639 (midpoints) as calculated by subtracting previously applied technologies. Although the costs are higher than those used in the NPRM they are lower than an estimate supplied in confidential comments. Additionally the process used to establish the cost estimates in the NPRM, the outcome of which was questioned by NPRM commenters, lacked the accuracy and robustness of the method used in the final rule. The 2MHEV technology is projected to be in low volume use at the beginning of the rulemaking period, therefore low volume, unlearned costs are used and volume-based learning factors are applied. NHTSA notes that fully learned costs will be reduced by 36 percent.

Given the relatively large size of the 2 mode powertrain, this technology was assumed to be applicable to the Small through Large Truck/SUV classes. In the NPRM, a phase-in rate of 3 percent year over year was assumed for 2 mode hybrids. The 2-modes have recently been introduced in the marketplace on a few vehicle platforms. The engineering resources that are needed both at the OEMs and Tier 1s to develop this across many more platforms are considerable. For purposes of the final rule, the phase-in rate has been set to a maximum of 8 percent by 2015.

The NPRM proposed that all of the hybrid technologies could be introduced during the redesign model year only, consistent with manufacturer's views. Given this, for this final rule NHTSA has retained the redesign application timing.

(x) Plug-In Hybrid

Plug-In Hybrid Electric Vehicles (PHEV) are very similar to other strong hybrid electric vehicles, but with significant functional differences. The key distinguishing feature is the ability to charge the battery pack from an outside source of electricity (usually the electric grid). A PHEV would have a larger battery pack with greater energy capacity, and an ability to be discharged further (referred to as "depth of discharge"). No major manufacturer currently has a PHEV in production, although both GM and Toyota have publicly announced that they will launch plug-in hybrids in limited volumes by 2010.

PHEVs offer a significant opportunity to displace petroleum-derived fuels with electricity from the electrical grid. The reduction in petroleum use depends on the electric-drive range capability and the vehicle usage (*i.e.*, trip distance between recharging, ambient temperature, etc.). PHEVs can have a wide variation in the All

Electric Range (AER) that they offer. Some PHEVs are of the "blended" type where the engine is on during most of the vehicle operation, but the proportion of electric energy that is used to propel the vehicle is significantly higher than that used in a PSHEV or 2MHEV.

The fuel consumption effectiveness from a PHEV are currently difficult to quantify objectively because there is no standardized fuel economy test procedure yet for a PHEV. However, the fuel consumption effectiveness of PHEVs is heavily dependent on the all-electric range, and hence the battery capacity. While test procedures are not standardized yet, one confidential manufacturer data point for the Compact Car class suggests an absolute effectiveness range of 65 to 69 percent over the baseline vehicle. This value was used for all classes where the PHEV was applied. The incremental effectiveness stated in the input sheets was calculated from the absolute values for the plug-in hybrid by subtracting previous technologies.

The NPRM did not have a cost for this technology, because it was not included there. Using the hybrid technology cost method described previously, an absolute cost range of approximately \$22,500 to \$33,600 (incrementals from ~\$20k to \$30k) was developed for vehicle segments ranging from the Subcompact Car segment through the Performance Midsize Car Segments as compared to the conventional baseline vehicle. The incremental costs for a PHEV have a significant range primarily because of the wide variation in vehicle size and weight. NHTSA received limited manufacturer costs estimates in confidential comments with one confidential commenter quoting net variable costs in the \$19,000 - \$22,000 (suggesting RPE costs of \$28,500 - \$33,000) for its PHEV technology; however the commenter did not specify details about the vehicle's size or type. Another confidential commenter provided an incremental RPE estimate of approximately $24,000 on a small to midsize truck or SUV which would be comparable to the final rule estimate for Small Truck/SUV subclasses (approximately $24,300).

PHEVs were not projected to be in volume use in the NPRM, but due to confidential manufacturer product plans, PHEVs do appear in limited volumes in the final rule analysis. Therefore low volume, unlearned costs are assumed, and volume based learning factors, which will result in a 36 percent cost reduction, are applied by the Volpe model. This technology is applicable to all car subclasses except the Large Performance, and also to the Small Truck/SUV subclass but not the Midsize and Large Truck/SUV subclasses. The manufacturer-stated production volumes of PHEVs are very low, so for the final rule NHTSA has placed a phase-in cap of 1 percent in MY 2015, beyond the PHEVs already planned to appear. The NPRM proposed that all of the hybrid technologies could be introduced during the redesign model year only, consistent with manufacturer's views. Given this, for this final rule NHTSA has allowed application of PHEVs in redesign model years only.

(e) Vehicle Technologies

(i) Material Substitution (MS1, MS2, MS5)

The term "material substitution" encompasses a variety of techniques with a variety of costs and lead times. These techniques may include using lighter-weight and/or higher-strength materials, redesigning components, and size matching of components. Lighter-weight materials involve using lower-density materials in vehicle components, such as replacing steel parts with aluminum or plastic. The use of higher-strength materials involves the substitution of one material for another that possesses higher strength and less weight. An example would be using high strength alloy steel versus cold rolled steel. Component redesign is an ongoing process to reduce costs and/or weight of components, while improving performance and reliability. The Aluminum Association commented that lightweight structures are a significant enabler for the new powertrain technologies. Smaller and less expensive powertrains are required and the combination of reduced power and weight reduction positively reinforce and result in optimal fuel economy performance. An example would be a subsystem replacing multiple components and mounting hardware.

However, the cost of reducing weight is difficult to determine and depends upon the methods used. For example, a change in design that reduces weight on a new model may or may not save money. On the other hand, material substitution can result in an increase in price per application of the technology if more expensive materials are used. As discussed further below in Section VIII, for purposes of this final rule, NHTSA has considered only vehicles weighing greater than 5,000 lbs (curb weight) for weight reduction through materials substitution. A typical BOM for Material Substitution would include primarily substitution of high strength steels for heavier steels or other structural, materials on a vehicle. This BOM was established for each class but was not adjusted for each class due to the fact that the vehicle technology of Material Substitution is already scaled by it being based on percent of curb weight at or over 5,000 lbs.

In the NPRM, NHTSA estimated fuel economy effectiveness of a 2 percent incremental reduction in fuel consumption per each 3 percent reduction in vehicle weight. Nissan commented that NHTSA's modeling of material substitution application was overly optimistic, but did not elaborate further. Confidential manufacturer comments in response to the NPRM did not provide standardized effectiveness estimates, but ranged from 3.3 to 3.9 percent mpg improvement for a 10 percent reduction in mass, to 0.20 to 0.75 percent per 1 percent weight reduction, to 1 percent reduction on the FTP city cycle per 100 lbs reduced, with a maximum possible weight reduction of 5 percent.

Bearing in mind that NHTSA only assumes material substitution for vehicles at or above 5,000 lbs curb weight and based on manufacturer comments which together suggest an incremental improvement in fuel consumption of approximately 0.60 percent to 0.9 percent per 3 percent reduction in material weight, NHTSA has estimated an incremental improvement in fuel consumption of 1 percent (corresponding to a 3 percent reduction in vehicle weight, or roughly 0.35 percent fuel consumption per 1 percent reduction in vehicle weight). This estimate is consistent with the majority of the manufacturer comments.

As for costs, in the NPRM NHTSA estimated incremental costs of $0.75 to $1.25 per pound reduced through material substitution. The costs for material substitution were not clearly commented on in the confidential manufacturer responses. Confidential manufacturer estimates ranged from $50 to $511 for 1 percent reduction, although in most cases the cost estimates were not for the entire range of substitution (1-5 percent) and did not provide any additional clarification on how they specifically applied to the material substitution technology. Consequently, for purposes of the final rule NHTSA retained the existing NPRM cost estimates with adjustments to 2007 dollar levels resulting in an incremental $1 to $2 per pound of substituted material, which applies to the MS1 and MS2 technology, and $2 to $4 per pound for the MS5 technology. Costs for material substitution are not adjusted by vehicle subclass, as the technology costs are based on a percentage of the vehicle weight (per pound) and limited to Medium and Large Truck/SUV Van subclasses above 5,000 lbs curb weight.

The agency notes that comments from the Alliance and the Aluminum Association associated engine downsizing with weight reduction/material substitution and quoted effectiveness for this action as well. NHTSA considers engine downsizing separately from typical material substitution efforts, and consequently did not include those cost and fuel economy effectiveness for this technology.

In the NPRM, NHTSA assumed a 17 percent phase-in rate for material substitution. NHTSA received only one confidential manufacturer comment regarding material substitution phase-in percentage, suggesting 17 to 30 percent, but the agency notes that it generally received comments suggesting a higher (but non-linear) phase-in rate than the current NPRM value, which also suggested phase-in over a 5-year period. In response to these comments, NHTSA revised the initial phase-in percentage to 5 percent for year 1 to account for lead time limitations in the early years, and then incorporated a non-linear phase-in through year 5 to better replicate the lead-time and front-loading concerns noted in the confidential manufacturers data, where an accelerated ramp-up of approved and tested materials are incorporated into additional vehicle classes, and to reach an 80 percent level at 2015 for all three technologies.

For material substitution technologies, neither volume-based cost reductions nor time-based cost reductions are applied. This technology does not employ a particular list of components to employ credible cost reduction.

In the NPRM, NHTSA assumed that material substitution (1 percent) could be applied during a redesign model year only. For this final rule, based on confidential manufacturer comments, NHTSA estimated that material substitution (1 percent) could be applied during either a refresh or a redesign model year, due to minimal design changes with minimal component or vehicle-level testing required. However, NHTSA retained the assumption that material substitution (2 percent and 5 percent) could be applied during redesign model year only, as in the NPRM, because the agency neither received comments to contradict this assumption nor found other data to substantiate a change. The technology title was changed from Material Substitution (3 percent) to Material Substitution (5 percent) to more accurately represent the cumulative amount for the technology.

(ii) Low Drag Brakes (LDB)

Low drag brakes reduce the sliding friction of disc brake pads on rotors when the brakes are not engaged because the brake pads are pulled away from the rotating rotor. A typical BOM for Low Drag Brakes would typically include changes in brake caliper speed by changing the brake control system, springs, etc. on a vehicles brake system. This BOM was established for each class and was not adjusted for each class due to the fact that the vehicle technology BOM would not change by class across vehicle classes. Confidential manufacturer comments in response to the NPRM indicated that most passenger cars have already adopted this technology, but that ladder frame trucks have not yet adopted this technology. Consequently, in the final rule this technology was assumed to be applicable only to the Large Performance Passenger Car and Medium and Large Truck classes.

In the NPRM, NHTSA assumed an incremental improvement in fuel consumption of 1 to 2 percent for low drag brakes. Confidential manufacturer comments submitted in response to the NPRM indicated an effective range of 0.5-1.0 percent for this technology and this range was applied in the final rule. As for costs, NHTSA assumed in the NPRM incremental costs of $85 to $90 for the addition of low drag brakes. For the final rule, NHTSA took the average and adjusted it to 2007 dollars to establish an $89 final rule cost.

The NPRM assumed a phase-in rate for low drag brakes of 25 percent in each model year. For the final rule the phase-in rate begins with 20 percent and follows a linear increase to reach 100 percent at the 2015 year. No learning curve was applied in the NPRM however for the final rule, low drag brakes were considered a high volume, mature and stable technology, and thus time based learning was applied. Low drag brakes are assumed in the final rule to be applicable at refresh cycle only.

(iii) Low Rolling Resistance Tires (ROLL)

Tire rolling resistance is the frictional loss associated mainly with the energy dissipated in the deformation of the tires under load – and thus, influence fuel economy. Other tire design characteristics (*e.g.*, materials, construction, and tread design) influence durability, traction control (both wet and dry grip), vehicle handling, and ride comfort in addition to rolling resistance. A typical low rolling resistance tires BOM would include: tire inflation pressure, material change, and constructions with less hysteresis, geometry changes (*e.g.*, reduced aspect ratios), reduction in sidewall and tread deflection, potential spring and shock tuning. Low rolling resistance tires are applicable to all classes of vehicles, except for ladder frame light trucks and performance vehicles. NHTSA assumed that this technology should not be applied to vehicles in the Large truck class due to the increased traction and handling requirements for off-road and braking performance at payload and towing limits which cannot be met with low resistance tire designs. Likewise, this technology was not applied to vehicles in the Performance Car classes due to increased traction requirements for braking and handling which cannot be met with low roll resistance tire designs. Confidential manufacturer comments received regarding applicability of this technology to particular vehicle classes confirmed NHTSA's assumption.

In the NPRM, NHTSA assumed an incremental reduction in fuel consumption of 1 to 2 percent for application of low rolling resistance tires. Confidential manufacturer comments varied widely and addressed the conflicting objectives of increasing safety by increasing rolling resistance for better tire traction, and improving fuel economy with lower rolling resistance tires that provide reduced traction. Confidential manufacturer comments suggested fuel consumption effectiveness of negative impact to a positive 0.1 percent per year over the next five years from 2008, while other confidential manufacturer comments indicate that the percentage effectiveness of low rolling resistance tires would increase each year, although it would apply differently for performance classes. Confidential manufacturer comments also indicated that some manufacturers have already applied this technology and consequently would receive no further effectiveness from this technology. The 2002 NAS Report indicated that an assumed 10 percent rolling resistance reduction would provide an increase in fuel economy of 1 to 2 percent. NHTSA believes the NAS effectiveness is still valid and used 1 to 2 percent incremental reduction in fuel consumption for application of low rolling resistance tires in the final rule.

NHTSA estimated the incremental cost of four low rolling resistance tires to be $6 per vehicle in the NPRM, independent of vehicle class, although not applicable to large trucks. NHTSA received few specific comments on the costs of applying low rolling resistance tires however confidential manufacturer comments that were received provided widely ranging and higher costs. NHTSA increased the range from the NPRM cost estimates to $6 to $9 per vehicle in the final rule.

In the NPRM, NHTSA assumed a phase-in rate of 25 percent for low rolling resistance tires for each model year. Confidential manufacturer comments on the phase-in rate for low rolling resistance tires varied, with some suggesting a higher phase-in rate than the NPRM's 25 percent, and some suggesting that many vehicle classes already had high phase-in rates planned or accomplished. As discussed above, the comments also suggested a non-linear phase-in plan over the 5-year period. Confidential manufacturer data was in the 25-30 percent range. Based on confidential manufacturer comments received and NHTSA's analysis, the final rule includes a phase-in rate for low rolling resistance tires that begins with 20 percent in year 1 and follows with an annual 20 percent increase for subsequent model years.

For low rolling resistant tire technology, neither volume-based cost reductions nor time based cost reductions are applied. This technology is presumed to be significantly dependent on commodity raw material prices and to be priced independent of particular design or manufacturing savings.

In the NPRM, NHTSA assumed that low rolling resistance tires could be applied during any model year. However, based on confidential manufacturer comments NHTSA recognizes that there are some vehicle attribute impacts which may result from application of low rolling resistance tires, such as changes to vehicle dynamics and braking. Vehicle validation testing for safety and vehicle attribute prove-out is not usually planned for every model year, so NHTSA assumed that this technology can be applied during a redesign or refresh model year for purposes of the final rule.

(iv) Front or Secondary Axle Disconnect for Four-Wheel Drive Systems (SAX)

To provide shift-on-the-fly capabilities, reduce wear and tear on secondary axles, and improve performance and fuel economy, many part-time four-wheel drive (4WD) systems use some type of axle disconnect. Axle disconnects are typically used on 4WD vehicles with two-wheel drive (2WD) operating modes. When shifting from 2WD to 4WD "on the fly" (while moving), the front axle disconnect couples the front driveshaft to the front differential side gear only when the transfer case's synchronizing mechanism has spun the front driveshaft, transfer case chain or gear set and differential carrier up to the same speed as the rear driveshaft. 4WD systems that have axle disconnect typically do not have either manual- or automatic-locking hubs. For example, to isolate the front wheels from the rest of the front driveline, front axle disconnects use a sliding sleeve to connect or disconnect an axle shaft from the front differential side gear. The effectiveness to fuel efficiency is created by reducing inertial, chain, bearing and gear losses (parasitic losses).

Full time 4WD or all-wheel-drive (AWD) systems used for on-road performance and safety do not use axle disconnect systems due to the need for instantaneous activation of torque to wheels, and the agency is not aware of any manufacturer or suppliers who are developing a system to allow secondary axle disconnect suitable for use on AWD systems at this time. Secondary axle disconnect technology is primarily found on solid axle 4WD systems and not on the transaxle and/or independent axle systems typically found in AWD vehicles; thus, the application of this technology to AWD systems has not been considered for purposes of this rulemaking. The technology will be evaluated in future rulemakings.

Vehicle technology BOM information was not adjusted by vehicle classes due to the fact that the vehicle technology is limited to transfer case and front axle design changes. Scaling of components might be impacted but the components themselves will be the same. This is consistent with NHTSA's assumptions in the NPRM, and is supported by comments from confidential supplier and manufacturers. Secondary Axle Disconnect BOM typically involves a transfer case which includes electronic solenoid with clutch system to disconnect front drive and using axle mounted vacuum or electric disconnect that still allows driveshaft rotation without connection to wheel ends.

In the NPRM, NHTSA employed "unibody" and "ladder frame" terms to differentiate application of this technology, and had suggested "unibody" AWD systems could apply this same technology. In actuality, most 4WD vehicles are "ladder frame" technology and AWD are "unibody" designs (which for the reasons stated above will not be considered for this technology). Ladder frame technology is typically associated with greater payload, towing, and off-road capability, whereas unibody designs are typically used in smaller, usually front-wheel drive vehicles, and are typically not associated with higher payload, towing, and off-road use. For the final rule, NHTSA removed these vehicle design criteria since it is not a requirement to incorporate axle disconnect technology, only a historical design point and vehicle manufacturers should not be limited to a specific vehicle or chassis configuration to apply this technology. Therefore, this technology is applicable to 4WD vehicles in all vehicle classes (independent of chassis or frame design).

In the NPRM, NHTSA estimated an incremental reduction in fuel consumption of 1 to 1.5 percent for axle disconnect. Confidential manufacturer comments suggested an incremental effectiveness of 1 to 1.5 percent. Supported by this confidential manufacturer data, NHTSA maintained an incremental effectiveness of 1 to 1.5 percent for axle disconnect for the final rule.

As for costs, the NPRM estimated the incremental cost for adding axle disconnect technology at $114 for 4WD systems and the $676 estimate was for the AWD systems which are not applied in the final rule. NHTSA received no specific comments on costs for this technology and found no additional sources to support a change from this value for the 4WD value of $114, so for purposes of the final rule, NHTSA revised the $114 figure to 2007 dollars to establish a $117 final rule cost.

In the NPRM, NHTSA assumed a phase-in rate of 17 percent for secondary axle disconnect for each model year covered by the rulemaking. No specific comments were received regarding the phase-in rate for this technology, but as discussed above, manufacturers generally argued for a non-linear phase-in plan over the 5-year period covered by the rulemaking. Based on general comments received and NHTSA's analysis, the final rule includes a phase-in rate for secondary axle disconnect that begins with 17 percent in year 1 and follows the non-linear increase for subsequent model years to reach 100 percent in 2015.

In the NPRM, NHTSA assumed a volume-based learning curve factor of 20 percent for secondary axle disconnect. For the final rule, secondary axle disconnect learning was established as time-based due to confidential manufacturer data demonstrating that this is a mature technology, such that additional volumes will provide no additional advantage for incorporation by manufacturers.

In the NPRM, NHTSA assumed that secondary axle disconnect could be applied to a vehicle either during refresh or redesign model years. NHTSA received no comments and found no sources to disagree with this assumption, and since testing to validate the functional requirements and vehicle attribute prove-out testing is usually not planned for every model year, NHTSA has retained this assumption for the final rule.

(v) Aerodynamic Drag Reduction (AERO)

Several factors affect a vehicle's aerodynamic drag and the resulting power required to move it through the air. While these values change with air density and the square and cube of vehicle speed, respectively, the overall drag effect is determined by the product of its frontal area and drag coefficient. Reductions in these quantities can therefore reduce fuel consumption. While frontal areas tend to be relatively similar within a vehicle class (mostly due to market-competitive size requirements), significant variations in drag coefficient can be observed. Significant fleet aerodynamic drag reductions may require incorporation into a manufacturer's new model phase-in schedules depending on the mix of vehicle classes distributed across the manufacturer's lineup. However, shorter-term aerodynamic reductions, with less of a fuel economy effectiveness, may be achieved through the use of revised exterior components (typically at a model refresh in mid-cycle) and add-on devices that are in general circulation today.

The latter list would include revised front and rear fascias, modified front air dams and rear valances, addition of rear deck lips and underbody panels, and more efficient exterior mirrors.

Vehicle technology BOM information was not adjusted by vehicle classes due to the fact that Aero Drag Reductions are already scaled based on percent overall vehicle coefficient of drag CdA. Aero Drag Reduction BOM could include (but would not be limited to) the following components or subsystems: underbody covers, front lower air dams, overall front fascia changes, headlights, hood, fenders, grill, windshield angle, A-Pillar angle, door seal gaps, roof (which would both be high impact and very high cost), side view mirrors, door handles (low impact), ride height, rear deck lip, wheels, wheel covers, and optimizing the cooling flow path.

In the NPRM, NHTSA estimated an incremental aerodynamic drag reduction of 20 percent for cars, and 10 percent for trucks. Confidential manufacturer comments received indicated that the 20 percent reduction for cars in the NPRM may have been overly optimistic, as significant changes in aero drag have already been applied to those vehicle classes. However, confidential manufacturer comments agreed with the 10 percent aerodynamic drag reduction for trucks, since there are still significant opportunities to improve aero drag in trucks designed for truck-related utility. The Sierra Research study submitted by the Alliance concluded that a 10 percent incremental aerodynamic drag reduction for mid-size cars gives a 1.5 percent improvement in vehicle fuel economy. Thus, for purposes of the final rule, NHTSA has estimated that a fleet average of 10 percent total aerodynamic drag reduction is attainable (with a caveat for "high-performance" vehicles described below), which equates to incremental reductions in fuel consumption of 2 percent and 3 percent for cars and trucks, respectively. These numbers are in agreement with publicly-available technical literature[197] and are supported by confidential manufacturer information. Performance car classes are excluded from this technology improvement because they have largely applied this technology already.

As for costs, in the NPRM NHTSA assumed an incremental cost of $0 to $75 for aero drag reduction on both cars and trucks. After reviewing the 2008 Martec Report, however, NHTSA concluded that a lower-bound cost of $0 was not supportable. NHTSA replaced the lower-bound cost with $40 (non-RPE) based on the assumptions that the underbody cover and acoustic covers described in the Martec report approximates the cost for one large underbody cover as might be required for minimal aero drag reduction actions.[198] The upper limit was determined by updating the NPRM upper cost to 2007 dollars and applying an RPE uplift thereby establishing the incremental cost, independent of vehicle class, to range from $60 to $116 (RPE) for the final rule

In the NPRM, NHTSA assumed a 17 percent phase-in rate for aero drag reduction for each model year covered by the rulemaking. No specific comments were received regarding the phase-in rate for this technology, but as discussed above, manufacturers generally argued for a non-linear phase-in plan over the 5-year period covered by the rulemaking. Based on comments received and NHTSA's analysis, the final rule includes a phase-in rate for aero drag reduction that begins with 17 percent in year 1 and follows the non-linear increase to 100 percent in 2015. Neither volume-based cost reductions nor

[197] Sue Elliott-Sink, "Improving Aerodynamics to Boost Fuel Economy," May 2, 2006. *Available at* http://www.edmunds.com/advice/fueleconomy/articles/106954/article.html (last accessed Oct. 5, 2008).
[2] 2008 Martec Report, at 25. NHTSA also assumed that the cost of fuel pulsation dampening technology noted in the Martec report grouped with the underbody cover and acoustic covers does not significantly impact the $40 cost as fuel pulsation dampening technology is very low in cost relative to the other actions. Therefore NHTSA did not modify the $40 estimate.

time based cost reductions are applied. In the NPRM, NHTSA assumed that aero drag reduction could be applied in either a refresh or a redesign model year and that assumption has been retained for the final rule.

(f) Technologies considered but not included in the final rule analysis

Although discussed and considered as potentially viable in the NPRM, NHTSA has determined that three technologies will be unavailable in the MY 2011-2015 time frame. Thus, for the reasons discussed below, these technologies were not applied by the Volpe model in the final rule. The technologies are camless valve actuation (CVA), lean burn gasoline direct injection (LBDI), homogeneous charge compression ignition (HCCI), and electric assist turbocharging. Although not applied in this rulemaking, NHTSA will continue to monitor the industry and system suppliers for progress on these technologies, and should they become available, consider them for use in any future rulemaking activity.

(i) Camless Valve Actuation

Camless valve actuation relies on electromechanical actuators instead of camshafts to open and close the cylinder valves. When electromechanical actuators are used to replace cams and coupled with sensors and microprocessor controls, valve timing and lift can be optimized over all conditions. An engine valvetrain that operates independently of any mechanical means provides the ultimate in flexibility for intake and exhaust timing and lift optimization. With it comes infinite valve overlap variability, the rapid response required to change between operating modes (such as HCCI and GDI), intake valve throttling, cylinder deactivation, and elimination of the camshafts (reduced friction). This level of control can enable even further incremental reductions in fuel consumption.

As noted in the NPRM, this technology has been under research for many decades and although some progress is being made, NHTSA has found no evidence to support that the technology can be successfully implemented, costed, or have defined fuel consumption effectiveness within the MY 2011-2015 time frame.

(ii) Lean-Burn Gasoline Direct Injection Technology

One way to improve an engine's thermodynamic efficiency dramatically is by operating at a lean air-fuel mixture (excess air). Fuel system improvements, changes in combustion chamber design and repositioning of the injectors have allowed for better air/fuel mixing and combustion efficiency. There is currently a shift from wall-guided injection to spray guided injection, which improves injection precision and targeting towards the spark plug, increasing lean combustion stability. Combined with advances in NO_x after-treatment, lean-burn GDI engines may eventually be a possibility in North America.

However, as noted in the NPRM, a key technical requirement for lean-burn GDI engines to meet EPA's Tier 2 NO_x emissions levels is the availability of low-sulfur gasoline, which is projected to be unavailable during MY 2011-2015. Therefore the technology was not applied in the final rule

(iii) Homogeneous Charge Compression Ignition

Homogeneous charge compression ignition (HCCI), also referred to as controlled auto ignition (CAI), is an alternate engine operating mode that does not rely on a spark event to initiate combustion. The principles are more closely aligned with a diesel combustion cycle, in which the compressed charge exceeds a temperature and pressure necessary for spontaneous ignition. The resulting burn is much shorter in duration with higher thermal efficiency. Shorter combustion times and higher EGR tolerance permit very high compression ratios (which also increase thermodynamic efficiency), and additionally, pumping losses are reduced because the engine can run unthrottled.

NHTSA noted in the NPRM that several manufacturers had made public statements about the viability of incorporating HCCI into production vehicles over the next 10 years. Upon further review of confidential product plan information, and reviewing comments received in response to the NPRM, NHTSA has determined the technology will not be available within the MY 2011-2015 time frame. Consequently, the technology was not applied in the final rule.

(iv) Electric Assist Turbocharging

The Alliance commented that global development of electric assist turbocharging has not demonstrated the fuel efficiency effectiveness of a 12V EAT up to 2kW power levels since the 2004 NESCCAF study, and stated that it saw remote probability of its application by the 2015 model year.[199] While hybrid vehicles lower the incremental hardware requirements for higher-voltage, higher-power EAT systems, NHTSA believes that significant development work is required to demonstrate effective systems and that implementation in significant volumes will not occur by 2015. Thus, this technology was not included on the decision trees.

E. Cost and effectiveness tables

[199] NHTSA-2008-0089-0169.1, at 41.

The tables representing the Volpe model input files for incremental technology costs by vehicle subclass are presented below. The tables have been divided into passenger cars, performance passenger cars, and light trucks to make them easier to read.

Table IV-15. Technology Incremental Cost Estimates, Passenger Cars

VEHICLE TECHNOLOGY RETAIL PRICE EQUIVALENT INCREMENTAL COSTS PER VEHICLE ($) BY VEHICLE TECHNICAL CLASS - PASSENGER CARS					
		Subcompac Car	Compact Car	Midsize Car	Large Car
Nominal Baseline Engine (For Cost Basis)		Inline 4	Inline 4	Inline 4	V6
Low Friction Lubricants	LUB	5	5	5	5
Engine Friction Reduction	EFR	52 - 196	52 - 196	52 - 196	78 - 294
VVT - Coupled Cam Phasing (CCP) on SOHC	CCPS	61	61	61	122
Discrete Variable Valve Lift (DVVL) on SOHC	DVVLS	201	201	201	306
Cylinder Deactivation on SOHC	DEACS	n.a.	n.a.	n.a.	75
VVT - Intake Cam Phasing (ICP)	ICP	61	61	61	122
VVT - Dual Cam Phasing (DCP)	DCP	61	61	61	122
Discrete Variable Valve Lift (DVVL) on DOHC	DVVLD	201	201	201	306
Continuously Variable Valve Lift (CVVL)	CVVL	306	306	306	432
Cylinder Deactivation on DOHC	DEACD	n.a.	n.a.	n.a.	75
Cylinder Deactivation on OHV	DEACO	n.a.	n.a.	n.a.	306
VVT - Coupled Cam Phasing (CCP) on OHV	CCPO	61	61	61	122
Discrete Variable Valve Lift (DVVL) on OHV	DVVLO	201	201	201	76
Conversion to DOHC with DCP	CDOHC	373	373	373	590
Stoichiometric Gasoline Direct Injection (GDI)	SGDI	293 - 440	293 - 440	293 - 440	384 - 558
Combustion Restart	CBRST	141	141	141	141
Turbocharging and Downsizing	TRBDS	1223	1223	1223	822
Exhaust Gas Recirculation (EGR) Boost	EGRB	173	173	173	173
Conversion to Diesel following CBRST	DSLC	2,963 - 3,254	2,963 - 3,254	2,963 - 3,254	4,105 - 4,490
Conversion to Diesel following TRBDS	DSLT	1,567 - 1,858	1,567 - 1,858	1,567 - 1,858	3,110 - 3,495
Electric Power Steering	EPS	105 - 120	105 - 120	105 - 120	105 - 120
Improved Accessories	IACC	173 - 211	173 - 211	173 - 211	173 - 211
12V Micro-Hybrid	MHEV	372	408	453	490
Higher Voltage/Improved Alternator	HVIA	84	84	84	84
Integrated Starter Generator (Belt/Crank)	ISG	1713	2019	2190	2386
6-Speed Manual/Improved Internals	6MAN	338	338	338	338
Improved Auto. Trans. Controls/Externals	IATC	59	59	59	59
Continuously Variable Transmission	CVT	300	300	300	300
6/7/8-Speed Auto. Trans with Improved Internals	NAUTO	323	323	323	323
Dual Clutch or Automated Manual Transmission	DCTAM	68	68	218	218
Power Split Hybrid	PSHEV	1,409 - 1,462	1,742 - 1,795	2,175 - 2,228	2,534 - 2,587
2-Mode Hybrid	2MHEV	n.a.	n.a.	n.a.	n.a.
Plug-in Hybrid	PHEV	19,648 - 19,701	23,670 - 23,723	26,702 - 26,755	n.a.
Material Substitution (1%)	MS1	n.a.	n.a.	n.a.	n.a.
Material Substitution (2%)	MS2	n.a.	n.a.	n.a.	n.a.
Material Substitution (5%)	MS5	n.a.	n.a.	n.a.	n.a.
Low Rolling Resistance Tires	ROLL	6 - 9	6 - 9	6 - 9	6 - 9
Low Drag Brakes	LDB	n.a.	n.a.	n.a.	n.a.
Secondary Axle Disconnect	SAX	117	117	117	117
Aero Drag Reduction	AERO	60 - 116	60 - 116	60 - 116	60 - 116

Table IV-16. Technology Incremental Cost Estimates, Performance Passenger Cars

VEHICLE TECHNOLOGY RETAIL PRICE EQUIVALENT INCREMENTAL COSTS PER VEHICLE ($) BY VEHICLE TECHNICAL CLASS - PERFORMANCE CARS					
		Perform. Subcomp. Car	Perform. Compact Car	Perform. Midsize Car	Perform. Large Car
Nominal Baseline Engine (For Cost Basis)		Inline 4	V6	V6	V8
Low Friction Lubricants	LUB	5	5	5	5
Engine Friction Reduction	EFR	52 - 196	78 - 294	78 - 294	104 - 392
VVT - Coupled Cam Phasing (CCP) on SOHC	CCPS	61	122	122	122
Discrete Variable Valve Lift (DVVL) on SOHC	DVVLS	201	306	306	396
Cylinder Deactivation on SOHC	DEACS	n.a.	75	75	75
VVT - Intake Cam Phasing (ICP)	ICP	61	122	122	122
VVT - Dual Cam Phasing (DCP)	DCP	61	122	122	122
Discrete Variable Valve Lift (DVVL) on DOHC	DVVLD	201	306	306	396
Continuously Variable Valve Lift (CVVL)	CVVL	306	432	432	582
Cylinder Deactivation on DOHC	DEACD	n.a.	75	75	75
Cylinder Deactivation on OHV	DEACO	n.a.	306	306	400
VVT - Coupled Cam Phasing (CCP) on OHV	CCPO	61	122	122	122
Discrete Variable Valve Lift (DVVL) on OHV	DVVLO	201	76	76	76
Conversion to DOHC with DCP	CDOHC	373	590	590	746
Stoichiometric Gasoline Direct Injection (GDI)	SGDI	293 - 440	384 - 558	384 - 558	512 - 744
Combustion Restart	CBRST	141	141	141	141
Turbocharging and Downsizing	TRBDS	1,223	822	822	1,229
Exhaust Gas Recirculation (EGR) Boost	EGRB	173	173	173	173
Conversion to Diesel following CBRST	DSLC	2,963 - 3,254	4,105 - 4,490	4,105 - 4,490	5,125 - 5,617
Conversion to Diesel following TRBDS	DSLT	1,567 - 1,858	3,110 - 3,495	3,110 - 3,495	3,723 - 4,215
Electric Power Steering	EPS	105 - 120	105 - 120	105 - 120	105 - 120
Improved Accessories	IACC	173 - 211	173 - 211	173 - 211	173 - 211
12V Micro-Hybrid	MHEV	406	443	494	549
Higher Voltage/Improved Alternator	HVIA	84	84	84	84
Integrated Starter Generator (Belt/Crank)	ISG	1,864	2,054	2,183	2,351
6-Speed Manual/Improved Internals	6MAN	338	338	338	338
Improved Auto. Trans. Controls/Externals	IATC	59	59	59	59
Continuously Variable Transmission	CVT	300	300	300	n.a.
6/7/8-Speed Auto. Trans with Improved Internals	NAUTO	323 - 638	323 - 638	323 - 638	323 - 638
Dual Clutch or Automated Manual Transmission	DCTAM	(97) - 218	(97) - 218	(97) - 218	(97) - 218
Power Split Hybrid	PSHEV	2,838 - 2,966	3,144 - 3,197	4,093 - 4,146	5,467 - 5,520
2-Mode Hybrid	2MHEV	n.a.	n.a.	n.a.	n.a.
Plug-in Hybrid	PHEV	23,736 - 23,864	26,790 - 26,843	30,110 - 30,163	n.a.
Material Substitution (1%)	MS1	n.a.	n.a.	n.a.	n.a.
Material Substitution (2%)	MS2	n.a.	n.a.	n.a.	n.a.
Material Substitution (5%)	MS5	n.a.	n.a.	n.a.	n.a.
Low Rolling Resistance Tires	ROLL	n.a.	n.a.	n.a.	n.a.
Low Drag Brakes	LDB	n.a.	n.a.	n.a.	n.a.
Secondary Axle Disconnect	SAX	117	117	117	117
Aero Drag Reduction	AERO	60 - 116	60 - 116	60 - 116	60 - 116

Table IV-17. Technology Incremental Cost Estimates, Light Trucks

VEHICLE TECHNOLOGY RETAIL PRICE EQUIVALENT INCREMENTAL COSTS PER VEHICLE ($) BY VEHICLE TECHNICAL CLASS - LIGHT TRUCKS					
		Minivan LT	Small LT	Midsize LT	Large LT
Nominal Baseline Engine (For Cost Basis)		V6	Inline 4	V6	V8
Low Friction Lubricants	LUB	5	5	5	5
Engine Friction Reduction	EFR	78 - 294	52 - 196	78 - 294	104 - 392
VVT - Coupled Cam Phasing (CCP) on SOHC	CCPS	122	61	122	122
Discrete Variable Valve Lift (DVVL) on SOHC	DVVLS	306	201	306	396
Cylinder Deactivation on SOHC	DEACS	75	n.a.	75	75
VVT - Intake Cam Phasing (ICP)	ICP	122	61	122	122
VVT - Dual Cam Phasing (DCP)	DCP	122	61	122	122
Discrete Variable Valve Lift (DVVL) on DOHC	DVVLD	306	201	306	396
Continuously Variable Valve Lift (CVVL)	CVVL	432	306	432	582
Cylinder Deactivation on DOHC	DEACD	75	n.a.	75	75
Cylinder Deactivation on OHV	DEACO	306	n.a.	306	400
VVT - Coupled Cam Phasing (CCP) on OHV	CCPO	122	61	122	122
Discrete Variable Valve Lift (DVVL) on OHV	DVVLO	76	201	76	76
Conversion to DOHC with DCP	CDOHC	590	373	590	746
Stoichiometric Gasoline Direct Injection (GDI)	SGDI	384 - 558	293 - 440	384 - 558	512 - 744
Combustion Restart	CBRST	141	141	141	141
Turbocharging and Downsizing	TRBDS	822	1223	822	1229
Exhaust Gas Recirculation (EGR) Boost	EGRB	173	173	173	173
Conversion to Diesel following CBRST	DSLC	4,105 - 4,490	2,963 - 3,254	4,105 - 4,490	5,125 - 5,617
Conversion to Diesel following TRBDS	DSLT	3,110 - 3,495	1,567 - 1,858	3,110 - 3,495	3,723 - 4,215
Electric Power Steering	EPS	105 - 120	105 - 120	105 - 120	n.a.
Improved Accessories	IACC	173 - 211	173 - 211	n.a.	n.a.
12V Micro-Hybrid	MHEV	490	427	502	n.a.
Higher Voltage/Improved Alternator	HVIA	84	84	84	n.a.
Integrated Starter Generator (Belt/Crank)	ISG	2386	2029	2457	n.a.
6-Speed Manual/Improved Internals	6MAN	338	338	338	338
Improved Auto. Trans. Controls/Externals	IATC	59	59	59	59
Continuously Variable Transmission	CVT	300	300	n.a.	n.a.
6/7/8-Speed Auto. Trans with Improved Internals	NAUTO	323	323 - 638	323 - 638	323 - 638
Dual Clutch or Automated Manual Transmission	DCTAM	218	(97) - 218	(97) - 218	(97) - 218
Power Split Hybrid	PSHEV	2,534 - 2,587	1,932 - 1,985	3,173 - 3,188	n.a.
2-Mode Hybrid	2MHEV	n.a.	6,376 - 6,429	8,313 - 8,328	14,106-15,171
Plug-in Hybrid	PHEV	n.a.	24,276 - 24,329	n.a.	n.a.
Material Substitution (1%)	MS1	n.a.	n.a.	1 - 2	1 - 2
Material Substitution (2%)	MS2	n.a.	n.a.	1 - 2	1 - 2
Material Substitution (5%)	MS5	n.a.	n.a.	2 - 4	2 - 4
Low Rolling Resistance Tires	ROLL	6 - 9	6 - 9	6 - 9	n.a.
Low Drag Brakes	LDB	n.a.	n.a.	89	89
Secondary Axle Disconnect	SAX	117	117	117	117
Aero Drag Reduction	AERO	60 - 116	60 - 116	60 - 116	60 - 116

The tables representing the Volpe model input files for incremental technology effectiveness values by vehicle subclass are presented below. The tables have been divided into passenger cars, performance passenger cars, and light trucks to make them easier to read.

Table IV-18. Technology Incremental Effectiveness Estimates, Passenger Cars

VEHICLE TECHNOLOGY INCREMENTAL FUEL CONSUMPTION REDUCTION (-%) BY VEHICLE TECHNOLOGY CLASS - PASSENGER CARS					
		Subcompact Car	Compact Car	Midsize Car	Large Car
Nominal Baseline Engine (For Cost Basis)		Inline 4	Inline 4	Inline 4	V6
Low Friction Lubricants	LUB	0.5	0.5	0.5	0.5
Engine Friction Reduction	EFR	1.0 - 2.0	1.0 - 2.0	1.0 - 2.0	1.0 - 2.0
VVT - Coupled Cam Phasing (CCP) on SOHC	CCPS	1.0 - 3.0	1.0 - 3.0	1.0 - 3.0	1.0 - 3.0
Discrete Variable Valve Lift (DVVL) on SOHC	DVVLS	1.0 - 3.0	1.0 - 3.0	1.0 - 3.0	1.0 - 3.0
Cylinder Deactivation on SOHC	DEACS	n.a.	n.a.	n.a.	2.5 - 3.0
VVT - Intake Cam Phasing (ICP)	ICP	1.0 - 2.0	1.0 - 2.0	1.0 - 2.0	1.0 - 2.0
VVT - Dual Cam Phasing (DCP)	DCP	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Discrete Variable Valve Lift (DVVL) on DOHC	DVVLD	1.0 - 3.0	1.0 - 3.0	1.0 - 3.0	1.0 - 3.0
Continuously Variable Valve Lift (CVVL)	CVVL	1.5 - 3.5	1.5 - 3.5	1.5 - 3.5	1.5 - 3.5
Cylinder Deactivation on DOHC	DEACD	n.a.	n.a.	n.a.	0 - 0.5
Cylinder Deactivation on OHV	DEACO	n.a.	n.a.	n.a.	3.9 - 5.5
VVT - Coupled Cam Phasing (CCP) on OHV	CCPO	1.0 - 1.5	1.0 - 1.5	1.0 - 1.5	1.0 - 1.5
Discrete Variable Valve Lift (DVVL) on OHV	DVVLO	0.5 - 2.6	0.5 - 2.6	0.5 - 2.6	0.5 - 2.6
Conversion to DOHC with DCP	CDOHC	1.0 - 2.6	1.0 - 2.6	1.0 - 2.6	1.0 - 2.6
Stoichiometric Gasoline Direct Injection (GDI)	SGDI	1.9 - 2.9	1.9 - 2.9	1.9 - 2.9	1.9 - 2.9
Combustion Restart	CBRST	1.8 - 2.4	1.8 - 2.4	1.8 - 2.4	1.8 - 2.4
Turbocharging and Downsizing	TRBDS	4.5 - 5.2	4.5 - 5.2	4.5 - 5.2	2.1 - 2.2
Exhaust Gas Recirculation (EGR) Boost	EGRB	3.9 - 4.0	3.9 - 4.0	3.9 - 4.0	3.9 - 4.0
Conversion to Diesel following CBRST	DSLC	15.0 - 15.3	15.0 - 15.3	13.8 - 14.2	11.1 - 12.0
Conversion to Diesel following TRBDS	DSLT	6.6 - 7.7	6.6 - 7.7	5.3 - 6.5	5.3 - 6.5
Electric Power Steering	EPS	1.0 - 2.0	1.0 - 2.0	1.0 - 2.0	1.0 - 2.0
Improved Accessories	IACC	1.0 - 2.0	1.0 - 2.0	1.0 - 2.0	1.0 - 2.0
12V Micro-Hybrid	MHEV	1.0 - 2.9	1.0 - 2.9	3.4 - 4.0	3.4 - 4.0
Higher Voltage/Improved Alternator	HVIA	0.2 - 0.9	0.2 - 0.9	0.2 - 0.6	0.2 - 0.6
Integrated Starter Generator (Belt/Crank)	ISG	5.7 - 6.5	5.7 - 6.5	5.7 - 6.5	5.7 - 6.5
6-Speed Manual/Improved Internals	6MAN	1	1	1	1
Improved Auto. Trans. Controls/Externals	IATC	1.5 - 2.5	1.5 - 2.5	1.5 - 2.5	1.5 - 2.5
Continuously Variable Transmission	CVT	0.7 - 2.0	0.7 - 2.0	0.7 - 2.0	0.7 - 2.0
6/7/8-Speed Auto. Trans with Improved Internals	NAUTO	1.4 - 3.4	1.4 - 3.4	1.4 - 3.4	1.4 - 3.4
Dual Clutch or Automated Manual Transmission	DCTAM	5.5 - 7.5	5.5 - 7.5	2.7 - 4.1	2.7 - 4.1
Power Split Hybrid	PSHEV	13.5 - 13.9	13.5 - 13.9	11.8 - 12.8	11.8 - 12.8
2-Mode Hybrid	2MHEV	n.a.	n.a.	n.a.	n.a.
Plug-in Hybrid	PHEV	61 - 63	61 - 63	60 - 63	n.a.
Material Substitution (1%)	MS1	n.a.	n.a.	n.a.	n.a.
Material Substitution (2%)	MS2	n.a.	n.a.	n.a.	n.a.
Material Substitution (5%)	MS5	n.a.	n.a.	n.a.	n.a.
Low Rolling Resistance Tires	ROLL	1.0 - 2.0	1.0 - 2.0	1.0 - 2.0	1.0 - 2.0
Low Drag Brakes	LDB	n.a.	n.a.	n.a.	n.a.
Secondary Axle Disconnect	SAX	1.0 - 1.5	1.0 - 1.5	1.0 - 1.5	1.0 - 1.5
Aero Drag Reduction	AERO	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0

Table IV-19. Technology Incremental Effectiveness Estimates, Performance Cars

VEHICLE TECHNOLOGY INCREMENTAL FUEL CONSUMPTION REDUCTION (-%) BY VEHICLE TECHNOLOGY CLASS - PERFORMANCE CARS					
		Perform. Subcomp. Car	Perform. Compact Car	Perform. Midsize Car	Perform. Large Car
Nominal Baseline Engine (For Cost Basis)		Inline 4	V6	V6	V8
Low Friction Lubricants	LUB	0.5	0.5	0.5	0.5
Engine Friction Reduction	EFR	1.0 - 2.0	1.0 - 2.0	1.0 - 2.0	1.0 - 2.0
VVT - Coupled Cam Phasing (CCP) on SOHC	CCPS	1.0 - 3.0	1.0 - 3.0	1.0 - 3.0	1.0 - 3.0
Discrete Variable Valve Lift (DVVL) on SOHC	DVVLS	1.0 - 3.0	1.0 - 3.0	1.0 - 3.0	1.0 - 3.0
Cylinder Deactivation on SOHC	DEACS	n.a.	2.5 - 3.0	2.5 - 3.0	2.5 - 3.0
VVT - Intake Cam Phasing (ICP)	ICP	1.0 - 2.0	1.0 - 2.0	1.0 - 2.0	1.0 - 2.0
VVT - Dual Cam Phasing (DCP)	DCP	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Discrete Variable Valve Lift (DVVL) on DOHC	DVVLD	1.0 - 3.0	1.0 - 3.0	1.0 - 3.0	1.0 - 3.0
Continuously Variable Valve Lift (CVVL)	CVVL	1.5 - 3.5	1.5 - 3.5	1.5 - 3.5	1.5 - 3.5
Cylinder Deactivation on DOHC	DEACD	n.a.	0 - 0.5	0 - 0.5	0 - 0.5
Cylinder Deactivation on OHV	DEACO	n.a.	3.9 - 5.5	3.9 - 5.5	3.9 - 5.5
VVT - Coupled Cam Phasing (CCP) on OHV	CCPO	1.0 - 1.5	1.0 - 1.5	1.0 - 1.5	1.0 - 1.5
Discrete Variable Valve Lift (DVVL) on OHV	DVVLO	0.5 - 2.6	0.5 - 2.6	0.5 - 2.6	0.5 - 2.6
Conversion to DOHC with DCP	CDOHC	1.0 - 2.6	1.0 - 2.6	1.0 - 2.6	1.0 - 2.6
Stoichiometric Gasoline Direct Injection (GDI)	SGDI	1.9 - 2.9	1.9 - 2.9	1.9 - 2.9	1.9 - 2.9
Combustion Restart	CBRST	1.8 - 2.4	1.8 - 2.4	1.8 - 2.4	1.8 - 2.4
Turbocharging and Downsizing	TRBDS	4.5 - 5.2	2.1 - 2.2	2.1 - 2.2	2.1 - 2.2
Exhaust Gas Recirculation (EGR) Boost	EGRB	3.9 - 4.0	3.9 - 4.0	3.9 - 4.0	3.9 - 4.0
Conversion to Diesel following CBRST	DSLC	15.0 - 15.3	12.3 - 13.1	11.1 - 12.0	11.1 - 12.0
Conversion to Diesel following TRBDS	DSLT	6.6 - 7.7	6.6 - 7.7	5.3 - 6.5	5.3 - 6.5
Electric Power Steering	EPS	1.0 - 2.0	1.0 - 2.0	1.0 - 2.0	1.0 - 2.0
Improved Accessories	IACC	1.0 - 2.0	1.0 - 2.0	1.0 - 2.0	1.0 - 2.0
12V Micro-Hybrid	MHEV	1.0 - 2.9	1.2 - 2.9	3.4 - 4.0	3.4 - 4.0
Higher Voltage/Improved Alternator	HVIA	0.2 - 0.9	0.2 - 0.9	0.2 - 0.6	0.2 - 0.6
Integrated Starter Generator (Belt/Crank)	ISG	1.8 - 2.6	1.8 - 2.6	1.8 - 1.9	1.8 - 2.6
6-Speed Manual/Improved Internals	6MAN	0.5	0.5	0.5	0.5
Improved Auto. Trans. Controls/Externals	IATC	1.5 - 2.5	1.5 - 2.5	1.5 - 2.5	1.5 - 2.5
Continuously Variable Transmission	CVT	0.7 - 2.0	0.7 - 2.0	0.7 - 2.0	n.a.
6/7/8-Speed Auto. Trans with Improved Internals	NAUTO	1.4 - 3.4	1.4 - 3.4	1.4 - 3.4	1.4 - 3.4
Dual Clutch or Automated Manual Transmission	DCTAM	2.7 - 4.1	2.7 - 4.1	2.7 - 4.1	2.7 - 4.1
Power Split Hybrid	PSHEV	14.6 - 15.2	14.6 - 15.0	13.1 - 14.6	13.7 - 15.7
2-Mode Hybrid	2MHEV	n.a.	n.a.	n.a.	n.a.
Plug-in Hybrid	PHEV	62 - 65	62 - 65	61 - 65	n.a.
Material Substitution (1%)	MS1	n.a.	n.a.	n.a.	n.a.
Material Substitution (2%)	MS2	n.a.	n.a.	n.a.	n.a.
Material Substitution (5%)	MS5	n.a.	n.a.	n.a.	n.a.
Low Rolling Resistance Tires	ROLL	n.a.	n.a.	n.a.	n.a.
Low Drag Brakes	LDB	n.a.	n.a.	n.a.	n.a.
Secondary Axle Disconnect	SAX	1.0 - 1.5	1.0 - 1.5	1.0 - 1.5	1.0 - 1.5
Aero Drag Reduction	AERO	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0

Table IV-20. Technology Incremental Effectiveness Estimates, Light Trucks

VEHICLE TECHNOLOGY INCREMENTAL FUEL CONSUMPTION REDUCTION (-%) BY VEHICLE TECHNOLOGY CLASS - LIGHT TRUCKS					
		Minivan LT	Small LT	Midsize LT	Large LT
Nominal Baseline Engine (For Cost Basis)		V6	Inline 4	V6	V8
Low Friction Lubricants	LUB	0.5	0.5	0.5	0.5
Engine Friction Reduction	EFR	1.0 - 2.0	1.0 - 2.0	1.0 - 2.0	1.0 - 2.0
VVT - Coupled Cam Phasing (CCP) on SOHC	CCPS	1.0 - 3.0	1.0 - 3.0	1.0 - 3.0	1.0 - 3.0
Discrete Variable Valve Lift (DVVL) on SOHC	DVVLS	1.0 - 3.0	1.0 - 3.0	1.0 - 3.0	1.0 - 3.0
Cylinder Deactivation on SOHC	DEACS	2.5 - 3.0	n.a.	2.5 - 3.0	2.5 - 3.0
VVT - Intake Cam Phasing (ICP)	ICP	1.0 - 2.0	1.0 - 2.0	1.0 - 2.0	1.0 - 2.0
VVT - Dual Cam Phasing (DCP)	DCP	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Discrete Variable Valve Lift (DVVL) on DOHC	DVVLD	1.0 - 3.0	1.0 - 3.0	1.0 - 3.0	1.0 - 3.0
Continuously Variable Valve Lift (CVVL)	CVVL	1.5 - 3.5	1.5 - 3.5	1.5 - 3.5	1.5 - 3.5
Cylinder Deactivation on DOHC	DEACD	0 - 0.5	n.a.	0 - 0.5	0 - 0.5
Cylinder Deactivation on OHV	DEACO	3.9 - 5.5	n.a.	3.9 - 5.5	3.9 - 5.5
VVT - Coupled Cam Phasing (CCP) on OHV	CCPO	1.0 - 1.5	1.0 - 1.5	1.0 - 1.5	1.0 - 1.5
Discrete Variable Valve Lift (DVVL) on OHV	DVVLO	0.5 - 2.6	0.5 - 2.6	0.5 - 2.6	0.5 - 2.6
Conversion to DOHC with DCP	CDOHC	1.0 - 2.6	1.0 - 2.6	1.0 - 2.6	1.0 - 2.6
Stoichiometric Gasoline Direct Injection (GDI)	SGDI	1.9 - 2.9	1.9 - 2.9	1.9 - 2.9	1.9 - 2.9
Combustion Restart	CBRST	1.8 - 2.4	1.8 - 2.4	1.8 - 2.4	1.8 - 2.4
Turbocharging and Downsizing	TRBDS	2.1 - 2.2	4.5 - 5.2	2.1 - 2.2	2.1 - 2.2
Exhaust Gas Recirculation (EGR) Boost	EGRB	3.9 - 4.0	3.9 - 4.0	3.9 - 4.0	3.9 - 4.0
Conversion to Diesel following CBRST	DSLC	11.1 - 12.0	13.8 - 14.2	9.9 - 12.0	10.0 - 10.9
Conversion to Diesel following TRBDS	DSLT	5.3 - 6.5	5.3 - 6.5	4.0 - 6.5	4.0 - 5.3
Electric Power Steering	EPS	1.0 - 2.0	1.0 - 2.0	1.0 - 2.0	n.a.
Improved Accessories	IACC	1.0 - 2.0	1.0 - 2.0	n.a.	n.a.
12V Micro-Hybrid	MHEV	3.4 - 4.0	1.0 - 2.9	3.4 - 4.0	n.a.
Higher Voltage/Improved Alternator	HVIA	0.2 - 0.6	0.2 - 0.9	0.2 - 0.6	n.a.
Integrated Starter Generator (Belt/Crank)	ISG	5.7 - 6.5	5.7 - 6.5	5.7 - 6.5	n.a.
6-Speed Manual/Improved Internals	6MAN	0.5	0.5	0.5	0.5
Improved Auto. Trans. Controls/Externals	IATC	1.5 - 2.5	1.5 - 2.5	1.5 - 2.5	1.5 - 2.5
Continuously Variable Transmission	CVT	0.7 - 2.0	0.7 - 2.0	n.a.	n.a.
6/7/8-Speed Auto. Trans with Improved Internals	NAUTO	1.4 - 3.4	1.4 - 3.4	1.4 - 3.4	1.4 - 3.4
Dual Clutch or Automated Manual Transmission	DCTAM	2.7 - 4.1	2.7 - 4.1	2.7 - 4.1	2.7 - 4.1
Power Split Hybrid	PSHEV	11.8 - 12.8	13.5 - 13.9	13.3 - 16.2	n.a.
2-Mode Hybrid	2MHEV	n.a.	(1.5) - 4.3	(0.3) - 2.9	7.9 - 8.7
Plug-in Hybrid	PHEV	n.a.	61 - 63	n.a.	n.a.
Material Substitution (1%)	MS1	n.a.	n.a.	0.4	0.4
Material Substitution (2%)	MS2	n.a.	n.a.	0.4	0.4
Material Substitution (5%)	MS5	n.a.	n.a.	1.0	1.0
Low Rolling Resistance Tires	ROLL	1.0 - 2.0	1.0 - 2.0	1.0 - 2.0	n.a.
Low Drag Brakes	LDB	n.a.	n.a.	0.5 - 1.0	0.5 - 1.0
Secondary Axle Disconnect	SAX	1.0 - 1.5	1.0 - 1.5	1.0 - 1.5	1.0 - 1.5
Aero Drag Reduction	AERO	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0

The tables representing the Volpe model input files for approximate net (accumulated) technology costs by vehicle subclass are presented below. The tables have been divided into passenger cars, performance passenger cars, and light trucks to make them easier to read.

Table IV-21. Approximate Net (Accumulated) Technology Costs, Passenger Cars

APPROXIMATE RETAIL PRICE EQUIVALENT NET COSTS PER VEHICLE ($) BY VEHICLE CLASS TO KEY TECHNOLOGIES (Rounded to nearest $100)				
Final Technology (As compared to baseline vehicle before any technologies are applied)	Subcompact Car	Compact Car	Midsize Car	Large Car
Stoichiometric Gas Direct Injection (SGDI)	600 - 1,100	600 - 1,100	600 - 1,100	1,000 - 1,900
Turbocharge and Downsize (TRBDS)	2,000 - 2,600	2,000 - 2,600	2,000 - 2,600	1,900 - 2,700
Diesel Engine (DSLT/DSLC)	4,000	4,000	4,000	5,600
Dual Clutch Transmission (DCTAM)	500	500	600	600
Integrated Starter Generator Mild-hybrid (ISG)	2,400 - 2,500	2,800	3,000 - 3,100	3,200 - 3,300
Power Split Hybrid (PSHEV)	4,300	4,900	5,600	6,200
Two-Mode Hybrid (2MHEV)	n.a.	n.a.	n.a.	n.a.
Plug-in Hybrid (PHEV)	22,500	26,700	30,000	n.a.

Table IV-22. Approximate Net (Accumulated) Technology Costs, Performance Passenger Cars

APPROXIMATE RETAIL PRICE EQUIVALENT NET COSTS PER VEHICLE ($) BY VEHICLE CLASS TO KEY TECHNOLOGIES (Rounded to nearest $100)				
Final Technology (As compared to baseline vehicle before any technologies are applied)	Performance Subcompact Car	Performance Compact Car	Performance Midsize Car	Performance Large Car
Stoichiometric Gas Direct Injection (SGDI)	600 - 1,100	1,000 - 1,700	1,000 - 1,900	1,200 - 2,400
Turbocharge and Downsize (TRBDS)	2,000 - 2,600	1,900 - 2,700	1,900 - 2,700	2,600 - 3,700
Diesel Engine (DSLT/DSLC)	4,000	5,600	5,600	7,000
Dual Clutch Transmission (DCTAM)	600	600	600	600
Integrated Starter Generator Mild-hybrid (ISG)	2,500 - 2,700	2,900	3,000 - 3,100	3,300
Power Split Hybrid (PSHEV)	5,900	6,400	7,500	8,800
Two-Mode Hybrid (2MHEV)	n.a.	n.a.	n.a.	n.a.
Plug-in Hybrid (PHEV)	26,800	30,100	33,600	n.a.

Table IV-23. Approximate Net (Accumulated) Technology Costs, Light Trucks

APPROXIMATE RETAIL PRICE EQUIVALENT NET COSTS PER VEHICLE ($) BY VEHICLE CLASS TO KEY TECHNOLOGIES (Rounded to nearest $100)				
Final Technology (As compared to baseline vehicle before any technologies are applied)	Minivan LT	Small LT	Midsize LT	Large LT
Stoichiometric Gas Direct Injection (SGDI)	1,000 - 1,900	600 - 1,100	1,000 - 1,900	1,200 - 2,400
Turbocharge and Downsize (TRBDS)	1,900 - 2,700	2,000 - 2,600	1,900 - 2,700	2,600 - 3,700
Diesel Engine (DSLT/DSLC)	5,600	4,000	5,600	7,000
Dual Clutch Transmission (DCTAM)	600	600	600	600
Integrated Starter Generator Mild-hybrid (ISG)	3,200 - 3,300	2,800 - 2,900	3,200	n.a.
Power Split Hybrid (PSHEV)	6,200	5,200	6,400	n.a.
Two-Mode Hybrid (2MHEV)	n.a.	9,800	12,100	15,300
Plug-in Hybrid (PHEV)	n.a.	27,500	n.a.	n.a.

The tables representing the Volpe model input files for approximate net (accumulated) technology effectiveness values by vehicle subclass are presented below. The tables have been divided into passenger cars, performance passenger cars, and light trucks to make them easier to read.

Table IV-24. Approximate Net Technology Effectiveness, Passenger Cars

NET EFFECTIVENESS ESTIMATES FUEL CONSUMPTION REDUCTION PER VEHICLE (-%) BY VEHICLE CLASS TO KEY TECHNOLOGIES (Rounded to nearest 1/2%)				
Final Technology (As compared to baseline vehicle before any technologies are applied)	Subcompact Car	Compact Car	Midsize Car	Large Car
Stoichiometric Gas Direct Injection (SGDI)	5.0 - 13.0	5.0 - 13.0	5.0 - 13.0	7.0 - 14.0
Turbocharge and Downsize (TRBDS)	11.0 - 17.5	11.0 - 17.5	11.0 - 17.5	11.0 - 17.5
Diesel Engine (DSLT/DSLC)	21.0 - 26.0	21.0 - 26.0	20.0 - 25.0	20.0 - 25.0
Dual Clutch Transmission (DCTAM)	8.0 - 13.0	8.0 - 13.0	5.5 - 9.5	5.5 - 9.5
Integrated Starter Generator Mild-hybrid (ISG)	8.5 - 13.5	8.5 - 13.5	11.0 - 14.5	11.0 - 14.5
Power Split Hybrid (PSHEV)	23.0 - 28.5	23.0 - 28.5	23.0 - 28.5	23.0 - 28.5
Two-Mode Hybrid (2MHEV)	n.a.	n.a.	n.a.	n.a.
Plug-in Hybrid (HEV)	65.0 - 69.5	65.0 - 69.5	65.0 - 69.5	n.a.

Table IV-25. Approximate Net Technology Effectiveness, Performance Passenger Cars

APPROXIMATE NET EFFECTIVENESS (FC REDUCTION) PER VEHICLE (-%) BY VEHICLE CLASS TO KEY TECHNOLOGIES (Rounded to nearest 1/2%)				
Final Technology (As compared to baseline vehicle before any technologies are applied)	Performance Subcompact Car	Performance Compact Car	Performance Midsize Car	Performance Large Car
Stoichiometric Gas Direct Injection (SGDI)	5.0 - 13.0	7.0 - 14.0	7.0 - 14.0	7.0 - 14.0
Turbocharge and Downsize (TRBDS)	11.0 - 17.0	11.0 - 17.0	11.0 - 17.0	11.0 - 17.0
Diesel Engine (DSLT/DSLC)	21.0 - 26.0	21.0 - 26.0	20.0 - 25.0	20.0 - 25.0
Dual Clutch Transmission (DCTAM)	5.5 - 9.5	5.5 - 9.5	5.5 - 9.5	5.5 - 9.5
Integrated Starter Generator Mild-hybrid (ISG)	5.0 - 10.0	5.0 - 10.0	7.0 - 10.0	7.0 - 10.0
Power Split Hybrid (PSHEV)	21.0 - 26.5	21.0 - 26.5	21.0 - 26.5	21.0 - 26.5
Two-Mode Hybrid (2MHEV)	n.a.	n.a.	n.a.	n.a.
Plug-in Hybrid (HEV)	65.0 - 69.5	65.0 - 69.5	65.0 - 69.5	n.a.

Table IV-26. Approximate Net Technology Effectiveness, Light Trucks

APPROXIMATE NET EFFECTIVENESS (FC REDUCTION) PER VEHICLE (-%) BY VEHICLE CLASS TO KEY TECHNOLOGIES (Rounded to nearest 1/2%)				
Final Technology (As compared to baseline vehicle before any technologies are applied)	Minivan LT	Small LT	Midsize LT	Large LT
Stoichiometric Gas Direct Injection (SGDI)	7.0 - 14.0	4.5 - 13.0	7.0 - 14.0	7.0 - 14.0
Turbocharge and Downsize (TRBDS)	11.0 - 17.5	11.0 - 17.5	11.0 - 17.5	11.0 - 17.5
Diesel Engine (DSLT/DSLC)	20.0 - 25.0	20.0 - 25.0	20.0 - 24.0	19.0 - 24.0
Dual Clutch Transmission (DCTAM)	5.5 - 9.5	5.5 - 9.5	5.5 - 9.5	5.5 - 9.5
Integrated Starter Generator Mild-hybrid (ISG)	11.0 -14.5	8.5 - 13.5	10.0 - 12.5	n.a.
Power Split Hybrid (PSHEV)	23.0 - 28.5	23.0 - 28.5	23.0 - 28.5	n.a.
Two-Mode Hybrid (2MHEV)	n.a.	17.5 - 21.0	17.5 - 21.0	13.5 - 17.0
Plug-in Hybrid (HEV)	n.a.	65.0 - 69.5	n.a.	n.a.

V. Economic assumptions used in NHTSA's analysis

A. Introduction: how NHTSA uses the economic assumptions in its analysis

NHTSA's analysis of alternative CAFE standards for model year 2011-15 passenger cars and light trucks relies on a range of market information, estimates of the cost and effectiveness of technologies to increase fuel economy, forecasts of critical economic variables, and estimates of the values of important behavioral parameters. This section describes the sources NHTSA has relied upon to obtain this information, as well as how the agency developed the specific parameter values used in the analysis. Like the product plan information it obtains from vehicle manufacturers, these economic variables, forecasts, and parameter values play important roles in determining the level of CAFE standards, although some variables have larger impacts on the final standards than others.

As discussed above, the Volpe model uses the estimates of the costs and effectiveness of individual technologies to simulate the improvements manufacturers could elect to make to the fuel economy of their individual models in order to comply with higher CAFE standards at the lowest cost, and to estimate each manufacturer's total costs for meeting new standards. To calculate the reductions in fuel use over the lifetime of each car and light truck model from the resulting increases in fuel economy, the model then combines those increases with estimates of the fraction of cars and light trucks that remain in service at different ages, the number of miles they are driven at each age, and the size of the fuel economy rebound effect. Forecasts of future fuel prices are then applied to these fuel savings to estimate their economic value during each year the vehicles affected by the higher CAFE standards are projected to remain in service. The Volpe model also uses estimates of the fractions of fuel savings that will reduce U.S. imports of crude petroleum and refined fuel to estimate the reduction in economic externalities that result from U.S. imports.

Using emission rates per mile driven by different types of vehicles or per gallon of fuel consumed, together with estimates of emissions that occur within the U.S. in the process of refining and distributing fuel, the Volpe model calculates changes in emissions of regulated (or criteria) air pollutants and carbon dioxide (CO_2), the main greenhouse gas emitted during fuel production and vehicle use. These are combined with estimates of the economic damages to human health and property caused by regulated air pollutants, and by projected future changes in the global climate resulting from increases CO_2 emissions, to estimate the benefits from the resulting reductions in emissions. Finally, the model calculates benefits to vehicle owners from having to refuel less frequently based on the estimated values of vehicle occupants' time, the decline in vehicle operating costs due to lower fuel consumption, and the increase in mobility afforded by added rebound-effect driving.

As the following discussion makes clear, the costs and effectiveness of fuel economy technologies, forecasts of future gasoline prices, and the discount rate applied to future benefits have the largest influence over the level of the standards. In contrast, estimates of the value of economic externalities generated by U.S. petroleum imports, the fuel economy rebound effect, the gap between test and on-road fuel economy, and the economic values of reducing emissions of greenhouse gases and regulated air pollutants each have more modest effects on determining the final CAFE standards. NHTSA has analyzed the sensitivity of the final standards and their resulting benefits to plausible variation in the most important of these inputs, both by varying their values individually and conducting a Monte Carlo-type analysis of joint variation in their probably values.

For the reader's reference, Table V-1 below summarizes the values of many of the variables NHTSA uses to estimate the costs, fuel savings, and resulting economic benefits from increases in car and light truck CAFE standards.

Table V-1. Economic Values for Benefits Computations (2007$)

Fuel Prices (average retail gasoline price per gallon, 2011-30)	$3.33
Discount Rates Applied to Future Benefits	
Reductions in CO_2 Emissions	3%
Other Benefits	7%
Economic Costs of Oil Imports ($/gallon)	
"Monopsony" Component	$0.27
Price Shock Component	$0.12
Total Economic Costs	$0.39
Fuel Economy Rebound Effect	15%
"Gap" between Test and On-Road mpg	20%
Value of Refueling Time ($/vehicle-hour)	$24.64
External Costs from Additional Automobile Use Due to "Rebound" Effect ($/vehicle-mile)	
Congestion	$0.054
Accidents	$0.023
Noise	$0.001
Total External Costs	$0.078
External Costs from Additional Light Truck Use Due to "Rebound" Effect ($/vehicle-mile)	
Congestion	$0.048
Accidents	$0.026
Noise	$0.001
Total External Costs	$0.075
Emission Damage Costs	
Carbon Monoxide ($/ton)	$ 0
Volatile Organic Compounds ($/ton)	$1,700
Nitrogen Oxides ($/ton)	$4,000
Particulate Matter ($/ton)	$168,000
Sulfur Dioxide ($/ton)	$16,000
Carbon Dioxide ($/metric ton)	$ 2.00
Annual Increase in CO_2 Damage Cost	2.4%

B. What economic assumptions does NHTSA use in its analysis?

1. Costs of fuel economy technologies

NHTSA developed detailed estimates for the NPRM of the costs of applying fuel economy-improving technologies to vehicle models for use in analyzing the impacts of the alternative standards considered in this rulemaking. NHTSA explained that the NPRM estimates were based on those reported by the 2002 NAS Report analyzing costs for increasing fuel economy, but NHTSA modified those costs for purposes of this analysis as a result of extensive consultations among engineers from NHTSA, EPA, and the Volpe Center. As part of this process, NHTSA also developed varying cost estimates for applying certain fuel economy technologies to vehicles of different sizes and body styles. NHTSA stated that it may adjust these cost estimates based on comments received to the NPRM.

NHTSA explained that the technology cost estimates used in the agency's analysis are intended to represent manufacturers' direct costs for high-volume production of vehicles with these technologies and sufficient experience with their application so that all cost reductions due to "learning curve" effects were fully realized. However, NHTSA recognized that manufacturers may also incur additional corporate overhead, marketing, or distribution and selling expenses as a consequence of their efforts to improve the fuel economy of individual vehicle models and their overall product lines.

In order to account for these additional costs, NHTSA applied an indirect cost multiplier in the NPRM of 1.5 to the estimate of the vehicle manufacturers' direct costs for producing or acquiring each fuel economy-improving technology. Historically, NHTSA used an almost identical multiplier, 1.51, for the markup from variable costs or direct manufacturing costs to consumer costs. The markup takes into account fixed costs, burden, manufacturer's profit, and dealers' profit. NHTSA's methodology for determining this markup was peer-reviewed in 2006.[200]

NHTSA stated in the NPRM that the estimate of 1.5 was confirmed by Argonne National Laboratory in a recent review of vehicle manufacturers' indirect costs. The Argonne study was specifically intended to improve the accuracy of future cost estimates for production of vehicles that achieve high fuel economy by employing many of the

[200] *See* Docket No. NHTSA-2007-27453, Item 4.

same advanced technologies considered in NHTSA's analysis.[201] Thus, NHTSA stated that it believed that applying a multiplier of 1.5 to direct manufacturing costs to reflect manufacturers' increased indirect costs for deploying advanced fuel economy technologies is appropriate for use in the analysis for this rulemaking. NHTSA describes this multiplier above as the Retail Price Equivalent factor, or RPE factor.

Some commenters argued that NHTSA's mark-up factor of 1.5 was too high. NESCAUM commented that NHTSA had relied on 2004 NESCCAF study as one source for its technology estimates, but appeared to have incorrectly reported information from that study with regard to the mark-up factor (retail price equivalent, or RPE).[202] NESCAUM stated that in the report, entitled "Reducing Greenhouse Gas Emissions from Light-Duty Motor Vehicles," NESCCAF only used a 1.4 RPE, but "NHTSA applies a 1.5 retail price equivalent (RPE) factor to the manufacturer costs presented in Appendix C of the NESCCAF report, and at other times uses a 1.4 RPE – and presents both costs as NESCCAF costs." NESCAUM argued that "The reporting of costs using the 1.5 multiplier as NESCCAF costs is incorrect and leads to uncertainty as to how the costs were developed."[203] NESCAUM stated that "All reported costs and benefits, attributed to NESCCAF by NHTSA, [should] be reviewed carefully for errors and amended accordingly." CARB also stated that there was "inconsistency…in the treatment of

[201] Vyas, Anant, Dan Santini, and Roy Cuenca, *Comparison of Indirect Cost Multipliers for Vehicle Manufacturing*, Center for Transportation Research, Argonne National Laboratory, April 2000. *Available at* http://www.transportation.anl.gov/pdfs/TA/57.pdf (last accessed August 14, 2008).

[202] NESCAUM stated that NESCCAF, or Northeast States Center for a Clean Air Future, is an affiliate organization of NESCAUM.

[203] NESCAUM gave a specific example with regard to the cost of a turbocharger, as follows:

> NHTSA states the NESCCAF turbocharger cost is $600. In this case, NHTSA applied a 1.5 RPE factor to manufacturer costs presented in Appendix C of the NESCCAF report to arrive at the $600 cost. This is different from the cost that NESCCAF developed. Conversely, on page 24369 of the Federal Register notice, NHTSA accurately states the NESCCAF cylinder deactivation costs ranged from $161 to $210. This cost accurately reflects manufacturer costs presented in Appendix C of the NESCCAF report, multiplied by the 1.4 retail price equivalent used by NESCCAF.

NESCCAF costs," because NHTSA sometimes used a 1.5 markup and sometimes 1.4, and argued that "These errors in citing the NESCCAF report raise doubts about whether RPE costs from other sources are cited accurately."

CARB further commented that NHTSA had inconsistently added costs for the engineering effort required to add some technologies to vehicles, when those costs should have been covered by the RPE markup. CARB cited NHTSA's language in the NPRM that "manufacturers' actual costs for applying these technologies to specific vehicle models are likely to include *additional outlays for accompanying design or engineering changes to each model,* development and testing of prototype versions, recalibrating engine operating parameters, and integrating the technology with other attributes of the vehicle." (Emphasis added) CARB argued that adding additional costs for engineering effort to any technology amounted to double-counting. CARB also commented that NHTSA's methodology for determining the indirect cost markup is unsound, because "the cost to incorporate a technology is the same regardless of vehicle production," and because "manufacturers are moving toward global vehicle architectures in an effort to spread development costs across the largest volume of vehicles possible, thus reducing engineering costs." CARB argued that "The engineering cost methodology cited in the NPRM conflicts with this trend as well."

Other commenters argued that NHTSA's mark-up factor of 1.5 was too low. The Alliance commented that the RPE mark-up factor of 1.5 used by NHTSA is "far too low," and cited the Sierra Research report and a study by Wynn V. Bussman, submitted as an attachment by the Alliance, as concluding that "the best estimate for RPE is more on the order of 2.0." The Alliance argued that NHTSA's citation of the Argonne study as support for an RPE of 1.5 was incorrect and out of context, stating that "As both Bussman and Sierra noted, the Argonne National Laboratory recommended use of 2.0 as the RPE factor." The Alliance stated that the Argonne study had simply used a 1.5 RPE for outsourced components, because "Manufacturers that outsource components do not bear warranty and other costs under typical contractual arrangements." The Alliance argued that "A 1.5 RPE … is simply unrepresentative for components that are developed in house by the original equipment manufacturers ("OEMs")." The Alliance further argued that "Use of a 1.5 RPE for all purposes also glosses over the fact that outsourced components can nevertheless require significant integration expenditures from manufacturers putting together and selling entire vehicles."[204] Chrysler concurred separately with the Alliance that "NHTSA's use of an RPE of 1.5 does not adequately account for the full cost of implementing new technologies," and stated that an RPE of 2.0 "is the appropriate factor to use for new technologies."

The Alliance also commented that Bussman had "considered the literature on RPE factors extensively," and "concluded that studies that advised RPEs of approximately 1.5 were filled with errors and that when these errors were corrected, these studies also supported the conclusion that the proper RPE is 2.0." The Alliance concluded by arguing that the Sierra Research report had found that "some recent analyses of RPE are based on unrepresentative and unsustainable profit levels by manufacturers," and that "If realistic long-term profit rates are used, then the RPE increases from 2.0 to a range of 2.09 to 2.15."

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[204] The Alliance cited the Sierra Research report as stating that "…the 1.5 multiplier clearly does not apply to changes in engines, transmissions, or bodies in cases where the vehicle manufacturer designs and produces its own engines, transmissions, and bodies." Sierra Research report at 61.

NADA did not expressly agree or disagree with a mark-up factor of 1.5, but commented that since the NPRM states that the 1.5 multiplier includes "dealer profit" among other related additional costs, NHTSA "should review whether its estimates include *all* dealer costs-of-sales when calculating 'dealer profit' and the extent to which it has properly accounted for the finance costs consumers typically pay when purchasing new automobiles."

Agency response: NHTSA notes that the analysis for this final rule relies on entirely new cost estimates for fuel economy technologies that rely primarily on the 2008 Martec report and are not based on the 2004 NESCCAF study, so the issue of apparent inconsistency in the RPE factor applied to those estimates noted by NESCAUM and CARB is no longer relevant. The agency also notes that both the production and application of fuel economy-improving technologies include separate engineering cost components. Developing these technologies and readying them for high-volume production entails significant initial investments in product design and engineering, while as the NPRM pointed out, applying individual technologies to specific vehicle models can entail significant additional costs for accompanying engineering changes to its existing drive train, development and testing of prototype versions, recalibrating engine operating parameters, and integrating the technology with other attributes of the vehicle. While design and engineering costs for developing fuel economy-improving technologies are included the production cost estimates for individual technologies, additional engineering costs incurred by manufacturers in applying them to specific vehicle models are included in NHTSA's estimate of the RPE factor. Finally, the agency notes that its estimate of the RPE factor includes is consistent with high-volume production and application of fuel economy technologies, because it assumes that initial design and engineering costs to develop and begin production of these technologies will be recovered over large production volumes. Thus NHTSA believes that CARB's concerns about potential double-counting of engineering costs for developing and applying fuel economy technologies reflect a failure to recognize that engineering costs arise in both their development and application. The agency also believes that CARB's concern about whether NHTSA's RPE factor assumes the spreading of initial design and engineering costs for developing these technologies over insufficiently high production volumes is unfounded.

In response to the concerns expressed by the Alliance and others that NHTSA's RPE factor is too low, the agency notes that the RPE factor of 2.0 reported in the Argonne and Sierra Research studies includes various categories of production overhead costs (for product development and engineering, depreciation and amortization of production facilities, and warranty) that are included in NHTSA's estimates of production costs for fuel economy technologies. When applied to technology production costs defined to include these components, the agency's RPE factor of 1.5 is thus consistent with full recovery of these cost components. This conclusion is independent of whether overhead costs for developing and producing fuel economy technologies are initially borne by equipment suppliers or by vehicle manufacturers themselves. Thus NHTSA has continued to employ an RPE factor of 1.5 in its analysis for this final rule.

2. Potential opportunity costs of improved fuel economy

In the NPRM, NHTSA discussed the issue of whether achieving the fuel economy improvements required by alternative CAFE standards would require manufacturers to compromise the performance, carrying capacity, safety, or comfort of some vehicle models. If so, the resulting reduction in the value of those models to potential buyers would represent an additional cost of achieving the improvements in fuel economy required by stricter CAFE standards. While exact dollar values of these attributes to consumers are difficult to infer from vehicle purchase prices, changing vehicle attributes can affect the utility that vehicles provide to their owners, and thus their value to potential buyers.

NHTSA has approached this potential problem by developing tentative cost estimates for fuel economy-improving technologies that include any additional production costs necessary to maintain the product plan levels of performance, comfort, capacity, and safety of the models on which they are used. In doing so, NHTSA primarily followed the precedent established by the 2002 NAS Report, although the NPRM updated its assumptions as necessary for the purposes of the current rulemaking. The NAS Report estimated "constant performance and utility" costs for fuel economy technologies, and NHTSA used those as the basis for its further efforts to develop the initial technology costs employed in analyzing manufacturers' costs for complying with alternative CAFE standards.

NHTSA acknowledged the difficulty of estimating technology costs that include costs for the accompanying changes in vehicle design that are necessary to maintain performance, capacity, and utility. However, as NHTSA stated in the NPRM, the agency believes that the tentative cost estimates for fuel economy-improving technologies should be generally sufficient to prevent significant reductions in consumer welfare provided by vehicle models to which manufacturers apply those technologies. Nonetheless, the NPRM sought comment on alternative ways to address these issues.

NHTSA did not receive comments that explicitly addressed NHTSA's question of whether there are better ways for the agency to estimate technology costs that capture changes in vehicle design so that fuel economy can be improved while maintaining performance, capacity, and utility. Some comments, however, expressed concerns that the proposed CAFE standards, and more stringent CAFE standards generally, would prevent manufacturers from maintaining intended levels of performance, comfort, capacity, and/or safety of at least some of their vehicle models.

For example, the American Farm Bureau Federation commented on its concern that the proposed standards would result in "more expensive trucks that lack the power needed to perform the tasks required" of them by farmers, and that "trucks laden with expensive untested technologies may prove undependable and costly to repair." AFBF stated that farmers need trucks that can haul and tow heavy loads and trailers, which requires "heavy frames, strong engines, and adequate horsepower and torque." AFBF argued that the proposal would cause manufacturers either to downsize and reduce power in their vehicles, or to sell fewer powerful trucks and increase their cost, all of which would create hardship for farmers who need such trucks for their livelihoods.

NADA similarly suggested in its comments that the proposed standards could constrain the ability of light truck manufacturers to meet "market needs" for towing and hauling capability, as well as space and power. NADA also stated that manufacturers of small high-performance (*i.e.*, sports cars), might be forced by the stringency of the proposed standards to exit the market or reduce product offerings.

BMW expressed concern that the proposed footprint-based standards will "provide a disincentive to install safety devices on vehicles," since "In general, safety devices add mass," and "additional mass will lead to higher fuel consumption." Thus, BMW argued, all manufacturers will think twice before adding safety equipment to a vehicle, in order not to hurt their chances of meeting the CAFE standards. Along those lines, BMW argued that its vehicles were "high feature-density vehicles," which it defined as "those that include extraordinary safety, comfort, and convenience features like electronic/advanced stability, braking, suspension, steering, lighting, and security controls." BMW stated that these vehicles "have a high mass per footprint density," and suggested that the proposed footprint-based standards provide manufacturers with a disincentive to continue offering this type of vehicle.

Agency response: The agency did not include a reduction in performance as one of the countermeasures that the manufacturers could take to meet the final rule for two main reasons. First, the agency believes that manufacturers could meet the standards adopted in this final rule at the estimated compliance costs without noticeably affecting vehicle performance or utility. As noted previously, NHTSA's cost estimates for individual fuel economy-improving technologies are intended to include any additional production costs necessary to maintain the performance, comfort, capacity, and safety of the models on which they are used. The agency has reviewed its cost estimates for individual fuel economy technologies in detail, and is confident that they include sufficient allowances to prevent significant reductions in these critical attributes, and this in the utility that vehicle models to which manufacturers apply those technologies will provide to potential buyers.

Second, NHTSA believes that the commenters' concerns about potential opportunity costs for reduced vehicle performance and utility are largely unfounded. Manufacturers are technically capable of producing vehicles with reduced performance, as evidenced by the fact that most manufacturers offer otherwise similar vehicle models that feature a range of engine sizes, and thus different levels of power and performance. Although some manufacturers offer versions of the same vehicle model with a smaller engine in Europe than is sold in the United States, their decisions not to market these vehicles domestically demonstrates that they do not believe that they can produce and sell such vehicles to U.S. buyers in sufficient quantities to be profitable. This is presumably because in order to sell vehicles that do not meet U.S. buyers' preferences for power and performance, manufacturers would be required to discount their prices sufficiently to compensate for their lower levels of these attributes.

While it may be true that a manufacturer could produce lower-performance versions of its vehicle models at reduced costs compared to a higher-performance version of that same model, this does not make performance reduction a zero or negative cost compliance option. Manufacturers apparently estimate that the reduction in the values of lower-performing versions to their potential buyers exceeds their savings in manufacturing costs to produce them, since otherwise they would already produce and offer lower-performance versions of their existing models for sale. The net cost of reducing performance, which is measured by the difference between the reduced value of lower-performance models to buyers and manufacturers' cost savings for producing them, represents a cost of employing performance reduction as a compliance strategy.

Both manufacturers and NHTSA experience difficulty in determining how much value consumers place on performance, as well as in determining whether this value would remain stable over time. While NHTSA recognizes that there may be specific situations where performance reduction may be a cost-effective compliance strategy for certain manufacturers, the agency believes that the net cost of reducing performance must generally be comparable to or higher than that of technological approaches to fuel economy improvement. Thus the outcome of this rulemaking process is not significantly affected by omission of performance reduction as an explicit compliance strategy.

In response to BMW's comment that footprint-based standards may discourage manufacturers from offering safety and other features that increase vehicle weight, NHTSA notes that increased vehicle weight due to safety and other features will make it more difficult for manufacturers to meet any kind of CAFE standard, not just attribute-based standards. Further, NHTSA believes that manufacturers will continue to include features whose value to potential buyers exceeds manufacturers' costs for supplying them. Those costs will include any outlays for additional fuel economy technologies that are necessary to compensate for the fuel economy penalties imposed by features that add weight, and thus enable manufacturers to comply with higher CAFE standards. NHTSA notes, however, that buyers generally appear to value such features highly, as evidenced by the prices of car and light truck models on which they are featured, as well as by prices that manufacturers generally charge when they offer such features as options. Any increase in costs to achieve CAFE compliance that BMW or other manufacturers might experience as a result of providing these features likely should not, therefore, affect significantly the extent to which they are included as standard features or offered as optional features and purchased by vehicle buyers.

3. The on-road fuel economy 'gap'

NHTSA explained in the NPRM that actual fuel economy levels achieved by passenger cars and light trucks in on-road driving fall somewhat short of their levels measured under the laboratory-like test conditions that EPA uses to establish its published fuel economy ratings. In analyzing the fuel savings from alternative CAFE standards for previous light truck rulemakings, NHTSA adjusted the actual fuel economy performance of each light truck model downward by 15 percent from its rated value to reflect the expected size of this on-road fuel economy "gap."

However, in December 2006, EPA adopted changes to its regulations on fuel economy labeling which were intended to bring vehicles' rated fuel economy levels closer to their actual on-road fuel economy levels.[205] In its Final Rule, EPA estimated that actual on-road fuel economy for light-duty vehicles averages 20 percent lower than published fuel economy levels. For example, if the overall EPA fuel economy rating of a light truck is 20 mpg, the on-road fuel economy actually achieved by a typical driver of that vehicle is expected to be 16 mpg (20 mpg x 80%). In the NPRM, NHTSA employed EPA's revised estimate of this on-road fuel economy gap in its analysis of the fuel savings resulting from the proposed and alternative CAFE standards.

NHTSA received no explicit comments regarding the on-road fuel economy gap. CARB submitted a report by Greene *et al*. that addressed in-use fuel economy, but was completed prior to EPA's changes to its labeling regulations, and CARB did not indicate

[205] 71 FR 77871 (Dec. 27, 2006).

in its comments how this report was relevant to the CAFE rulemaking.[206] The report by Sierra Research included by the Alliance did not comment specifically on NHTSA's use of EPA's estimate of the on-road fuel economy gap, but employed different "adjustment factors" "to translate CAFE to customer service fuel economy," using a factor of 0.85 to "adjust[] the 'composite' CAFE value to what consumers are expected to achieve in customer service when the 'city' mpg is discounted by 10% and the 'highway' mpg is discounted by 22%." Sierra Research also used a 0.82 adjustment factor for hybrid vehicles. However, these estimates were presented as part of Sierra's analysis with no explanation of how they were derived, nor why they differed from EPA's estimate of 20 percent (which was available at the time when Sierra developed its report).[207] Moreover, neither Sierra nor the Alliance suggested that NHTSA use these numbers instead of EPA's for analyzing fuel savings.

Because no substantive comments were received on this issue, and because no new information on the magnitude of the on-road fuel economy gap has come to NHTSA's attention since the NPRM was published, NHTSA has continued to use the EPA estimate of a 20 percent on-road fuel economy gap for purposes of this final rule.

4. Fuel prices and the value of saving fuel

NHTSA explained in the NPRM that projected future fuel prices are a critical input into the economic analysis of alternative CAFE standards, because they determine the value of fuel savings both to new vehicle buyers and to society. NHTSA relied on the most recent fuel price projections from the U.S. Energy Information Administration's (EIA) *Annual Energy Outlook* (AEO) in analyzing the proposed standards. Specifically,

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[206] David L. Greene *et al.*, "Analysis of In-Use Fuel Economy Shortfall Based on Voluntarily Reported MPG Estimates," 2005. *Available at* Docket No. NHTSA-2008-0089-0173.11.

[207] Sierra Research report, at 96-97. *Available at* Docket No. NHTSA-2008-0089-0179.1, Attachment 2.

the agency used the AEO 2008 Early Release forecasts of inflation-adjusted (constant-dollar) retail gasoline and diesel fuel prices, which NHTSA stated represent the most up-to-date estimate of the most likely course of future prices for petroleum products.[208] Federal government agencies generally use EIA's projections in their assessments of future energy-related policies.

The retail fuel price forecasts presented in AEO 2008 span the period from 2008 through 2030. Measured in constant 2006 dollars, the Reference Case forecast of retail gasoline prices during calendar year 2020 in the Early Release was $2.36 per gallon, rising gradually to $2.51 by the year 2030 (these values include federal, state, and local taxes). However, NHTSA explained in the NPRM that valuing fuel savings over the 36-year maximum lifetime of light trucks assumed in this analysis required fuel price forecasts that extended through 2050, the last year during which a significant number of MY 2015 vehicles would remain in service.[209] To obtain fuel price forecasts for the years 2031 through 2050, NHTSA assumed that retail fuel prices would remain constant (in 2006 dollars) from 2031 through 2050.

NHTSA stated that the value to buyers of passenger cars and light trucks of fuel savings resulting from improved fuel economy is determined by the retail price of fuel, which includes federal, state, and any local taxes imposed on fuel sales. Total taxes on gasoline averaged $0.47 per gallon during 2006, while those levied on diesel averaged

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[208] U.S. Department of Energy, Energy Information Administration, *Annual Energy Outlook 2008*, *Early Release*, Reference Case Table 12. *Available at* http://www.eia.doe.gov/oiaf/aeo/pdf/aeotab_12.pdf (last accessed October 10, 2008). EIA released the full AEO 2008 in June 2008, which NHTSA stated in the NPRM it would use in the final rule. EIA explained upon releasing the full AEO 2008 that it had been updated from the Early Release to reflect EIA's expectations of the effect of EISA, which was enacted after the Early Release was made public. The full AEO 2008 is a*vailable at* http://www.eia.doe.gov/oiaf/aeo/pdf/0383(2008).pdf (last accessed October 10, 2008).

[209] The agency defines the maximum lifetime of vehicles as the highest age at which more than 2 percent of those originally produced during a model year remain in service. For recent model years, this age has typically been 25 years for passenger cars and 36 years for light trucks.

$0.53. These figures include federal taxes plus the sales-weighted average of state fuel taxes. Because fuel taxes represent transfers of resources from fuel buyers to government agencies, however, rather than real resources that are consumed in the process of supplying or using fuel, NHTSA explained that their value must be deducted from retail fuel prices to determine the value of fuel savings resulting from more stringent CAFE standards to the U.S. economy.

In estimating the economy-wide or "social" value of fuel savings due to increasing CAFE levels, NHTSA assumed that current fuel taxes would remain constant in real or inflation-adjusted terms over the lifetimes of the vehicles being regulated. In effect, this assumed that the average value per gallon of taxes on gasoline and diesel fuel levied by all levels of government would rise at the rate of inflation over that period. This value was deducted from each future year's forecast of retail gasoline and diesel prices reported in the AEO 2008 Early Release to determine the social value of each gallon of fuel saved during that year as a result of improved fuel economy. Subtracting fuel taxes resulted in a projected value for saving gasoline of $1.83 per gallon during 2020, rising to $2.02 per gallon by the year 2030.

In conducting the preliminary uncertainty analysis of benefits and costs from alternative CAFE standards, as required by OMB, NHTSA also considered higher and lower forecasts of future fuel prices. The results of the sensitivity runs were made available in the PRIA. EIA includes a "High Price Case" and a "Low Price Case" in each annual edition of its AEO, which reflect uncertainties regarding future conditions in the world petroleum market and the U.S. fuel refining and distribution system. However, EIA does not attach specific probabilities to either its Reference Case forecast or these alternative cases; instead, the High Price and Low Price cases are intended to illustrate the range of uncertainty that exists.[210]

The AEO 2008 Early Release included only a Reference Case forecast of fuel prices and did not include the High and Low Price Cases, so NHTSA estimated high and low fuel prices corresponding to the AEO 2008 Reference Case forecast by assuming that high and low price forecasts would bear the same relationship to the Reference Case forecast as the High and Low Price cases in AEO 2007.[211] These alternative scenarios projected retail gasoline prices that range from a low of \$1.94 per gallon to a high of \$3.26 per gallon during 2020, and from \$2.03 to \$3.70 per gallon during 2030. In conjunction with NHTSA's assumption that fuel taxes would remain constant in real or inflation-adjusted terms over this period, these forecasts implied social values of fuel savings ranging from \$1.47 to \$2.79 per gallon during 2020, and from \$1.56 to \$3.23 per gallon in 2030.

NHTSA explained that EIA is widely recognized as an impartial and authoritative source of analysis and forecasts of U.S. energy production, consumption, and prices. EIA has published annual forecasts of energy prices and consumption levels for the U.S. economy since 1982 in its Annual Energy Outlooks. These forecasts have been widely

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[210] In AEO 2008, EIA explains the High Price Case as follows:

> The high price case assumes that non-OPEC conventional oil resources are less plentiful, and the overall costs of extraction are higher, than assumed in the reference case. The high price case also assumes that OPEC will choose to allow a decline in its market share to 38 percent of total world liquids production.

EIA also explains the Low Price Case as follows:

> The low price case assumes that non-OPEC conventional oil resources are more plentiful, and the overall costs of extraction are lower, than in the reference case, and that OPEC will choose to increase its market share to 45 percent.

AEO 2008, at 51. As the reader can see, there is nothing probabilistic about either the Low or High Price Case vis-à-vis the Reference Case.

[211] EIA, *Annual Energy Outlook 2007*, High Price Case, Table 12, *available at* http://www.eia.doe.gov/oiaf/aeo/pdf/aeohptab_12.pdf (last accessed October 10, 2008); and *Annual Energy Outlook 2007*, Low Price Case, Table 12, *available at* http://www.eia.doe.gov/oiaf/aeo/pdf/aeolptab_12.pdf (last accessed October 10, 2008).

relied upon by federal agencies for use in regulatory analysis and for other purposes. Since 1994, EIA's annual forecasts have been based upon the agency's National Energy Modeling System (NEMS), which includes detailed representation of supply pathways, sources of demand, and their interaction to determine prices for different forms of energy.

From 1982 through 1993, EIA's forecasts of world oil prices—the primary determinant of prices for gasoline, diesel, and other transportation fuels derived from petroleum—consistently overestimated actual prices during future years, often very significantly. Of the total of 119 forecasts of future world oil prices for the years 1985 through 2005 that EIA reported in its 1982-1993 editions of the AEO, 109 overestimated the subsequent actual values for those years, on average exceeding their corresponding actual values by 75 percent.

Since that time, however, EIA's forecasts of future world oil prices show a more mixed record for accuracy. The 1994-2005 editions of the AEO reported 91 separate forecasts of world oil prices for the years 1995-2005, of which 33 subsequently proved too high, while the remaining 58 underestimated actual prices. The average absolute (*i.e.*, regardless of its direction) error of these forecasts has been 21 percent, but over- and underestimates have tended to offset one another, so that on average EIA's more recent forecasts have underestimated actual world oil prices by 7 percent. Although both its overestimates and underestimates of future world oil prices for recent years have often been large, the most recent editions of the AEO have significantly underestimated petroleum prices during those years for which actual prices are now available.

However, NHTSA explained that it did not regard EIA's recent tendency to underestimate future prices for petroleum and refined products or the high level of current fuel prices as adequate justification to employ forecasts that differed from the Reference Case forecast presented in the Revised Early Release. NHTSA stated that this was particularly the case because this forecast was revised upward significantly since the initial release of AEO 2008, which in turn represented a major upward revision from EIA's fuel price forecast reported in AEO 2007. NHTSA also noted that retail gasoline prices across the U.S. had averaged $2.94 per gallon (expressed in 2005 dollars) for the first three months of 2008, slightly *below* EIA's revised forecast that gasoline prices will average $2.98 per gallon (also in 2005 dollars) throughout 2008.

NHTSA also considered that comparing different forecasts of world oil prices showed that the Reference Case forecast in AEO 2007 was actually the *highest* of all six publicly-available forecasts of world oil prices over the 2010-2030 time period.[212] NHTSA stated that because world petroleum prices are the primary determinant of retail prices for refined petroleum products such as transportation fuels, this suggested that the Reference Case forecast of U.S. fuel prices reported in AEO 2007 was likely to be the highest of those projected by major forecasting services. Further, as indicated above, EIA's most recent fuel price forecasts had been revised significantly upward from those projected in AEO 2007.

NHTSA received several thousand comments regarding its fuel price assumptions, mostly from individuals stating that current pump prices were much higher than EIA's Reference Case forecasts for future prices, and arguing that NHTSA should use higher fuel price assumptions for setting more stringent standards in the final rule. Summaries of the comments are presented below, grouped according to the following categories: (1) fuel prices have the largest effect on CAFE stringency of any of

[212] *See* http://www.eia.doe.gov/oiaf/archive/aeo07/pdf/forecast.pdf, Table 19, at 106.

NHTSA's economic assumptions; (2) EIA's Reference Case is too low compared to current gas prices; (3) current gas prices reflect a fundamental change in market conditions that will affect future prices; (4) why NHTSA is incorrect in its representation of the Reference Case as the "most likely course" of future oil prices; (5) NHTSA's sensitivity analysis in the PRIA indicates that higher fuel price assumptions will lead to more stringent standards; (6) EIA's tendency to underestimate in its fuel price forecasts; (7) EIA's recent changes to its Short-Term Energy Outlook; (8) recent public statements by administration officials on NHTSA's fuel price assumptions; (9) comments in favor of or neutral with regard to NHTSA's use of the Reference Case for its fuel price assumptions; (10) what fuel price assumptions NHTSA should use in setting the standards in the final rule; and (11) whether NHTSA should hold public hearings regarding its fuel price assumptions.

(1) Fuel prices have the largest effect on CAFE stringency of any of NHTSA's economic assumptions

Several commenters addressed the impact that fuel price assumptions have on NHTSA's analysis of the appropriate stringency of CAFE standards. The Members of Congress[213] stated that fuel prices have the largest effect of "all the factors that could be considered on how high standards could be raised," and that therefore "NHTSA's reliance on these highly unrealistic projections have the effect of artificially lowering the calculated 'maximum feasible' fuel economy standards that NHTSA is directed by law to

[213] Representative Markey authored this comment, which was signed by himself and 44 other Members of Congress. In this section, when the term "Members of Congress" is used, this is the comment to which the agency refers. Besides the comments received from several Representatives and Senators regarding the fuel prices employed in NHTSA's analysis for the NPRM, Representative Markey and Senator Cantwell additionally submitted bills in the House and Senate to require NHTSA to use fuel prices at least as high as EIA's High Price Case in setting CAFE standards. Representative Markey introduced H.R. 6643 on July 29, 2008, and Senator Cantwell introduced S. 3403 on July 31, 2008.

promulgate." CFA commented that the underestimation of fuel prices affected every part of NHTSA's analysis, while CBD stated that "The use of an inappropriate gasoline price projection greatly skews the results," and argued that "NHTSA has failed to analyze a gas price that even approaches today's prices, even in the sensitivity analysis." EDF argued that because "Underestimating future gasoline prices would lead NHTSA to undervalue the benefits to the U.S. and consumers from stronger fuel economy standards and set inefficiently low standards," NHTSA should "perform extensive sensitivity analyses using higher gas price assumptions, including but not limited to the EIA 'high price' projections."

(2) EIA's Reference Case is too low compared to current gas prices

Many commenters, including CBD, EDF, NRDC, Sierra Club *et al*., UCS, CFA, the Attorneys General, NACAA, NESCAUM, the mayor of the City of Key West, 45 Members of Congress, and several thousand individual commenters, stated that NHTSA's fuel price assumptions based on EIA's Reference Case were unreasonably low given current gasoline prices. CBD, for example, commented that NHTSA's use of the Reference Case fuel price estimates was "impossible to justify" given current fuel prices and the fact that "there is every indication that the price of oil will continue to increase over the short term." UCS argued that although NHTSA "point[ed] to recent increased fuel prices in AEO 2008 to justify use of AEO Reference Case data," the Reference case projection "still falls well below current gasoline prices." The Attorneys General commented that EIA's Reference Case forecast indicated future fuel prices much lower than current pump prices, and argued that "Unless NHTSA can provide publicly-available, mainstream documentation supporting an almost fifty percent drop from current prices, it must substantially re-calibrate those estimates." CFA and the Attorneys General further argued that even EIA's High Price Case was too low given current gasoline prices.

UCS also submitted nearly 7,000 form letters from individual citizens, which generally stated that gas prices in their home areas are currently significantly higher than NHTSA's fuel price assumptions for the proposed standards. The individual citizens commented that NHTSA should "correct" its fuel price assumptions for the final rule, so as not to "allow automakers to shave three to four miles per gallon off of their CAFE requirements," and so as to achieve "a fleet average of approximately 40 miles per gallon by 2020," which the letters stated "is both feasible and cost effective using technology already available." Sierra Club submitted over 3,000 form letters from individual citizens commenting similarly that NHTSA must use "realistic" fuel prices for setting the standards in the final rule, given pump prices at that time of approximately $4 per gallon.

(3) Current gas prices reflect a fundamental change in market conditions that will affect future prices

A number of commenters argued that changed oil market conditions both make EIA's Reference Case out-of-date and will continue to impact future fuel prices. Public Citizen stated that "Gas prices have been rising steadily since 2004," but that "the price increases in the last six to 12 months have been especially dramatic, rising by over a third in the past six months, and by nearly 170 percent in five years." NESCAUM commented that current fuel prices are due principally to "high global demand in a supply constricted market." NESCAUM further argued that "There is little expectation that the gap between supply and demand will be narrowed in the foreseeable future," so "the price of gasoline should remain … well above the mid-$2.00 range." CFA argued that "geopolitical factors" are responsible for gasoline prices setting "record after record," and stated that the proposed standards "do not reflect the fundamental reality of this crisis" because NHTSA's "analysis [is not based] on a value of gasoline savings that is consistent with the real world." ACEEE argued that the "adherence [to the Reference Case forecast] is not justified, given recent changes in the oil market." However, ACEEE also argued that the High Price Case does not "necessarily capture fully current understanding of how high fuel prices are likely to be in the coming decades."

CARB stated that NHTSA's use of EIA's Reference Case "border[s] on the absurd given recent fuel price hikes, [and] recent assessments that the price hikes are structural." CARB cited and attached to its comments an "Economic Letter" by the Federal Reserve Bank of Dallas from May 2008, which stated that factors such as changes in global oil supply and demand, the weakening of the dollar, and the fact that much global oil production takes place in "politically unstable regions…suggest the days of relatively cheap oil are over and the global economy faces a future of high energy prices."

NRDC stated that other analysts such as Goldman Sachs and Citigroup predict higher gasoline prices at least through 2011, due to lack of "spare capacity" in either OPEC or non-OPEC supply. NRDC also cited EIA's June 25, 2008 International Energy Outlook (IEO), which has a similar reference case to AEO 2008, and which NRDC quoted as stating that given "current market conditions, it appears that world oil prices are on a path that more closely resembles the projection in the high price case than in the reference case."[214]

(4) Why NHTSA is incorrect in its representation of the Reference Case as the "most likely course" of future oil prices

UCS stated that NHTSA was incorrect to assume that EIA's Reference Case "represent[s] the EIA's most up-to-date estimate of the most likely course of future prices for petroleum products," arguing that EIA itself does not refer to the Reference Case projection as the "most likely course," but states that the Reference Case merely "assumes that current policies affecting the energy sector remain unchanged throughout the projection period."

(5) NHTSA's sensitivity analysis in the PRIA indicates that higher fuel price assumptions will lead to more stringent standards

A number of commenters, including NACAA, Public Citizen, UCS, Sierra Club *et al*. and ACEEE, cited NHTSA's sensitivity analysis using the EIA High Price case as evidence that, as the Members of Congress stated, "demonstrates that the technology is available to cost-effectively achieve a much higher fleet wide fuel economy of nearly 35 mpg in 2015." CFA also stated that the High Price Case, which NHTSA ran as a sensitivity analysis using approximately $3.40 per gallon in 2008 dollars for 2015, was a "more realistic fuel price scenario, one that is not terribly high."

(6) EIA's tendency to underestimate in its fuel price forecasts

Several commenters, including UCS, CFA, NRDC, CARB, and the Attorneys General argued that EIA estimates were unreliable because EIA had underestimated in

[214] Energy Information Administration (2008) International Energy Outlook 2008: Complete Highlights. June 25.

recent years. CARB cited NHTSA's statement on page 24406 of the NPRM (73 FR 24406, May 2, 2008) noting "EIA's own recent tendency to underestimate," as CARB put it, as indication that NHTSA's use of EIA's Reference Case "border[s] on the absurd." CFA argued that "EIA's projections of gasoline prices have been consistently low and NHTSA was not obligated to use those projections." NRDC analyzed EIA's forecasting accuracy in greater detail, concluding that "The past five versions of the AEO have all underestimated actual gasoline prices," in both the Reference and High Case scenarios, and providing a table comparing EIA Reference and High Case projections from one year prior to the actual average recorded price in 2003-2008, which showed actual prices as consistently higher than EIA projections.

(7) EIA's recent changes to its Short-Term Energy Outlook

Several commenters stated that recent EIA upward revisions to its Short-Term Energy Outlook fuel price forecasts indicate that the longer-term Reference Case forecasts are also in need of upward revision. CARB, for example argued that recent EIA upward revisions to its short-term fuel price forecasts provide further evidence that "the assumptions underlying the EIA long-term gasoline projections have significantly changed since EIA last made those long-term projections." CFA similarly argued that EIA needed to adjust its long-term projections upward given recent increases in short-term projections, and stated that extrapolating EIA's short-term projections linearly results in a gasoline price in 2015 of $5.50 per gallon in 2008 dollars, which might not itself be reliable for purposes of setting CAFE standards, but is high enough to indicate that "EIA's high price scenario seems much more appropriate as the basis for NHTSA's economic analysis." NRDC and the Attorneys General made similar arguments. The

Attorneys General suggested that consequently, NHTSA should attempt to "obtain from EIA a truly current projection for gasoline prices over the relevant period" for use in the final rule.

(8) Recent public statements by administration officials on NHTSA's fuel price assumptions

Several commenters, including the Members of Congress, Public Citizen, UCS, NRDC, Sierra Club *et al*., and the Attorneys General cited testimony by EIA Administrator Guy Caruso on June 11, 2008, before the House Select Committee on Energy Independence and Global Warming, as evidence that, as the Attorneys General argued, "Even EIA agrees that NHTSA should have not used its reference case for the analysis in this rulemaking, but instead should have used EIA's high price case." Administrator Caruso testified, in response to a question regarding whether NHTSA should use EIA's High Price Case scenario to set CAFE standards, that "We're on the higher price path right now. If you were to ask me today what I would use, I would use the higher price."[215]

The Members of Congress and Sierra Club *et al*. also cited DOT Secretary Peters' May 17, 2008 statement that "As we look toward the finalization of the rule and look again what the average fuel costs are then, I think we're going to make more progress on the miles per gallon at a lower overall cost."[216] The commenters argued that this statement indicated an expectation that fuel prices used in the final rule would be higher than those used in the NPRM.

[215] UCS stated that this quote was taken from "Global Warming Hearing on the Future of Oil," June 11, 2008, which it stated was available online at http://speaker.house.gov/blog.
[216] Sierra Club cited David Shepardson, "Gas prices may spur revision of mpg plan," Detroit News Washington, Saturday, May 17, 2008, for this quote from Secretary Peters.

(9) Comments in favor of or neutral with regard to NHTSA's use of the Reference Case for its fuel price assumptions

NADA was the only commenter arguing directly in favor of NHTSA continuing "to rely on the most recent reference case fuel price projections of the U.S. Energy Information Administration's (EIA)." NADA recognized that EIA has over- and under-estimated fuel prices in the past, but argued that "Despite the inherent volatility or uncertainty of fuel prices, EIA and NHTSA would be remiss if they were to arbitrarily abandon the best models and data available or to use 'high' or 'low' price case projections that are inherently not probabilistic." NADA further commented that "the use of a high price case to justify unduly costly CAFE standards could lead to decreased new motor vehicle sales and a commensurate lower than projected rate of fuel energy savings and greenhouse gas reduction benefits."

The Alliance did not argue that NHTSA should use any particular fuel price in its economic assumptions, but commented that NHTSA should not conclude that "recent increases in gasoline prices nationwide" would justify more stringent CAFE standards. The Alliance cited the Sierra Research and NERA reports, which it said performed sensitivity analyses using all of EIA's price scenarios (Low, Reference, and High), and "did not find that use of the 'high' case significantly altered its conclusions about the feasibility of imposing much higher costs on manufacturers." Given that Sierra and NERA both concluded that the proposed standards were already too stringent, this result is hardly surprising.

(10) What fuel price assumptions NHTSA should use in setting the standards in the final rule

Many commenters, including UCS, CARB, ACEEE, Sierra Club *et al*., the Attorneys General, and the Members of Congress stated that NHTSA should set standards in the final rule using fuel price assumptions equivalent to at least EIA's High Price Case. Wisconsin DNR suggested that NHTSA use the "high price fuel scenario" in EIA's International Energy Outlook (2008) for a "suitable higher estimate from a recognized federal agency."[217]

Several commenters calling for "at least" the High Price Case also suggested other preferred alternatives. CARB suggested that NHTSA delay the final rule until "recent volatility has stabilized and EIA can provide its final 2008 estimates in February 2009." The Attorneys General suggested NHTSA obtain "relevant, up-to-date data directly" from EIA "specifically for the docket in this rulemaking," or "wait for EIA's public, final 2008 estimates, which are scheduled to be released in December." ACEEE commented that NHTSA should "Work with EIA to produce an up-to-date fuel price projection for purposes of the final rule…." Sierra Club *et al*. stated that NHTSA should also "examine other fuel price estimates, such as the oil futures market price predictions which project prices for a barrel of oil through 2016."

Other commenters suggested that NHTSA develop estimates based on current pump-price equivalents for its fuel price assumptions. Public Citizen commented that NHTSA should "base its final rulemaking on a more realistic estimate of future fuel price based on the high estimate and an at-the-pump price that pushes the standard in the

[217] Wisconsin DNR cited the source of the "high price fuel scenario" as "DOE-EIA Report #0484(2008)," which is EIA's International Energy Outlook (IEO) for 2008. NHTSA assumes that the commenter intended to cite this source, and not AEO 2008. However, EIA describes the forecasts of world oil prices – a primary determinant of U.S. fuel prices – reported in IEO 2008 as "…consistent with those in the *Annual Energy Outlook 2008*," and cites AEO2008 as the source for those oil price projections. See U.S. Energy Information Administration, *International Energy Outlook 2008*, Chapter 2, "Liquid Fuels," Figure 30 and accompanying text. Available at http://www.eia.doe.gov/oiaf/ieo/liquid_fuels.html (last accessed October 4, 2008).

direction of real-world gas prices." NESCAUM urged NHTSA "to reevaluate the effect of a wider range of gasoline prices to the $4.00 per gallon level and above," stating that it would raise standards. EDF stated that NHTSA must set standards that "reflect real world gas prices." CBD stated that "Today's gas price must form the starting point for the analysis, and calculations must be performed that consider the overwhelmingly likely scenario that gas prices will be significantly higher than the projections used in the NPRM." NRDC stated that because both the Reference and High Case scenarios are too low, "NHTSA should develop a plausible and realistic projection of future oil prices for use in determining maximum feasible fuel economy levels."

(11) Whether NHTSA should hold public hearings regarding its fuel price assumptions

Several commenters called for NHTSA to hold hearings regarding the appropriate stringency of CAFE standards, specifically in light of fuel prices. CFA, in requesting hearings, commented that EIA's Reference Case resulted in fuel prices that are too low, and "have consistently been used [in recent CAFE rulemakings] to undercut the use of existing technology to meet the statutory goals. CFA stated that "The use of more realistic fuel prices make more technology cost-justified and will result in higher standards." Environment America, National Wildlife Federation, NRDC, Pew Environment Group, Sierra Club, and UCS also submitted a joint comment requesting public hearings and citing NHTSA's fuel price assumptions. Like CFA, the commenters stated that using the EIA Reference Case "vastly undercuts the potential for higher fuel economy" and that "If NHTSA used more realistic gas prices, we could be on a path to achieving higher fuel economy that is both technologically achievable and cost effective."

Agency response: NHTSA has carefully considered available evidence, recent trends in petroleum and fuel prices, and the comments it received on the NPRM analysis. After doing so, NHTSA has decided to use EIA's High Price Case forecast in its final rule analysis and to determine the MY 2011-2015 CAFE standards. As NHTSA recognized in the NPRM, commenters are correct that projected future fuel prices have the largest effect of all the economic assumptions that NHTSA employs in determining benefits both to new vehicle buyers and to society, and thus on CAFE stringency. This is why it is vital that NHTSA base its fuel price assumptions on what it believes to be the most accurate forecast available that covers the expected lifetimes of MY 2011-2015 passenger cars and light trucks, which can extend up to 25-35 years from the date they are produced. The long time horizon of NHTSA's analysis also makes it critical that the agency not rely excessively on current price levels as an indicator of the prices that are likely to prevail over an extended future period. Instead, NHTSA relies largely on EIA's professional expertise and extensive experience in developing forecasts of future trends in energy prices, as do most other federal agencies.

In addition, NHTSA notes that several manufacturers employed fuel prices consistent with or exceeding the AEO 2008 High Price Case for the time period covered by the rulemaking in their revised product plan estimates of fuel economy and sales for individual models. If the agency employs fuel price forecasts that differ from those used by manufacturers, it may incorrectly attribute the fuel savings resulting from increased market demand for fuel economy to higher CAFE standards, or underestimate the fuel savings resulting from increased standards by attributing too much of the increase in fuel economy to higher market demand. As a consequence, the agency's estimates of fuel savings and economic benefits resulting from the standards adopted in this final rule are conservative, because they are likely to underestimate fuel savings attributable to the increase in fuel economy above its market-determined level that is required by CAFE standards.

Although some commenters suggested that NHTSA develop its own fuel price forecasts based on current pump prices, NHTSA does not believe that it has the independent capability to provide a more reliable prediction of future fuel prices, or that it would have the credibility of EIA's forecasts. NHTSA would have overvalued the benefits attributed to fuel savings, and thus have established excessively stringent standards, if the agency were to assume that fuel prices were likely to remain at their recent peak levels, but prices instead declined. On the other hand, if fuel prices continued to rise and NHTSA's fuel price assumptions underestimate the future value of fuel savings, the agency might have established insufficiently stringent CAFE standards. Moreover, applying current fuel prices would be speculative. While petroleum prices were generally rising at the time the NPRM was published, eventually reaching nearly $140 per barrel, since then global average prices for crude oil have declined to levels as low as $65 per barrel.[218] The recent extreme volatility in petroleum and fuel prices illustrates the danger in relying on current prices as an indicator of their likely future levels, and gives NHTSA greater confidence in relying on EIA's forecasts of future movements in fuel prices in response to changes in demand and supply conditions in the marketplace.

[218] Energy Information Administration, World Crude Oil Prices, data for weeks ended 7/4/2008 and 10/24/2008, available at http://tonto.eia.doe.gov/dnav/pet/pet_pri_wco_k_w.htm (last accessed November 1, 2008).

While NHTSA also agrees with the commenters that the sensitivity analysis demonstrates that higher CAFE standards could be established if higher fuel price assumptions were employed, the agency cannot simply choose to employ higher fuel price assumptions because it wishes to raise CAFE levels. Doing so would be inconsistent with the agency's approach of using what it concludes is the most reliable cost information available to use in establishing fuel economy standards. NHTSA recognizes that predicting future oil prices is difficult, particularly during periods when world economic conditions are as volatile as they are today. Nevertheless, in order to provide manufacturers with the lead-time needed to make changes to their vehicles to comply with the MY 2011-2015 passenger car and light truck standards, NHTSA cannot delay this rulemaking process to await EIA's next edition of the AEO, which is not expected to be released until February 2009. If the agency chose to do so, it would not be able to allow manufacturers sufficient lead time to comply with higher standards for model year 2011. This would represent a missed opportunity to realize fuel savings and the range of accompanying benefits, and could also lead to a failure to meet the requirements of EISA.

NHTSA continues to believe that EIA's fuel price forecasts as reported in its AEO represent the best source for our fuel price assumptions. NHTSA recognizes that other forecasts exist, but NHTSA believes the EIA forecasts are the product of an impartial government agency with considerable and long-standing expertise in this field. Any simple extrapolation of current retail fuel prices, which commenters recognize have shown extreme volatility in recent months, is likely to provide a considerably less reliable forecast of future prices than the current AEO. Each time EIA issues a new AEO, it considers recent and likely future developments in the world oil market, the effect of the current geopolitical situation on oil supply and prices, and conditions in the domestic fuel supply industry that affect pump prices.[219]

For example, the Overview section to AEO 2008 states that because EISA was passed between the Early Release and the time of publication for AEO 2008, EIA updated the Reference Case to reflect the impact it expected EISA to have on fuel prices. EIA also updated its projections for the AEO 2008 Reference Case "to better reflect trends that are expected to persist in the economy and in energy markets," including a lower projection for U.S. economic growth (a key determinant of U.S. energy demand), higher price projections for crude oil and refined petroleum products, slower projected growth in energy demand, higher forecasts of domestic oil production (particularly in the near term), and slower projected growth in U.S. oil imports.[220] Thus NHTSA is confident that EIA is aware of and has accounted reasonably for current political and economic conditions that are likely to affect future trends in fuel supply, demand, and retail prices.

Although a majority of commenters asserted that EIA's Reference Case forecast is likely to underestimate future fuel prices significantly, and that NHTSA's reliance on the Reference Case resulted in insufficiently stringent proposed CAFE standards, they did so in an environment when retail fuel prices were at or above $4.00 per gallon. Commenters stated that at a minimum, NHTSA should use EIA's High Price Case as the

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[219] AEO 2008 states as follows with regard to factors which EIA accounts for in developing the Reference Case:

> As noted in AEO2007, energy markets are changing in response to readily observable factors, which include, among others: higher energy prices; the growing influence of developing countries on worldwide energy requirements; recently enacted legislation and regulations in the United States; changing public perceptions on issues related to emissions of air pollutants and greenhouse gases and the use of alternative fuels and; and the economic viability of various energy technologies.

[220] AEO 2008 Overview, *at* http://www.eia.doe.gov/oiaf/aeo/overview.html (last accessed October 10, 2008).

source for its fuel price forecasts, primarily because those appeared to be more consistent with then-current fuel prices. NRDC cited EIA's own International Energy Outlook 2008, published the same month as the AEO 2008, which stated that given "…current market conditions, it appears that world oil prices are on a path that more closely resembles the projection in the high price case than in the reference case."[221] Commenters also cited EIA Administrator Caruso's June 2008 statement that "We're on the higher price path right now. If you were to ask me today what I would use, I would use the higher price." NHTSA also notes that several manufacturers in their confidential product plan submissions indicated that they had based their product plans on gas price estimates that were either between EIA's Reference and High Price Cases, or above even the High Price Case.

The AEO High Price Case is best understood in the context of its relationship to the Reference Case. EIA described the Reference Case as follows in AEO 2008:

> The reference case represents EIA's current judgment regarding exploration and development costs and accessibility of oil resources in non- OPEC countries. It also assumes that OPEC producers will choose to maintain their share of the market and will schedule investments in incremental production capacity so that OPEC's conventional oil production will represent about 40 percent of the world's total liquids production.[222]

In contrast, EIA describes its Low Price case in the following terms:

> The low price case assumes that OPEC countries will increase their conventional oil production to obtain approximately a 44-percent share of total world liquids production, and that conventional oil resources in non-OPEC countries will be more accessible and/or less costly to produce (as a result of technology advances, more attractive fiscal regimes, or both) than in the reference case. With these

[221] Energy Information Administration (2008) International Energy Outlook 2008: Complete Highlights. June 25.

[222] AEO 2008, at 199. *Available at* http://www.eia.doe.gov/oiaf/aeo/pdf/0383(2008).pdf (last accessed October 10, 2008).

> assumptions, non-OPEC conventional oil production is higher in the low price case than in the reference case.[223]

Finally, EIA describes its High Price case as follows:

> The high price case assumes that OPEC countries will continue to hold their production at approximately the current rate, sacrificing market share as global liquids production increases. It also assumes that oil resources in non-OPEC countries will be less accessible and/or more costly to produce than assumed in the reference case.[224]

As these descriptions emphasize, EIA's Low and High Price Cases are based on specific assumptions about the possible behavior of oil-producing countries and future developments affecting global demand for petroleum energy, and how these might differ from the behavior assumed in constructing its Reference Case. However, this distinction does not necessarily imply that EIA expects either its Low Price or High Price Case forecast to be more accurate than its Reference Case forecast, since EIA offers no assessment of which set of assumptions underlying its Low Price, Reference, and High Price cases it believes is most reliable.

EIA did recognize that world oil prices at the time the final version of AEO 2008 were above even those forecast in its High Price Case. However, it attributed this situation to short-term developments, most or all of which were likely to prove transitory, as evidenced by its statement in the Overview to AEO 2008:

> As a result of recent strong economic growth worldwide, transitory shortages of experienced personnel, equipment, and construction materials in the oil industry, and political instability in some major producing regions, oil prices currently are above EIA's estimate of the long-run equilibrium price.[225]

[223] *Id*.
[224] *Id*.
[225] *Id*., at 5.

This observation is consistent with EIA's statement in IEO 2008 that current market conditions appeared to place world oil prices on a path closer to the High Price Case than the Reference Case. While EIA clearly expects prices to remain high in the near term, this does not necessarily imply that it expects its High Price Case forecast to be more reliable over the extended time horizon spanned by AEO 2008.

NHTSA has seriously considered the comments it received on the fuel price forecasts used in the NPRM analysis, and paid close attention to recent developments in the world oil market and in U.S. retail fuel prices. The agency has also reviewed forecasts of world oil prices and U.S. fuel prices available from sources other than EIA, the views expressed by petroleum market experts, professional publications, and press reports.[226] The agency notes that although both the views of experts and projections of petroleum prices differ widely, the emerging consensus appears to be that world petroleum and U.S. retail fuel prices are likely to remain at levels that are more consistent with those forecast in the AEO 2008 High Price Case than with the Reference Case forecasts over the foreseeable future.[227]

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[226] These include EIA, Short-Term Energy Outlook, various issues, *available at* http://www.eia.doe.gov/emeu/steo/pub/contents.html (last accessed November 13, 2008); International Energy Agency, *World Energy Outlook 2008*, summary *available at* http://www.iea.org/Textbase/npsum/WEO2008SUM.pdf (last accessed November 13, 2008); AJM Petroleum Consultants, The AJM Price Forecast, *available at* http://www.ajmpetroleumconsultants.com/index.php?page=price-forecast (last accessed Novemebr 13, 2008); PetroStrategies, Inc, Survey of Oil Price Forecasts, *available at* http://www.petrostrategies.org/Graphs/Oil_Price_Forecasts.htm (last accessed November 13, 2008); International Monetary Fund, World Economic Outlook, October 2008, Chapter 3: Is Inflation Back? Commodity Prices and Inflation, *available at* http://www.imf.org/external/pubs/ft/weo/2008/02/pdf/c3.pdf (last accessed November 13, 2008); and Federal Reserve Bank of Dallas Economic Letter, Volume 3, No. 5, May 2008, *available at* http://www.dallasfed.org/research/eclett/2008/el0805.html (last accessed November 13, 2008).

[227] In the AEO High Price Case, prices for imported petroleum are projected to average about $75 per barrel over the next 10 years, while U.S. retail gasoline prices are forecast to average $2.90 per gallon over that same period; see AEO 2008, High Price Case Table 12, available at http://www.eia.doe.gov/oiaf/aeo/excel/aeohptab_12.xls (last accessed October 19, 2008).

NHTSA also notes that although world oil prices have declined to levels that are currently close to the average prices for the year 2008 projected in the AEO 2008 Reference and High Price Cases, their year-to-date average remains well above those forecast for the entire year in the AEO 2008 High Price Case.[228] Similarly, although U.S. retail gasoline prices have declined sharply since those at the time comments on the NPRM were submitted, their average for 2008 remains well above the AEO 2008 High Price forecast for year 2008.[229]

In the NPRM and earlier rulemakings, NHTSA has consistently relied on the expertise and oil price projections of the Energy Information Administration. In the current rulemaking, however, the agency is confronted with a difficult choice about whether to use the AEO 2008 Reference Case or High Price Case forecasts of fuel prices. There are serious risks associated both with using forecast prices that ultimately prove to be too high, and with using projections that later prove to be too low in determining the level of future CAFE standards. In either case, there is significant risk that manufacturers responding to new CAFE standards would produce a range of automobile and light truck models that is not well-matched to the demands of the future marketplace for fuel economy and other vehicle attributes. This situation requires NHTSA to weigh the risk of using too high a price, and thus requiring manufacturers and vehicle buyers to "over-

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[228] The AEO 2008 High Price Case projects that prices for crude oil imported into the U.S. will average about $73 per barrel throughout 2008; see AEO 2008, High Price Case Table 12, available at http://www.eia.doe.gov/oiaf/aeo/excel/aeohptab_12.xls (last accessed October 19, 2008). EIA reports that actual prices for imported crude oil averaged $106 per barrel from January through July of 2008; see EIA, Monthly Energy Review, September 2008, Table 9.1 Crude Oil Price Summary, available at http://tonto.eia.doe.gov/merquery/mer_data.asp?table=T09.01 (last accessed October 19, 2008).

[229] The AEO 2008 High Price Case projects that U.S. gasoline prices will average $2.99 per gallon throughout 2008; see AEO 2008, High Price Case Table 12, available at http://www.eia.doe.gov/oiaf/aeo/excel/aeohptab_12.xls (last accessed October 19, 2008). EIA reports that retail gasoline prices averages $3.62 per gallon from January through September 2008; see EIA, Weekly Retail Gasoline and Diesel Prices, available at http://tonto.eia.doe.gov/dnav/pet/hist/mg_tt_usw.htm (last accessed October 19, 2008).

invest" in fuel economy improvements, against the potential consequences of using too low a price, including taking insufficient action to promote energy independence and address climate change.

The agency appreciates that a majority of the commenters urged that, based on the then recent history in gasoline prices, the agency use the AEO 2008 High Price Case forecast of gasoline prices. However, the history of crude oil and retail gasoline prices over the past year, and particularly in recent months, suggests that caution is in order when using current price levels as an indicator of likely future prices for the purpose of setting CAFE standards. NHTSA also appreciates that the EIA Administrator recently recommended at a Congressional hearing that this agency use the AEO 2008 High Price Case forecast of fuel prices, based on the expectation of continued growth in global demand for petroleum and the fact that prices then significantly exceeded the High Price Case forecast for the current year, and that EIA repeated this observation about the trend in prices in its 2008 IEO.

In an attempt to resolve this issue, the agency examined EIA's monthly Short Term Energy Outlooks (STEO), focusing particularly on those for recent months. After considering recent events, including the impact of global economic conditions on the demand for petroleum in OECD countries and in countries with developing economies, EIA continues to anticipate relatively high gasoline prices through the end of 2009. For example, the October 7 STEO noted the following:

> The current slowdown in economic growth is contributing to the recent decline in oil demand and the sharp decline in prices since July. Nonetheless, oil markets are expected to remain relatively tight because of sluggish production growth. Absent a major worldwide economic

> downturn that significantly impacts global demand, West Texas Intermediate (WTI) crude oil prices are projected to average about $112 per barrel in both 2008 and 2009.

Considering the risks identified above, the prospect for continuing long term growth in the demand for petroleum, particularly in the developing economies of the world, and increasing reliance on high-cost production capacity to keep pace with growth in petroleum demand, the agency believes it is reasonable to use the AEO 2008 High Price Case forecasts, and has elected to do so for the purpose of this final rule. The agency believes that the global factors causing increases in petroleum consumption continue to be present and operative, and appear likely to remain so in the long term. Thus the agency believes it is reasonable to assume that once the global economic outlook improves, growth in world demand for petroleum energy will return to the pace that was evident until the very recent changes in that outlook.

In addition, the agency has concluded that, given its statutory mandate, that the potential consequences from overestimating fuel prices may be less severe than the risks of under-predicting future fuel prices. If prices remain below projected levels, vehicle manufacturers and purchasers will experience unnecessarily high vehicle costs without corresponding increases in the value of new vehicles. On the other hand, if oil prices prove to be higher than projected, not only will manufacturers and the public have underinvested in fuel economy, but the higher prices may require even more expensive investments in fuel conserving technologies.

Over the period from 2011, when the standards adopted in this final rule would take effect, and 2030, the outer time horizon of the AEO 2008 forecasts, retail gasoline prices in the AEO 2008 High Price case are projected to rise steadily from $2.95 to $3.62

per gallon, averaging $3.33 per gallon (all prices expressed in 2007 dollars). For the years 2031 and beyond, the agency's analysis assumes that retail fuel prices will remain at their forecast values for the year 2030.

These prices are significantly higher than the AEO 2008 Revised Early Release Reference Case forecast used in the agency's NPRM analysis, which averaged $2.34 per gallon (in 2006 dollars) over that same period.[230] After deducting state and federal fuel taxes, this revised forecast results in an average value of $3.08 per gallon of fuel saved over the lifetimes of 2011-15 passenger cars and light trucks. Because of the uncertainty surrounding future gasoline prices, the agency also conducted sensitivity analyses using EIA's Reference and Low Price case forecasts of retail fuel prices.

5. Consumer valuation of fuel economy and payback period

In the NPRM, NHTSA explained that in estimating the value of fuel economy improvements that would result from alternative CAFE standards to potential vehicle buyers, NHTSA assumed that buyers value the resulting fuel savings over only part of the expected lifetime of the vehicles they purchase. Specifically, we assume that buyers value fuel savings over the first five years of a new vehicle's lifetime, and that buyers behave as if they do not discount the value of these future fuel savings. NHTSA chose the five-year figure because it represents the current average term of consumer loans to

[230] The fuel price forecasts reported in EIA's AEO 2008 Revised Early Release and Final Release reflect the estimates effects of various provisions of EISA – including the requirement to achieve a combined CAFE level of 35 mpg by model year 2020 – on the demand for and supply of gasoline and other transportation fuels. Thus the fuel price forecasts reported in these versions of AEO 2008 may already account for the reduction in fuel demand expected to result form the CAFE standards adopted in this Final Rule, whereas the agency's analysis of their effects would ideally use fuel price forecasts that do not assume the adoption of higher CAFE standards for model years 2011-20. However, the agency notes that the difference between the Reference Case forecasts of retail gasoline prices for 2011-30 between EIA's Early Release of AEO 2008, which did not incorporate the effects of EISA, and its subsequent Revised Early Release, which did reflect EISA, averaged only $0.0004 (*i.e.*, less than one-half cent) per gallon over the period 2011-30, This suggests that accounting for the effect of EISA would have had only a minimal effect on the fuel price forecasts used in this analysis.

finance the purchase of new vehicles. NHTSA recognized that the period over which individual buyers finance new vehicle purchases may not correspond to the time horizons they apply in valuing fuel savings from higher fuel economy, but NHTSA expressed its belief that five years represents a reasonable estimate of the average period over which buyers who finance their purchases of new vehicles receive—and thus are compelled to recognize—the monetary value of future fuel savings resulting from higher fuel economy.

NHTSA explained that the value of fuel savings over the first five years of a vehicle model's lifetime that would result under each alternative fuel economy standard is calculated using the projections of retail fuel prices described in the section above. The value of fuel savings is then deducted from the technology costs incurred by the vehicle's manufacturer to produce the improvement in that model's fuel economy estimated for each alternative standard, to determine the increase in the "effective price" to buyers of that vehicle model. The Volpe model uses these estimates of effective costs for increasing the fuel economy of each vehicle model to identify the order in which manufacturers would be likely to select models for the application of fuel economy-improving technologies in order to comply with stricter standards. The average value of the resulting increase in effective cost from each manufacturer's simulated compliance strategy is also used to estimate the impact of alternative standards on manufacturers' total sales for future model years.

However, NHTSA stated that it is important to recognize that the agency estimates the aggregate value to the U.S. economy of fuel savings resulting from alternative standards—or their "social" value—over the *entire* expected lifetimes of vehicles manufactured under those standards, rather than over this shorter "payback period" that NHTSA assumes for vehicle buyers. This point is discussed in the section below titled "Vehicle survival and use assumptions." NHTSA noted that as indicated previously, the maximum vehicle lifetimes used to analyze the effects of alternative fuel economy standards are estimated to be 25 years for passenger cars and 36 years for light trucks.

NADA and Sierra Research agreed with the agency's assumption of a 5-year payback period for consumer valuation of fuel economy. NADA commented that NHTSA's assumption of a 5 year payback period for consumer valuation of fuel economy was reasonable. NADA argued that "Even at high fuel prices, consumers who view fuel economy as an important purchase criteria are hard pressed to make the case for buying a more fuel efficient new vehicle if the up-front capital costs associated with doing so cannot be recouped in short order." Thus, NADA concluded, "NHTSA should assume that most prospective purchasers will not invest in fuel economy improvements that do not exhibit a payback of five years or sooner." NADA also added that factors other than the value of fuel savings should also be taken into account in calculating the length of the payback period; specifically, it stated that "for purposes of calculating payback, real-world purchaser finance costs, opportunity costs, and additional maintenance costs all should be accounted for."

The Sierra Research report submitted by the Alliance as Attachment 2 to its comments "considered fuel cost savings over 'payback' periods of 5 and 20 years," but stated parenthetically that "It is more likely that average consumers would consider the savings during the period of time they expect to own the vehicle, likely closer to the five-year period."

Other commenters disagreed with the agency's assumption of a 5-year payback period for consumer valuation of fuel economy. Mr. Delucchi stated simply that NHTSA "should not do a "payback" analysis with a zero discount rate and a 5-year payback period, because there is no economic theory or consumer behavioral evidence to support this." However, he offered no additional suggestions as to what NHTSA should use instead. Similarly, as part of its discussion on fuel price estimates, the Sierra Club commented that NHTSA had "arbitrarily restricted" the consumer payback period to 5 years, but offered no further comments or explanation of this point.

CFA commented that "the five year payback constraint plays a critical role in ordering the technologies that are included in the fleet to comply with various levels of the standard," and argued that while NHTSA should perhaps not have included a payback period at all, if it intended to do so, it should justify the 5-year payback period better and consider a longer payback period. CFA commented that "it is not clear that one must assume a payback for any component of a vehicle purchase. But if one does, the logical connection is between the period of ownership and the payback, not the loan period." CFA further commented that NHTSA failed to recognize the extent to which "consumers and the market appreciate fuel economy," arguing that "even if one looks at the ownership period, most alternative investment opportunities available to consumers do not yield a five year payback period; hybrids, many of which have payback periods of ten years or more, are flying off auto dealer lots. Increasing the payback period by one year raises the value of the fuel savings substantially, by 20 percent."

Ford commented that NHTSA should not have used the increase in the “effective price” to buyers to determine consumer valuation of fuel economy, for two reasons. First, Ford argued that while NHTSA “implicitly assumed that the technology costs incurred by the manufactures can be fully passed on to buyers,” this is not true “in the competitive environment of the U.S. automotive market.” Second, Ford commented that the estimates of “effective price” depend on fuel price assumptions, such that “a higher gasoline price assumption will lower the effective price estimates, holding everything else constant.” Ford cited the June 26, 2008 analysis by Sierra Research that “estimates that a consumer would not breakeven over a 20 year period unless gas prices are sustained at $4.47 a gallon. Sierra also concluded that by using a more conservative payback period of 5 years the estimated breakeven gas price would have to be $6.59.”

Ford argued that NHTSA should instead use “hedonic pricing technique in estimating the consumer valuation of fuel economy,” which “determines the price of a vehicle by the characteristics of the car such as towing, cargo volume, performance etc.” Ford also argued that NHTSA should not use “effective price” as a way of identifying in which order manufacturers would apply technologies, because “It is quite unlikely that manufacturers are using this metric for selecting models, since most manufacturers do not assume the technology costs can be fully passed on to the buyers.”

Agency response: NHTSA notes that the payback period and the effective cost calculation affect only the order in which manufacturers are assumed to apply technologies in order to improve the fuel economy of specific vehicles, and thus has no effect on the final CAFE standards. Thus the assumptions about the length of the payback period and discount rate that affect these calculations, while subject to some uncertainty, are not a critical determinant of CAFE standards themselves. Instead, their main role is to estimate the increase in the value to potential buyers of the increases in fuel economy of specific vehicle models, and to provide some indication of the extent to which manufacturers are likely to be able to recoup their costs for complying with higher CAFE standards through increases in those vehicles' sales prices. The agency also reiterates that it estimates the social benefits of fuel savings resulting from alternative standards over the entire expected lifetimes of cars and light trucks subject to higher CAFE standards, rather than over the payback period assumed for vehicle buyers. Although many commenters mistakenly believe that the payback period has an important effect on the stringency of the fuel economy standards and therefore were suggesting different periods, no commenter provided any data to support a different number of years for payback. Thus NHTSA has continued to employ the same assumptions used in the NPRM in developing the CAFE standards adopted in this final rule.

6. Vehicle survival and use assumptions

NHTSA stated in the NPRM that its preliminary analysis of fuel savings and related benefits from adopting alternative standards for MY 2011-2015 passenger cars and light trucks was based on estimates of the resulting changes in fuel use over their entire lifetimes in the U.S. vehicle fleet. NHTSA's first step in estimating lifetime fuel consumption by vehicles produced during a model year is to calculate the number of vehicles that are expected to remain in service during each future year after they are produced and sold.[231] This number is calculated by multiplying the number of vehicles

[231] Vehicles are defined to be of age 1 during the calendar year corresponding to the model year in which they are produced. Thus, for example, model year 2000 vehicles are considered to be of age 1 during calendar year 2000, age 2 during calendar year 2001, and to reach their maximum age of 26 years during calendar year 2025. NHTSA considers the maximum lifetime of vehicles to be the age after which less

originally produced during a model year by the proportion expected to remain in service at the age they will have reached during each subsequent year, often referred to as a "survival rate."

NHTSA explained that for the number of passenger cars and light trucks that will be produced during future years, it relies on projections reported by the EIA in its AEO Reference Case forecast.[232] For age-specific survival rates for cars and light trucks, NHTSA uses updated values estimated from yearly registration data for vehicles produced during recent model years, to ensure that forecasts of the number of vehicles in use reflect recent increases in the durability and expected life spans of cars and light trucks.[233] These updated survival rates suggest that the expected lifetimes of recent-model passenger cars and light trucks are 13.8 and 14.5 years, respectively.

NHTSA's next step in estimating fuel use was to calculate the total number of miles that the cars and light trucks produced in each model year affected by the proposed CAFE standards will be driven during each year of their lifetimes. To estimate total miles driven, the number of cars and light trucks projected to remain in use during each future year (calculated as described above) was multiplied by the average number of miles that they are expected to be driven at the age they will have reached in that year.

The agency initially estimated the average number of miles driven annually by cars and light trucks of each age using data from the Federal Highway Administration's

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than 2 percent of the vehicles originally produced during a model year remain in service. Applying these conventions to vehicle registration data indicates that passenger cars have a maximum age of 26 years, while light trucks have a maximum lifetime of 36 years. *See* Lu, S., NHTSA, Regulatory Analysis and Evaluation Division, "Vehicle Survivability and Travel Mileage Schedules," DOT HS 809 952 (January 2006), at 8-11. *Available at* http://www-nrd.nhtsa.dot.gov/pdf/nrd-30/NCSA/Rpts/2006/809952.pdf (last accessed August 21, 2008).

[232] U.S. Energy Information Administration, *Annual Energy Outlook 200* ,Reference Case Table 43. *Available at* (last accessed October 4, 2008).

[233] *See* Lu, *supra* note 223, at 8-11.

2001 National Household Transportation Survey (NHTS).[234] The agency then adjusted the NHTS estimates of annual vehicle use to account for the effect of differences in fuel cost per mile driven between the date the NHTS was conducted and the future years when MY 2011-15 cars and light trucks would be in use. This adjustment is intended to account for the "rebound effect" on vehicle use caused by changes in fuel cost per mile (see Section V.B.8. below). Fuel cost per mile driven is measured by the retail price of fuel per gallon forecast for a future calendar year, divided by the estimated on-road fuel economy in miles per gallon achieved by vehicles of each model year that remain in service during that future year. The agency made this adjustment by applying its estimate of the rebound effect to the difference in fuel cost per mile driven between 2001, when the NHTS was conducted, and the projected average fuel cost per mile over the lifetimes of MY 2011-15 cars and light trucks.

Finally, NHTSA estimated fuel consumption during each year of a model year's lifetime by dividing the total number of miles that that model year's surviving vehicles are driven by the fuel economy that they are expected to achieve under each alternative CAFE standard. Each model year's total lifetime fuel consumption is the sum of the fuel use by the cars or light trucks produced during that model year that are projected to remain in use during each year of their expected lifetimes. In turn, the *savings* in a model year's lifetime fuel use that would result from each alternative CAFE standard would be the difference between its lifetime fuel use at the fuel economy level it attains under the Baseline (No Action) alternative, and its lifetime fuel use at the higher fuel economy level it is projected to achieve under that alternative standard.

[234] For a description of the NHTS, *see* http://nhts.ornl.gov/quickStart.shtml (last accessed August 21, 2008).

As an illustration of this procedure, the revised estimates of new vehicle sales used in the final rule analysis project that 7.17 million light trucks will be produced during 2013, and NHTSA's updated survival rates showed that slightly more than half of these—50.1 percent, or 3.59 million—are projected to remain in service during the year 2027, when they will have reached an age of 14 years. At that age, the estimates of vehicle use employed in this final rule analysis indicate that light trucks achieving the fuel economy level required under the Baseline alternative would be driven an average of 9,385 miles, assuming that the AEO 2008 High fuel price forecast proves to be correct. Thus surviving model year 2013 light trucks are projected to be driven a total of 33.72 billion miles (= 3.59 million surviving vehicles x 9,385 miles per vehicle) during 2027. Summing the results of similar calculations for each year of their 36-year maximum lifetime, the 7.17 million light trucks originally produced during model year 2013 would be driven a total of 1,231 billion miles under the Baseline alternative.

Under the Baseline alternative, model year 2013 light trucks are projected to achieve a test fuel economy level of 25.4 mpg, which corresponds to actual on-road fuel economy of 20.4 mpg (= 25.4 mpg X 80 percent). Thus, their lifetime fuel use under the Baseline alternative is projected to be 60.3 billion gallons (1,231 billion miles divided by 20.4 miles per gallon). Under the Optimized CAFE standard for model year 2013, light trucks are projected to achieve test fuel economy of 27.2 mpg, which corresponds to actual on-road mpg of 24.2. After adjusting their average annual mileage to reflect the increase in usage that results from the rebound effect of improved fuel economy, model year 2013 light trucks are projected to be driven a total of 1,265 billion miles over their expected lifetimes. Thus their lifetime fuel consumption under the Optimized CAFE standard is projected to amount to 52.2 billion gallons (1,265 billion gallons divided by 24.2 miles per gallon), a reduction of 8.1 billion gallons from the 60.3 billion gallons they would consume under the Baseline alternative.

NHTSA received no specific comments regarding the assumptions about vehicle survival and use described in the NPRM. The exact figures for annual vehicle use that are employed in the agency's analysis supporting the Final Rule are updated to reflect differences in estimated fuel economy levels under alternative CAFE standards, but are otherwise unchanged from those used in the NPRM.

7. Growth in total vehicle use

In the NPRM, NHTSA also explained its assumptions for potential future growth in average annual vehicle use. By assuming that the average number of miles driven by cars and light trucks at each age – and thus their lifetime total mileage – will remain constant over the future, NHTSA effectively assumes that future growth in total vehicle-miles driven stems only from increases in the *number* of vehicles in use, rather than from continuing increases in the average number of miles that cars and light trucks are driven each year.[235] Similarly, because the survival rates used to estimate the number of cars and light trucks remaining in service to various ages are assumed to remain fixed for future model years, growth in the total number of cars and light trucks in use is effectively assumed to result only from increasing sales of *new* vehicles. In order to

[235] As described in the preceding section, increases in fuel economy required by CAFE standards are assumed to increase lifetime usage of cars and light trucks due to the fuel economy rebound effect. Because a vehicle's fuel economy is determined when it is produced, however, the resulting changes in its average annual use at each age and its expected lifetime mileage are also determined when it is produced. While the fuel economy rebound effect thus contributes to differences in annual and lifetime vehicle use between the Baseline alternative and Optimized CAFE standards, it is not a source of continuing growth in average annual miles per vehicle or in total annual VMT over the future.

determine the validity of these assumptions, the agency conducted a detailed analysis of the causes of recent growth in total car and light truck use.

From 1985 through 2005, the total number of miles driven (usually referred to as vehicle-miles traveled, or VMT) by passenger cars increased 35 percent, equivalent to a compound annual growth rate of 1.5 percent.[236] During that time the total number of passenger cars registered in the U.S. grew by about 0.3 percent annually, almost exclusively as a result of increasing sales of new cars.[237] Thus, growth in the average number of miles that passenger cars are driven each year accounted for the remaining 1.2 percent (= 1.5 percent – 0.3 percent) annual growth in total passenger car use.[238]

The NPRM explained, however, that over this same period, total VMT by light trucks increased much faster, growing at an annual rate of 5.1 percent. In contrast to the causes of growth in passenger car use, nearly all growth in light truck use over these two decades was attributable to rapid increases in the *number* of light trucks in use. FHWA data show that growth in total miles driven by "Two-axle, four-tire trucks," a category that includes most or all light trucks subject to CAFE standards, averaged 5.1 percent annually from 1985 through 2005. However, the number of miles that light trucks are driven each year averaged 11,114 during 2005, almost unchanged from the average figure

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[236] Calculated from data reported in FHWA, Highway Statistics, Summary to 1995, Table VM-201a, *available at* http://www.fhwa.dot.gov/ohim/summary95/vm201a.xlw (last accessed August 20, 2008), and Highway Statistics Publications, Annual Editions 1996-2005, Table VM-1, *available at* http://www.fhwa.dot.gov/policy/ohpi/hss/hsspubs.cfm (last accessed October 4, 2008); follow links to individual annual editions, select Section V: Roadway Extent Characteristics, and Performance, scroll down to section entitled "Traffic and Travel Data," and select link to Table VM-1.

[237] An increase in the fraction of new passenger cars remaining in service beyond age 10 accounted for approximately one-tenth of total growth in the U.S. automobile fleet from 1985 to 2005, while the remaining 90% was accounted for by growth in sales of new automobiles. The fraction of new automobiles remaining in service to various ages was computed from R.L. Polk vehicle registration data for 1997 through 2005 by the agency's Center for Statistical Analysis.

[238] *See supra* note 228.

of 11,016 miles during 1985.[239] This means that virtually all of the growth in total light truck VMT over this period resulted from growth in the number of these vehicles in service, rather than from growth in their average annual use. In turn, growth in the size of the nation's light truck fleet has resulted almost exclusively from rising production and sales of new light trucks, since the fraction of new light trucks remaining in service to various ages has remained stable or declined very slightly over the past two decades.[240]

On the basis of this analysis, NHTSA tentatively concluded in the NPRM that its projections of future growth in light truck VMT account fully for the primary cause of its recent growth, which has been the rapid increase in sales of new light trucks during recent model year. However, the assumption that average annual use of passenger cars will remain fixed over the future seemed to ignore an important source of recent growth in their total use, the gradual increase in the average number of miles they are driven. NHTSA explained that to the extent that this factor continued to represent a significant source of growth in future passenger car use, the agency's analysis would be likely to *underestimate* the reductions in fuel use and related environmental impacts resulting from more stringent CAFE standards for passenger cars.[241] NHTSA stated that it planned to account explicitly for potential future growth in average annual use of *both* cars and light

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[239] *Id*.
[240] *See* the Lu study, *supra* note 223.
[241] NHTSA explained that assuming that average annual miles driven per passenger car will continue to increase over the future would increase the agency's estimates of total lifetime mileage for MY 2011-2015 passenger cars. Their estimated lifetime fuel use would also increase under each alternative standard considered in the NPRM, but in inverse relation to their fuel economy. Thus, NHTSA explained, lifetime fuel use would increase by more under the No Increase alternative than under any of the alternatives that would increase passenger car CAFE standards, and by progressively less for the alternatives that impose stricter standards. NHTSA stated that taking account of this factor would thus increase the agency's estimates of fuel savings for those alternatives, just as omitting it would cause the agency's analysis to underestimate those fuel savings.

trucks in the analysis for the final rule. NHTSA received no specific comments to the NPRM about vehicle survival and use.

In its analysis for this final rule, the agency has used estimates of the annual number of miles driven by model year 2011-15 passenger cars and light trucks at each age of their expected lifetimes that reflect the previously-discussed adjustment for increased use due to the fuel economy rebound effect. Similarly, these estimates also reflect the effect on vehicle use of differences in fuel prices between the year 2001, when the National Household Travel Survey (NHTS), the agency's source original for its estimates of annual vehicle use by age) was conducted, and the AEO 2008 forecast of fuel prices for the period when these vehicles will be in use. As discussed briefly in the preceding section and in more detail in the following section, changes in fuel prices are also assumed to cause a rebound effect in vehicle use, because – like increases in fuel economy – variation in retail fuel prices directly affects vehicles' fuel cost per mile driven. Because future fuel prices are projected to be significantly higher than the $1.80 (2007 dollars) average that prevailed at the time the NHTS was conducted, this adjustment reduces projected average vehicle use during future years, thus partly offsetting the effect of higher fuel economy.

Finally, the agency's estimates of vehicle use assume that the average number of miles driven by passenger cars will continue to rise by 1 percent annually, slightly below its 1.2 percent average annual growth rate over the past two decades. This growth is assumed to be independent of the changes in passenger car use that are projected to result from increased fuel economy and higher fuel prices through the rebound effect. Because average annual use of light trucks has not increased significantly over the past two decades, no future change in light truck use is assumed to occur independently of those attributable to higher fuel prices and improved fuel economy through the rebound effect.

NHTSA received no specific comments regarding the assumptions about growth in total vehicle use presented in the NPRM. The assumptions employed in the agency's analysis supporting the Final Rule remain unchanged from those used in the NPRM.

8. Accounting for the rebound effect of higher fuel economy

As discussed in the NPRM, the rebound effect refers to the tendency of vehicle use to increase in response to higher fuel economy. The rebound effect occurs because an increase in a vehicle's fuel economy reduces its fuel cost for each mile driven (typically the largest single component of the cost of operating a vehicle), and vehicle owners take advantage of this reduced cost by driving more. Even with higher fuel economy, this additional driving uses some fuel, so the rebound effect reduces the fuel savings that would otherwise result when fuel economy standards require manufacturers to increase fuel economy. The rebound effect is usually expressed as the percentage by which annual vehicle use increases when the cost of driving each mile declines, due either to an increase in fuel economy or a reduction in the retail price of fuel.

The rebound effect is an important parameter in NHTSA's evaluation of alternative CAFE standards for future model years, because it affects the actual fuel savings that are likely to result from adopting stricter standards. The rebound effect can be measured by estimating the elasticity of vehicle use with respect either to fuel economy itself, or to fuel cost per mile driven.[242] When expressed as a positive percentage, either of these parameters gives the fraction of fuel savings that would be

[242] Fuel cost per mile is equal to the price of fuel in dollars per gallon divided by fuel economy in miles per gallon, so fuel cost per mile declines when a vehicle's fuel economy increases.

expected to result from increased fuel economy, but is offset by the added fuel use that occurs when vehicles with higher fuel economy are driven more.

In the NPRM, NHTSA summarized existing research on the rebound effect in order to explain its rationale for choosing the estimate of 15 percent it employed in analyzing alternative MY 2011-2015 fuel economy standards; the following paragraphs repeat NHTSA's summary for the reader's benefit.

Research on the magnitude of the rebound effect in light-duty vehicle use dates to the early 1980s, and almost unanimously concludes that a statistically-significant rebound effect occurs when vehicle fuel efficiency improves.[243] The most common approach to estimating its magnitude has been to analyze household survey data on vehicle use, fuel consumption, fuel prices (often obtained from external sources), and other determinants of household travel demand to isolate the response of vehicle use to higher fuel economy. Other studies have relied on econometric analysis of annual U.S. data on vehicle use, fuel economy, fuel prices, and other variables to identify the response of total or average vehicle use to changes in fuel economy. Two recent studies analyzed yearly variation in vehicle ownership and use, fuel prices, and fuel economy among individual states over an extended time period in order to measure the response of vehicle use to changing fuel economy. Most studies measure the influence of fuel economy on vehicle use indirectly through its effect on fuel cost per mile driven, although a few attempt to measure the direct effect of fuel economy on vehicle use.

[243] Most studies estimate that the long-run rebound effect is significantly larger than the immediate response to increased fuel efficiency, since over a longer period drivers have more opportunities to adjust their vehicle use to changes in fuel costs. This long-run effect is more appropriate for evaluating the fuel savings likely to result from stricter CAFE standards, since the increases in fuel economy they require would reduce fuel costs over the entire lifetimes of vehicles they affect. These lifetimes can extend up to 25 years for passenger cars, and up to 36 years for light trucks.

An important distinction among studies of the rebound effect is whether they assume that the effect is constant, or varies over time in response to prevailing fuel prices, fuel economy levels, personal income, and household vehicle ownership. This distinction ins important because studies that allow the rebound effect to vary in response to changes in these factors are likely to provide more reliable forecasts of its future value.

In order to arrive at a preliminary estimate of the rebound effect for use in assessing the fuel savings, emissions reductions, and other impacts of the alternative standards, NHTSA reviewed 22 studies of the rebound effect conducted from 1983 through 2007. NHTSA then conducted a detailed analysis of the 66 separate estimates of the long-run rebound effect reported in these studies, which is summarized in Table V-2 below.[244] As the table indicates, estimates of the long-run rebound effect range from as low as 7 percent to as high as 75 percent, with a mean of 23 percent. A higher rebound effect means that more of the savings in fuel use expected to result from higher fuel economy will be offset by additional driving, so that less fuel savings will actually result.

Limiting the sample of rebound effect estimates to the 50 estimates reported in the 17 published studies yields the same range but a slightly higher mean (24 percent), while focusing on the authors' preferred estimates from published these studies narrows this range and lowers its average slightly. In all three cases, the median estimate of the rebound effect, which is less likely to be influenced by unusually small and large estimates, is 22 percent. As Table V-2 indicates, approximately two-thirds of all

[244] Some studies did not separately present the overall rebound effect, so NHTSA derived estimates of the overall rebound effect when the studies reported more detailed results. For example, when studies estimated different rebound effects for households owning different numbers of vehicles, but did not report an overall rebound effect, NHTSA computed a weighted average of the reported values using the distribution of households among vehicle ownership categories.

estimates reviewed, all published estimates, and authors' preferred estimates fall in the range of 10 to 30 percent.

Table V-2. Summary of Rebound Effect Estimates

Category of estimates	Number of studies	Number of estimates	Range		Distribution		
			Low	High	Median	Mean	Std. Dev.
All estimates…………….	22	66	7%	75%	22%	23%	14%
Published estimates……..	17	50	7%	75%	22%	24%	14%
Authors' preferred estimates………………...	17	17	9%	75%	22%	22%	15%
U.S. time-series estimates………………...	7	34	7%	45%	14%	18%	9%
Household survey estimates………………...	13	23	9%	75%	31%	31%	16%
Pooled U.S. state estimates………………...	2	9	8%	58%	22%	25%	14%
Constant rebound effect (1)……………………….	15	37	7%	75%	20%	23%	16%
Variable rebound effect (1)……………………….							
Reported estimates……...	10	29	10%	45%	23%	23%	10%
Updated to 2006 (2)…….	10	29	6%	46%	16%	19%	12%

(1) Three studies estimate both constant and variable rebound effects.
(2) Reported estimates updated to reflect current conditions, using 2006 values of fuel prices, fuel economy, household income, and vehicle ownership.

The type of data used and authors' assumptions about whether the rebound effect varies over time have important effects on its estimated magnitude, although the reasons for these patterns are difficult to identify. As the table shows, the 34 estimates derived from analysis of U.S. annual time-series data produce a median estimate of 14 percent for the long-run rebound effect, while the median of the 23 estimates based on household survey data is more than twice as large (31 percent). The 37 estimates from studies that assume a constant rebound effect produce a median of 20 percent, while the 29 estimates from studies allowing the rebound to vary have a slightly higher median value (23 percent).

In selecting a value for the rebound effect to use in analyzing alternative fuel economy standards for MYs 2011-2015, NHTSA attached greater significance to studies that allow the rebound effect to vary in response to changes in the factors that affect its magnitude. The agency's view is that updating their estimates to reflect current economic conditions provides a more reliable indication of its likely magnitude over the lifetimes of vehicles that will be affected by those standards. As Table V-2 reports, recalculating these 29 original estimates using 2006 values for retail fuel prices, average fuel economy, personal income, and household vehicle ownership reduces their median estimate to 16 percent.[245] Considering the empirical evidence on the rebound effect as a whole, but according greater importance to the updated estimates from studies allowing the rebound effect to vary, NHTSA selected a rebound effect of 15 percent in the NPRM to evaluate the fuel savings and other effects of the alternative MY 2011-2015 fuel economy standards. However, NHTSA stated that it did not believe that evidence of the rebound effect's dependence on fuel prices or household income is sufficiently convincing to justify allowing its future value to vary in response to forecast changes in

[245] As an illustration, Small and Van Dender (2005) allow the rebound effect to vary over time in response to changes in real per capita income as well as in response to average fuel cost per mile driven. While their estimate for the entire interval (1966-2001) that they analyze is 22 percent, updating this estimate using 2007 values of these variables reduces the rebound effect to about 10 percent. Similarly, updating Greene's 1992 original estimate of a 15 percent rebound effect to reflect 2007 fuel prices and average fuel economy reduces it to approximately 7 percent. *See* David L. Greene, "Vehicle Use and Fuel Economy: How Big is the Rebound Effect?" The Energy Journal, 13:1 (1992), at 117-143.

In contrast, the distribution of households among vehicle ownership categories in the data samples used by Hensher et al. (1990) and Greene et al. (1999) are nearly identical to the most recent estimates for the U.S., so updating their original estimates to current U.S. conditions changes them very little. *See* David A. Hensher, Frank W. Milthorpe, and Nariida C. Smith, "The Demand for Vehicle Use in the Urban Household Sector: Theory and Empirical Evidence," Journal of Transport Economics and Policy, 24:2 (1990), at 119-137; *see also* David L. Greene, James R. Kahn, and Robert C. Gibson, "Fuel Economy Rebound Effect for Household Vehicles," The Energy Journal, 20:3 (1999), at 1-21.

these variables. A range extending from 10 percent to at least 20 percent, and perhaps as high as 25 percent, appeared to NHTSA to be appropriate for the required analysis of the uncertainty surrounding these estimates. While the agency selected 15 percent, it also conducted analyses using rebound effects of 10 and 20 percent. The results of these sensitivity analyses are shown in the FEIS at Section 3.4.4.2.

The only commenter suggesting that NHTSA use a larger rebound effect than 15 percent was the Alliance, which based its comments on analyses it commissioned from Sierra Research and NERA Economic Consulting, Inc. Sierra Research cited a 1999 paper by David Greene, *et al.*, at ORNL as evidence that the long-run rebound effect should be 20 percent,[246] and stated further that NHTSA used a rebound effect of 20 percent in its April 2003 final rule setting fuel economy standards for MY 2005-2007 light trucks. Sierra Research assumed a 17 percent rebound effect in its analysis for the Alliance "to be conservative." NERA's report argued that NHTSA should use a rebound effect of 20 percent, because 15 percent gave "disproportionate weight" to the Small and Van Dender study, which NERA called "a single study with empirical limitations." NERA stated that its analysis "corrected" the Small and Van Dender model, the primary correction apparently being to "properly account for differences in the cost of living across states," with respect to income and fuel prices. NERA consequently used a 24 percent rebound effect for its report.

Other commenters, including CARB, UCS, EDF, Public Citizen, CFA, and Mark Delucchi, argued that NHTSA should use a lower rebound effect than 15 percent, generally because Small and Van Dender's recent study found a lower rebound effect.

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[246] David L. Greene, *et al.*, "Fuel Economy Rebound Effect for U.S. Household Vehicles," The Energy Journal, Vol. 20, No. 3, 1999.

CARB, for example, commented that while it is true that the consensus estimate of past studies is that the rebound effect should be 15 percent, Small and Van Dender had found a long-run rebound effect of 4.9 percent for the 1997-2001 period in California due to higher incomes, and that it would decline even further by 2020. Thus, CARB argued, NHTSA should accept "two critical findings" of the Small and Van Dender study, specifically that (1) the future value of the rebound effect would decline as household real income increases; and that (2) as fuel prices increase, people spend a larger share of their income on fuel purchases, thus becoming more sensitive to fuel prices. CARB stated that NHTSA should use a rebound effect of no higher than 10 percent, and conduct a sensitivity analysis using a rebound effect of 5 percent.

UCS similarly commented that if NHTSA intends to "attach greater significance" to the Small and Van Dender study, as NHTSA stated in the NPRM, then it must accept Small and Van Dender's conclusion "that the rebound effect in the U.S. is small and has been getting smaller." Thus, UCS argued, NHTSA should employ a rebound effect of no greater than 10 percent, and only if NHTSA used higher fuel prices in the final rule. UCS implied, however, that NHTSA should apply no rebound effect at all unless it used higher fuel prices in the final rule, citing a 2005 final report by Small and Van Dender to CARB as stating that "…[the authors] cannot prove that there is any rebound effect resulting from stricter fuel efficiency regulations…." Mr. Delucchi also commented that NHTSA should use a lower rebound effect because the agency should "give more weight to Small and Van Dender," although he did not explain how the agency should give this additional weight. Mr. Delucchi also stated that a recent study by Hughes *et al*. "found a very low short-run price elasticity of demand for gasoline."

EDF and Public Citizen focused on other findings in the Small and Van Dender study to argue for a lower rebound effect. EDF commented that NHTSA should not have selected a 15 percent rebound effect based on existing rebound effect literature, because when Small and Van Dender reviewed the literature, the authors suggested "that many prior studies have overestimated the rebound effect because of some model specification problems, such as not allowing for the fact that fuel efficiency is endogenous, *i.e.*, driving more efficient cars might encourage more driving, but long commutes might encourage purchase of more fuel efficient vehicles." EDF argued that because Small and Van Dender's study did not have these biases, NHTSA should use a 10 percent rebound effect, "to be consistent with the latest findings and to reflect current conditions of income, urbanization and fuel costs."

EDF also suggested that the rebound effect may be zero, citing Greene's 2005 testimony before the House of Representatives Science Committee that "the rebound effect could be reduced to negligible if we '[take] into account the fact that increased fuel economy will increase the price of vehicles together with the likelihood that governments will respond to losses in highway revenues by raising motor fuel taxes.'" Public Citizen focused on Small and Van Dender's finding that "most empirical measurements of the rebound effect rely heavily on variations in the fuel price," stating that this "again raises the question of whether NHTSA's assumptions about the rebound effect are colored by the estimates of future fuel prices."

CFA commented that NHTSA should use a rebound effect of no higher than 5 percent, citing a recent analysis by the Congressional Budget Office that rising real incomes have made consumers much less responsive to short-run changes in gasoline prices. CFA thus argued that since gasoline is more expensive now, NHTSA was incorrect to assume "that consumers irrationally burn up their fuel savings on increased driving, rather than use it to buy other goods and services and applied this 'rebound' effect to analyses where it should not play a role." CFA also argued that NHTSA should have identified and provided more information about the conclusions in each of the studies it reviewed in developing its number for the rebound effect.

Agency response: NHTSA has updated the 29 estimates from studies that allowed the rebound effect to vary to reflect current (2008 to date) fuel prices, fuel economy, vehicle ownership levels, and household income. The resulting updated estimates are significantly higher than those reported in the NPRM, primarily because of the large increase in fuel prices since 2006 (the date to which the estimates reported in the NPRM were updated). The updated 2008 estimates of the fuel economy rebound effect range from 8 percent to 46 percent, with a median value of 19 percent. Using the average retail gasoline price forecast for 2011-30 from the AEO 2008 High Price case, the projected estimates of the rebound effect for those years would range from 7 percent to 46 percent, with a median value of 19 percent.

NHTSA also notes that the forecast of fuel prices used to develop its adopted CAFE standards for model years 2011-15 projects that retail gasoline prices will continue to rise by somewhat more than 1 percent annually over the lifetimes of vehicles affected by those standards. At the same time, real household incomes are projected to grow by about 2 percent annually over this same period. Given the relative sensitivity of the Small and Van Dender rebound effect estimate to changes in fuel prices and income, these forecasts suggest that future growth in fuel prices is likely to offset a significant fraction of the projected decline in the rebound effect that would result from income growth.

In response to the comment by EDF citing Greene's statement that the rebound effect could be negligible over the foreseeable future, NHTSA notes that increases in the purchase price or ownership cost of vehicles may not significantly affect the marginal cost of additional vehicle use, since the depreciation and financing components of vehicle ownership costs vary only minimally with vehicle use. In addition, the agency notes that Greene's assertion that governments are likely to respond to losses in fuel tax revenues by raising fuel tax rates (thus increasing retail fuel prices) is highly speculative, and there is limited evidence that this has actually occurred in response to recent declines in state fuel tax revenues.[247]

In light of these results, NHTSA has elected to continue to use a 15 percent rebound effect in its analysis of fuel savings and other benefits from higher CAFE standards for this Final Rule. Recognizing the uncertainty surrounding this estimate, the agency has analyzed the sensitivity of its benefits estimates to a range of values for the rebound effect from 10 percent to 20 percent.

9. Benefits from increased vehicle use

The NPRM explained that NHTSA also values the additional benefits that derive from increased vehicle use due to the rebound effect. This additional mobility provides drivers and their passengers better access to social and economic opportunities away from

[247] Federal Highway Administration data show that fuel tax revenues declined in only 5 of the 50 states between 2000 and 2006, and that none of these states raised gasoline taxes over that same period; see FHWA, *Highway Statistics 2006*, Table MF-205, *available at* http://www.fhwa.dot.gov/policy/ohim/hs06/pdf/mf205.pdf (last accessed November 13, 2008), Table MF-1 *available at* http://www.fhwa.dot.gov/policy/ohim/hs06/xls/mf1.xls (last accessed November 13, 2008), and *Highway Statistics 2000*, Table MF-1 *available at* http://www.fhwa.dot.gov/ohim/hs00/xls/mf1.xls (last accessed November 13, 2008).

home, because they are able to make longer or more frequent trips. The amount by which the total benefits from this additional travel exceed its costs (for fuel and other operating expenses) measures the net benefits that drivers receive from the additional travel, usually referred to as increased consumer surplus. NHTSA's analysis estimates the economic value of this increased consumer surplus using the conventional approximation, which is one half of the product of the decline in vehicle operating costs per mile and the resulting increase in the annual number of miles driven. The NPRM noted that the magnitude of these benefits represents a small fraction of the total benefits from the alternative fuel economy standards considered.

In its comment on the NPRM, NERA speculated that NHTSA "may have miscalculated the 'consumer surplus' associated with the additional driving due to the rebound effect." NERA stated that NHTSA

> …describes its calculation in terms of the conventional triangle under the demand curve but above the price paid. However, it appears that instead NHTSA estimated the total area under the demand curve for the extra VMT traveled. That is appropriate if NHTSA's estimates of net savings in fuel expenditures include additional expenditures on the additional fuel consumed as a result of the rebound effect.

NHTSA notes in response to NERA's comment that its estimates of net savings in fuel expenditures do reflect the costs for additional fuel consumed as a result of increased rebound-effect driving. Thus the agency has correctly calculated the increase in consumer surplus associated with the additional driving due to the rebound effect. Since it received no other comments on the estimates of benefits from increased vehicle use presented in the NPRM, NHTSA has calculated these benefits using the same procedure in its analysis supporting this Final Rule.

10. Added costs from congestion, crashes, and noise

NHTSA also factors in the additional costs from increased traffic congestion, motor vehicle accidents, and highway noise that result from additional vehicle use associated with the rebound effect. Increased vehicle use can contribute to traffic congestion and delays by increasing traffic volumes on facilities that are already heavily traveled, which may cost drivers more in terms of increased travel time and operating expenses. Increased vehicle use can also increase the external costs associated with traffic accidents; although drivers may consider the costs they (and their passengers) might face from the possibility of being involved in a traffic accident when they decide to make additional trips, it is very unlikely that they account for the potential "external" costs that any accident imposes on the occupants of other vehicles or on pedestrians.

Finally, increased vehicle use can also contribute to traffic noise, which causes inconvenience, irritation, and potentially even discomfort to occupants of other vehicles, to pedestrians and other bystanders, and to residents or occupants of surrounding property. Since drivers are unlikely to consider the effect their vehicle's noise has on others, noise represents another externality that NHTSA attempts to account for. Any increase in these externality costs, however, is dependent on the traffic conditions under which additional rebound-effect driving takes place.

In the NPRM, NHTSA relied on estimates developed by the Federal Highway Administration (FHWA) of the increased external costs of congestion, accidents (property damage and injuries), and noise costs caused by added driving due to the rebound effect.[248] These estimates are intended to measure the increases in costs due to these externalities caused by automobiles and light trucks that are borne by persons other

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[248] These estimates were developed by FHWA for use in its 1997 Federal Highway Cost Allocation Study. *See* http://www.fhwa.dot.gov/policy/hcas/final/index.htm (last accessed October 5, 2008).

than their drivers, or "marginal" external costs. Updated to 2007 dollars, FHWA's "Middle" estimates for marginal congestion, accident, and noise costs caused by automobile use amount to 5.4 cents, 2.3 cents, and 0.1 cents per vehicle-mile (or 7.8 cents per vehicle-mile in total), while costs for light trucks are 4.8 cents, 2.6 cents, and 0.1 cents per vehicle-mile (7.5 cents per vehicle-mile in total).[249] These costs are multiplied by the annual increases in automobile and light truck use from the rebound effect to yield the estimated increases in congestion, accident, and noise externality costs during each future year.

NHTSA received comments from the Alliance and from the Mercatus Center on the increased costs from congestion, crashes, and noise due to the rebound effect. The Alliance submitted an analysis by NERA Economic Consulting that argued that NHTSA had underestimated the increased costs from congestion, crashes, and noise. The NERA analysis disagreed with NHTSA's method for updating the FHWA estimates, arguing that it was unclear exactly how NHTSA had updated the FHWA values to 2006 dollars. The NERA analysis also argued that FHWA's estimate was "based on a value of $12.38 per vehicle hour (in 1994 dollars)," while NHTSA used a value of $24 per vehicle hour "to value time savings it estimates would result from fewer fill-ups as a result of higher MPG and increased range for a tank of fuel." Thus, the NERA analysis concluded that NHTSA had overvalued the time savings, which NERA seemed to attribute to its belief that NHTSA does not value time spent in traffic congestion "at least as highly as time spent in service stations while filling up."[250] Thus, the NERA analysis argued that congestion

[249] *Id*., at Tables V-22, V-23, and V-24 (last accessed October 5, 2008).
[250] NERA appears to suggest that time spent in service stations while filling up includes the fact that "stops at service stations often serve multiple purposes, not just refueling." NERA then appears to suggest that people feel similarly about time spent in traffic congestion.

costs per mile would increase by about 68 percent if NHTSA had updated FHWA's estimates in a "consistent" manner with "NHTSA's valuation of time savings for vehicle occupants in another part of its analysis."

The NERA analysis also argued that the baseline 1997 congestion values "should be adjusted upward even more to reflect increasing levels of congestion between then and now and the further increases likely" within the lifetimes of the vehicles, the basis for NHTSA's cost analysis. The analysis stated that this was because "With higher baseline congestion, the marginal impact of additional VMT will increase because congestion, like other queuing phenomena, increases at an increasing rate as capacity utilization grows." NERA also argued more generally that increased costs from congestion, crashes, and noise are proportional to the rebound effect, which means that a higher rebound effect would result in higher costs.[251]

The NERA analysis did not cover NHTSA's estimates of accident and noise costs per mile, but cited the same RFF study referred to in the NPRM to say that it "estimated a value per mile roughly 20 percent higher ($0.030 vs. $0.025) than NHTSA's."

The Mercatus Center focused only on congestion costs, and commented that NHTSA should consider "The possibility that the cost of increased congestion, a product of the 'rebound effect,' does not take into account likely increasing marginal costs as considered in NHTSA's model." The commenter stated that NHTSA's estimates "implicitly assume[] a constant marginal cost of congestion across all possible total quantities of vehicle miles driven for each vehicle category." However, it cited the FHWA study as stating that congestion cost impacts are "extremely sensitive" to peak

[251] NERA suggested using a rebound elasticity of -0.2 instead of -0.15, which it claimed would increase the costs from congestion, crashes, and noise by about one third.

versus off-peak traffic periods. Thus, the commenter argued, if the costs can vary within a day (as during peak and off-peak periods), they must certainly vary across years, if the total amount of traffic varies across years as well. In essence, if VMT increases, total congestion and the marginal cost of congestion must also increase, all other things held constant.

However, if all other things are not held constant, *e.g.* if new roads are built to handle increasing traffic, the commenter argued that "total congestion does not necessarily increase with increases in total vehicle miles driven." The commenter argued that NHTSA should include an estimate of the costs of building additional roads or altering existing ones to mitigate congestion due to the rebound effect. That estimate should include accounting for "the increasing difficulty of building a new road in an urbanized area," which the commenter stated is "probably one of the best examples of an activity that has rapidly increasing marginal costs," as well as the environmental costs of building new roads, *i.e.* costs due to sprawl. The commenter asserted that "It is incumbent upon NHTSA and the Environmental Protection Agency to produce an inclusive estimate of the costs of the rebound effect—one that either includes both increasing marginal cost of congestion and the cost of the new roads that will lead to increased congestion."

The Mercatus Center also pointed out an apparent inconsistency in the NPRM in the reporting of FHWA's estimates of passenger car versus light truck costs for increased congestion, crashes, and noise.

For this document, NHTSA has corrected the inconsistency in the NPRM's reporting of external costs from additional automobile and light truck use noted by the Mercatus Center.

NHTSA notes that congestion cost associated with additional travel may be particularly high if it occurs during peak travel periods and on facilities that are already heavily utilized. However, the FHWA estimates of increased congestion costs from added vehicle use assume that the increase in travel is distributed over the hours of the day and among specific routes in proportion to the existing temporal and geographic distributions of total VMT. Thus while some of the additional travel may impose significant costs for additional congestion and delays, much of it is likely to occur at times and locations where excess roadway capacity is available and congestion costs imposed by added vehicle use are minimal.

NHTSA believes it is reasonable to assume that additional vehicle use due to the fuel economy rebound effect will be distributed over the day and among locations in much the same way as current travel is distributed. As a consequence, the FHWA estimates of congestion costs from increased vehicle use are likely to provide more accurate estimates of the increased congestion costs caused by added rebound-effect driving than are the estimates submitted by commenters, which apply to peak travel periods and locations that experience high traffic volumes. Thus in the analysis supporting the Final Rule, NHTSA has continued to rely upon the FHWA values to estimate the increase in congestion costs likely to result from added rebound-effect driving.

11. Petroleum consumption and import externalities

The NPRM also discussed the fact that U.S. consumption and imports of petroleum products also impose costs on the domestic economy that are not reflected in the market price for crude petroleum, or in the prices paid by consumers of petroleum products such as gasoline. In economics literature on this subject, these costs include (1) higher prices for petroleum products resulting from the effect of U.S. oil import demand on the world oil price; (2) the risk of disruptions to the U.S. economy caused by sudden reductions in the supply of imported oil to the U.S.; and (3) expenses for maintaining a U.S. military presence to secure imported oil supplies from unstable regions, and for maintaining the Strategic Petroleum Reserve (SPR) to cushion against resulting price increases.[252] Higher U.S. imports of crude oil or refined petroleum products increase the magnitude of these external economic costs, thus increasing the true economic cost of supplying transportation fuels above the resource costs of producing them. Conversely, reducing U.S. imports of crude petroleum or refined fuels or reducing fuel consumption can reduce these external costs. Any reduction in their total value that results from improved passenger car and light truck fuel economy represents an economic benefit of setting more stringent CAFE standards, in addition to the value of fuel savings and emissions reductions themselves.

NHTSA explained that increased U.S. oil imports can impose higher costs on all purchasers of petroleum products, because the U.S. is a sufficiently large purchaser of foreign oil supplies that changes in U.S. demand can affect the world price. The effect of

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[252] *See, e.g.*, Bohi, Douglas R. and W. David Montgomery (1982). Oil Prices, Energy Security, and Import Policy, Washington, DC, Resources for the Future, Johns Hopkins University Press; Bohi, D.R. and M.A. Toman (1993). "Energy and Security: Externalities and Policies," Energy Policy 21: 1093-1109; and Toman, M.A. (1993). "The Economics of Energy Security: Theory, Evidence, Policy," *in* A.V. Kneese and J.L. Sweeney, eds. (1993). Handbook of Natural Resource and Energy Economics, Vol. III, Amsterdam, pp. 1167-1218.

U.S. petroleum imports on world oil prices is determined by the degree of OPEC monopoly power over global oil supplies, and the degree of monopsony power over world oil demand exerted by the U.S. The combination of these two factors means that increases in domestic demand for petroleum products that are met through higher oil imports can cause the price of oil in the world market to rise, which imposes economic costs on all other purchasers in the global petroleum market in excess of the higher prices paid by U.S. consumers.[253] Conversely, reducing U.S. oil imports can lower the world petroleum price, and thus generate benefits to other oil purchasers by reducing these "monopsony costs."

NHTSA stated that although the degree of current OPEC monopoly power is subject to debate, the consensus appears to be that OPEC remains able to exercise some degree of control over the response of world oil supplies to variation in world oil price so that the world oil market does not behave completely competitively.[254] The extent of U.S. monopsony power is determined by a complex set of factors, including the relative importance of U.S. imports in the world oil market, and the sensitivity of petroleum supply, and demand to its world price among other participants in the international oil market. Most evidence appears to suggest that variation in U.S. demand for imported

[253] For example, if the U.S imports 10 million barrels of petroleum per day at a world oil price of $20 per barrel, its total daily import bill is $200 million. If increasing imports to 11 million barrels per day causes the world oil price to rise to $21 per barrel, the daily U.S. import bill rises to $231 million. The resulting increase of $31 million per day is attributable to increasing daily imports by only 1 million barrels. This means that the incremental cost of importing each additional barrel is $31, or $10 more than the newly-increased world price of $21 per barrel. This additional $10 per barrel represents a cost imposed on all other purchasers in the global petroleum market by U.S. buyers, in excess of the price they pay to obtain those additional imports.

[254] For a summary of this issue, *see* Leiby, Paul N., Donald W. Jones, T. Randall Curlee, and Russell Lee, *Oil Imports: An Assessment of Benefits and Costs*, ORNL-6851, Oak Ridge National Laboratory, November 1, 1997, at 17. *Available at* http://pzl1.ed.ornl.gov/ORNL6851.pdf (last accessed August 26, 2008).

petroleum continues to exert some influence on world oil prices, although this influence appears to be limited.[255]

The second component of external economic costs imposed by U.S. petroleum imports that NHTSA considered arises partly because an increase in oil prices triggered by a disruption in the supply of imported oil reduces the level of output that the U.S. economy can produce. The reduction in potential U.S. economic output depends on the extent and duration of the increases in petroleum product prices that result from a disruption in the supply of imported oil, as well as on whether and how rapidly these prices return to pre-disruption levels. Even if prices for imported oil return completely to their original level, however, economic output will be at least temporarily reduced from the level that would have been possible without a disruption in oil supplies.

Because supply disruptions and resulting price increases tend to occur suddenly rather than gradually, they can also impose costs on businesses and households for adjusting their use of petroleum products more rapidly than if the same price increase had occurred gradually over time. These adjustments impose costs because they temporarily reduce economic output even below the level that would ultimately be reached once the U.S. economy completely adapted to higher petroleum prices. The additional costs to businesses and households reflect their inability to adjust prices, output levels, and their use of energy and other resources quickly and smoothly in response to rapid changes in prices for petroleum products.

Since future disruptions in foreign oil supplies are an uncertain prospect, each of these disruption costs must be adjusted by the probability that the supply of imported oil to the U.S. will actually be disrupted. The "expected value" of these costs—the product

[255] *Id.*, at 18-19.

of the probability that an oil import disruption will occur and the costs of reduced economic output and abrupt adjustment to sharply higher petroleum prices—is the appropriate measure of their magnitude. Any reduction in these expected disruption costs resulting from a measure that lowers U.S. oil imports represents an additional economic benefit beyond the direct value of savings from reduced purchases of petroleum products.

While the vulnerability of the U.S. economy to oil price shocks is widely thought to depend on total petroleum consumption rather than on the level of oil imports, variation in imports is still likely to have some effect on the magnitude of price increases resulting from a disruption of import supply. In addition, changing the quantity of petroleum imported into the U.S. may also affect the probability that such a disruption will occur. If either the size of the likely price increase or the probability that U.S. oil supplies will be disrupted is affected by oil imports, the expected value of the costs from a supply disruption will also depend on the level of imports.

NHTSA explained that businesses and households use a variety of market mechanisms, including oil futures markets, energy conservation measures, and technologies that permit rapid fuel switching to "insure" against higher petroleum prices and reduce their costs for adjusting to sudden price increases. While the availability of these market mechanisms has likely reduced the potential costs of disruptions to the supply of imported oil, consumers of petroleum products are unlikely to take account of costs they impose on others, so those costs are probably not reflected in the price of imported oil. Thus, changes in oil import levels probably continue to affect the expected cost to the U.S. economy from potential oil supply disruptions, although this component of oil import costs is likely to be significantly smaller than estimated by studies conducted in the wake of the oil supply disruptions during the 1970s.

The third component that NHTSA identified of the external economic costs of importing oil into the U.S. includes government outlays for maintaining a military presence to secure the supply of oil imports from potentially unstable regions of the world and to protect against their interruption. Some analysts also include outlays for maintaining the U.S. Strategic Petroleum Reserve (SPR), which is intended to cushion the U.S. economy against the consequences of disruption in the supply of imported oil, as additional costs of protecting the U.S. economy from oil supply disruptions.

NHTSA expressed its belief that while costs for U.S. military security may vary over time in response to long-term changes in the actual level of oil imports into the U.S., these costs are unlikely to decline in response to any reduction in U.S. oil imports resulting from raising future CAFE standards for passenger cars and light trucks. U.S. military activities in regions that represent vital sources of oil imports also serve a broader range of security and foreign policy objectives than simply protecting oil supplies, and as a consequence are unlikely to vary significantly in response to changes in the level of oil imports prompted by higher standards.

Similarly, NHTSA stated that while the optimal size of the SPR from the standpoint of its potential influence on domestic oil prices during a supply disruption may be related to the level of U.S. oil consumption and imports, its actual size has not appeared to vary in response to recent changes in oil imports. Thus while the budgetary costs for maintaining the SPR are similar to other external costs in that they are not likely to be reflected in the market price for imported oil, these costs do not appear to have varied in response to changes in oil import levels.

In analyzing benefits from its recent actions to increase light truck CAFE standards for model years 2005-2007 and 2008-2011, NHTSA relied on a 1997 study by Oak Ridge National Laboratory (ORNL) to estimate the value of reduced economic externalities from petroleum consumption and imports.[256] More recently, ORNL updated its estimates of the value of these externalities, using the analytic framework developed in its original 1997 study in conjunction with recent estimates of the variables and parameters that determine their value.[257] These include world oil prices, current and anticipated future levels of OPEC petroleum production, U.S. oil import levels, the estimated responsiveness of oil supplies and demands to prices in different regions of the world, and the likelihood of oil supply disruptions. ORNL prepared its updated estimates of oil import externalities for use by EPA in evaluating the benefits of reductions in U.S. oil consumption and imports expected to result from its Renewable Fuel Standard Rule of 2007 (RFS).[258]

The updated ORNL study was subjected to a detailed peer review by experts nominated by EPA, and its estimates of the value of oil import externalities were subsequently revised to reflect their comments and recommendations.[259] Specifically, reviewers recommended that ORNL increase its estimates of the sensitivity of oil supply by non-OPEC producers and oil demand by nations other than the U.S. to changes in the

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[256] *Id*.
[257] Leiby, Paul N., "Estimating the Energy Security Benefits of Reduced U.S. Oil Imports: Final Report," Oak Ridge National Laboratory, ORNL/TM-2007/028, Revised March 14, 2008. *Available at* http://pzl1.ed.ornl.gov/energysecurity.html (click on link below "Oil Imports Costs and Benefits") (last accessed August 26, 2008).
[258] 72 FR 23899 (May 1, 2007).
[259] *Peer Review Report Summary: Estimating the Energy Security Benefits of Reduced U.S. Oil Imports*, ICF, Inc., September 2007**.**

world oil price, as well as reduce its estimate of the sensitivity of U.S. GDP to potential sudden increases in world oil prices.

After making the revisions recommended by peer reviewers, ORNL's updated estimates of the monopsony cost associated with U.S. oil imports ranged from $2.77 to $13.11 per barrel, with a most likely estimate of $7.41 per barrel (in 2005 dollars). These estimates imply that each gallon of fuel saved as a result of adopting higher CAFE standards will reduce the monopsony costs of U.S. oil imports by $0.066 to $0.312, with the most likely value $0.176 per gallon saved. ORNL's updated and revised estimates of the increase in the expected costs associated with oil supply disruptions to the U.S. and the resulting rapid increase in prices for petroleum products amount to $2.10 to $7.40 per barrel, with a likely estimate of $4.59 per barrel (again in 2005 dollars). According to these estimates, each gallon of fuel saved will reduce the expected cost disruption to the U.S. economy by $0.050 to $0.176 per gallon, with the most likely value $0.109 per gallon.

NHTSA stated that when updated to 2006 dollars, the updated and revised ORNL estimates suggest that the combined reduction in monopsony costs and expected costs to the U.S. economy from oil supply disruptions resulting from lower fuel consumption total $0.120 to $0.504 per gallon, with a most likely estimate of $0.295 per gallon. This represents the additional economic benefit likely to result from each gallon of fuel saved by higher CAFE standards, *beyond* the savings in resource costs for producing and distributing each gallon of fuel saved. NHTSA explained that it employed this most likely estimate in its analysis of the benefits from fuel savings projected to result from alternative CAFE standards for model years 2011-2015. NHTSA also analyzed the effect on these benefits estimates from variation in this value over the range from $0.120 to $0.504 per gallon of fuel saved.

NHTSA's analysis of benefits from alternative CAFE standards for the NPRM did not include cost savings from either reduced outlays for U.S. military operations or maintaining a smaller SPR among the external benefits of reducing gasoline consumption and petroleum imports by means of tightening future standards. NHTSA stated that this view concurs with both the original ORNL study of economic costs from U.S. oil imports and its recent update, which conclude that savings in government outlays for these purposes are unlikely to result from reductions in consumption of petroleum products and oil imports on the scale of those likely to result from reductions in consumption of petroleum products and oil imports on the scale of those likely to result from the alternative increases in CAFE standards considered for model years 2011-2015.

All commenters addressing the issue of military costs argued that NHTSA should use a value higher than zero. Mr. Delucchi, CARB, and the Attorneys General all cited Mr. Delucchi's 2008 peer-reviewed article in *Energy Policy*[260] to argue that military costs should be higher than zero. CARB commented that the study "undermines the 15-year-old logic from a Congressional Research Study, which NHTSA appears to adopt here (page 24411), which concluded we have so many other security interests in the Middle East that sharply reducing oil imports, therefore, would not affect our military expense there." CARB argued that "to the contrary, the Energy Policy study authors conclude 'spending on defense of the Persian Gulf is in fact related to U.S. interests in the region, which are mainly, but not entirely, oil interests.'" CARB cited the study as stating that

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[260] Mark A. Delucchi and James J. Murphy, "US military expenditures to protect the use of Persian Gulf oil for motor vehicles," 36 *Energy Policy* 2253 (2008). *Available at* Docket No. NHTSA-2008-0089-0173.14.

the "best estimate of this relationship translates to \$0.03-\$0.15 per gallon…." The Attorneys General also cited the *Energy Policy* article as assigning "values to the military savings attributable to decreased oil imports, and referenced the same per-gallon conclusion.

The Attorneys General also argued that given that "one of the primary purposes of EISA is to achieve energy security," and given that the "impact of higher CAFE standards on energy security is not zero," it was "astounding" that "NHTSA assigned a value of *zero* to the government outlay aspect of energy security (increased military spending and purchases for the Strategic Petroleum Reserve)." (Emphasis in original.) The Attorneys General compared NHTSA's decision not to monetize military security costs in the NPRM to NHTSA's decision not to monetize benefits from reducing CO_2 emissions in the April 2006 light truck CAFE rule, and argued that the Ninth Circuit's decision in *CBD* supports their position that "Uncertainty about a benefit's value is not a valid reason to assign that value at zero."[261] The Attorneys General also argued that just as increases in CAFE standards cannot eliminate global warming, but are part of the overall global warming solution, increases in CAFE standards similarly "will not" in and of itself, eliminate these energy security costs," but are "a necessary piece of the puzzle in assessing all of the costs and benefits of a CAFE standard."

CFA cited the same Delucchi article to comment that "A zero for the military and strategic value of oil reduction is simply wrong." CFA argued that "There is a substantial policy and academic literature that believes oil has a military value," and that "The fact the statute had energy independence and security in its title should have alerted NHTSA to the likelihood that Congress considers the military and strategic value of oil

[261] Citing *CBD v. NHTSA*, 508 F.3d 508, 533-35.

important." CFA provided a fairly long excerpt from the Delucchi article to argue that there may be large unquantifiable costs beyond specific expenditures on the military with regard to the "entire relevant military or 'security' cost of using oil," including

> reduced flexibility in the conduct of U.S. foreign policy, strains on international relations due to the activities of the U.S. military and even due to competition for oil, anti-American sentiment due to the presence of the U.S. military in the Middle East, political destabilization of the Middle East, and the nonfinancial human-suffering cost of war and political instability related to U.S. demand for oil.[262]

CFA concluded that "NHTSA should have quantified what it could in the framework of the model," and "To the extent that there is a large and significant unquantifiable value, it should have oriented its considerations toward greater energy conservation." CFA suggested a value of $0.30 for military costs, apparently on the basis of this argument.

Public Citizen also commented that NHTSA's value for military security costs should be higher than zero. Public Citizen stated that NHTSA's rationale for assigning a zero value was similar to its logic in assigning a value of zero to reducing CO_2 emissions in the 2006 light truck CAFE final rule, and argued that the Ninth Circuit had "rejected this justification in *Center for Biological Diversity v. NHTSA*, finding that uncertainty about how to assign a value was not a justification for setting the value at zero." NRDC and the Sierra Club *et al*. also made this point in their comments.

NRDC stated that "the undisputed fact that there are currently military expenditures associated with the protection of access to oil supplies implies that there must be a positive military cost associated with each gallon of gasoline consumed." NRDC argued that "Since it can be assumed that the United States would expend little or no military resources to secure access to a non-strategic commodity, there must exist a positive benefit in moving the consumption to the point where oil is no longer a strategic

[262] CFA comments at 48, citing Delucchi at 2262.

commodity." NRDC described this value as "the country's opportunity to decrease military expenditure or respond more flexibly to supply threats, and must have a positive magnitude." NRDC suggested several "aggregate expenditure estimates [produced] through rigorous, data-driven analysis" for NHTSA to consider, including the estimate of $0.03 to $0.17 from the Delucchi article, a 2004 analysis for the National Commission on Energy Policy estimating a "peacetime per gallon" cost of $0.23 to $0.28,[263] and estimates of $0.14 to $0.26 per gallon based on a 2005 study by the International Center for Technology Assessment.[264] NRDC stated, however, that because "current expenditures may pale in comparison to the total future financial cost of military actions," "this presents a strong rationale for using per-gallon cost estimates near the upper bound of the determined range." NRDC argued that "The initial [literature] review herein suggests that the per gallon marginal benefit of reducing oil consumption may be as high as 28 cents per gallon of gasoline."

The Sierra Club *et al*. commented that NHTSA must "provide an accurate dollar value for" "the national security costs of oil," by "considering the relevant research." Sierra Club argued that the national security costs of oil are twofold, coming from both climate change and oil dependence. Regarding the national security costs expected from climate change, Sierra Club commented that a recent "report from the National Intelligence Council … found that climate change poses a serious national security threat to our country," in the form of "humanitarian disasters, economic migration, and food and water shortages" due to climate change contributing to "political instability, disputes

[263] Jaffe, Amy Myers (2004) *United States and the Middle East: Policies and Dilemmas.* Analysis commissioned by the National Commission on Energy Policy.

[264] International Center for Technology Assessment (2005) "Gasoline Cost Externalities: Security and Protection Services." NRDC stated that it adjusted the estimates found in the study from 2005 values of 13 to 23 cents into 2008 values using http://data.bls.gov/cgi-bin/cpicalc.pl.

over resources, and mass migrations" in many "at-risk regions" of the world, that will have economic impacts in the United States. Regarding the national security costs of oil dependence, Sierra Club cited the 2005 ICTA report mentioned by NRDC as an example of the "numerous studies … [that] document these costs."

Although UCS offered no discussion of military costs in its primary comment document, it submitted as an attachment a report suggesting that NHTSA use a value of $0.35 per gallon (in 2006 dollars) for "improved oil security." The report cited "A recent study from Oak Ridge National Laboratory [which] assesses these energy security benefits of reduced oil consumption at $14.51 per barrel, or $0.35 per gallon."[265] The report stated that "This is a conservative assessment, as it excludes all military program costs, as well as the 'difficult-to-quantify foreign policy impact of oil import reliance.' (Leiby 2007)"

NHTSA received no comments on the estimates of monopsony costs or potential costs from oil supply disruptions. Thus it has continued to employ the estimates of these costs reported in the updated ORNL study in establishing final CAFE standards and evaluating their benefits. The agency notes, however, that the monopsony cost varies directly with world oil prices, and that the forecast of world oil prices used in this analysis differs significantly from that assumed in the ORNL study. Thus NHTSA has adjusted the updated ORNL estimate of the monopsony cost to reflect the AEO 2008 High Price case forecast of world oil prices, which averages $88 per barrel (in 2007 dollars) over the period from 2011-30. Expressed in 2007 dollars, NHTSA's revised estimates of the reductions in monopsony costs and expected costs from oil supply disruptions are $0.266 and $0.116 per gallon of fuel saved.

[265] The report noted that it had updated this value from 2004 dollars to 2006 dollars.

NHTSA disagrees with commenters who asserted that fuel savings resulting from higher CAFE standards are likely to result directly in reductions in U.S. military expenses to protect the supply of petroleum imports, particularly from the Persian Gulf region. NHTSA agrees that by reducing fuel consumption and U.S. petroleum imports from politically unstable regions, higher CAFE standards might reduce the military and political risks posed by U.S. military deployments in these regions. However, the agency does not believe there is convincing evidence that reducing these risks would necessarily reduce U.S. military activities or expenditures in the Persian Gulf or elsewhere. None of the commenters presented any evidence that reductions in U.S. military spending would occur in response to fuel savings and reductions in U.S. petroleum imports, nor do any of the references included in their comments provide such evidence.

In particular, NHTSA does not agree with Public Citizen's analogy between energy security and "global warming costs." Although the economic valuation of climate-related benefits from reducing carbon dioxide emissions is uncertain, there is nevertheless a direct causal link between changes in U.S. oil consumption and changes in U.S. carbon dioxide emissions. In contrast, no such causal linkage – either scientific or empirical – exists between changes in U.S. oil consumption or imports and changes in U.S. military expenditures in the Persian Gulf, or elsewhere in the world. The agency notes that one particularly comprehensive and authoritative treatment of the potential security benefits from reducing U.S. energy consumption reaches exactly this same conclusion.[266]

[266] Douglas R. Bohi and Michael A. Toman, *Economics of Energy Security*, Kluwer Academic Publishers, 1996.

Although one recent economic analysis cited widely by commenters did estimate the value of U.S. military spending attributable to securing oil imports from the Persian Gulf region, this study does not estimate the extent to which U.S. military spending is likely to vary in response to changes in U.S. imports of Persian Gulf oil. Nor does it estimate the potential savings in U.S. military outlays that might result from reductions in U.S. oil imports of the magnitude likely to result from higher CAFE standards.[267]

The study argues that its purpose is to develop "the military cost of highway transportation." The authors attempt to do this in four steps:

- Estimate the amount spent annually to defend all U.S. interests in the Persian Gulf;
- Deduct the cost of defending U.S. interests other than oil in the Persian Gulf;
- Deduct the cost of defending against the possibility of a worldwide recession due to the effects of an oil price shock or supply interruption originating in the Persian Gulf on other countries; and
- Deduct the cost of defending the use of oil in sectors of the U.S. economy other than highway transportation.

This analysis yields an estimate of the annual "military cost of oil use by motor vehicles" in the United States ranging from $5.8 billion to $25.4 billion in 2004. The authors then divide these figures by 2004 U.S. gasoline and diesel consumption by on-road motor vehicles to arrive at an average "military cost of highway transportation" ranging from $0.03 to $0.15 per gallon of fuel.[268]

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[267] *See* Mark A. Delucchi and James J. Murphy, US Military Expenditures to Protect the Use of Persian Gulf Oil Imports, 36 Energy Policy 2253 (2008) (assigning a cost of between $0.03 and $0.15 per gallon). *Available at* Docket No. NHTSA-2008-0089-0173.14.
[268] *Id.*, at 2260.

However, the authors do *not* argue that U.S. military spending would be reduced by this – or any other – amount as a consequence of incremental reductions in domestic consumption of transportation fuels. Instead, they describe their estimate as follows in the following terms: "The bottom line of our analysis is that if all motor vehicles in the US (light-duty and heavy-duty) did not use oil, Congress might reduce defense spending by $6–$25 billion annually in the long run. This amounts to about $0.03–$0.15 per gallon ($0.01–$0.04 per liter) of all gasoline and diesel motor fuel in 2004." (p. 2260)

Thus the values they report estimates are clearly intended as estimates of the total and average per-gallon costs of U.S. military activities in the Persian Gulf that might reasonably be related to petroleum consumption by U.S. motor vehicles, and *not* as estimates of the extent to which those costs might be reduced as a consequence of lower fuel consumption by U.S. motor vehicles. Nothing in their analysis suggests that this average value bears any necessary relationship to the savings in military outlays that might results from modest reductions in U.S. petroleum consumption or imports. Although the authors speculate that the proportional reduction in these outlays might be larger than any proportional reduction in U.S. petroleum imports from the Persian Gulf region, they provide no support for this hypothesis.[269]

Nor does this study attempt to demonstrate any causal or empirical linkage between domestic consumption of transportation fuels and the level of U.S. military activities or spending in the Persian Gulf (or elsewhere). As the authors clearly acknowledge, achieving any reduction in U.S. military spending that might be facilitated by lower U.S. oil imports would require specific actions by Congress, and would not result automatically or necessarily. However carefully their analysis might be done,

[269] *Id.*, at 2261-2262.

defining some fraction of U.S. military expenditures as being allocated to the defense of oil interests in the Persian Gulf, and then dividing the resulting figure by some quantity of petroleum use does not demonstrate any causal linkage between changes in the numerator (military spending) and incremental changes in the denominator (petroleum consumption) of this calculation.

The analysis described above is irrelevant to NHTSA's analysis of fuel economy standards, because NHTSA's cost/benefit analysis is properly concerned with comparing two alternative states of the world: (1) the world as we expect it to exist over the next few years, in the absence of any new CAFE standards, compared with (2) an alternative world that is identical in every respect except that new CAFE standards are in place. NHTSA should, therefore, consider how U.S. defense expenditures might vary between these two states of the world. The relevant question for a cost-benefit analysis is: How much would U.S. military expenditures *change* if U.S. passenger-car and light-truck fuel consumption is several percent lower in the next decade than it otherwise would have been?

Neither the Congress nor the Executive Branch has ever attempted to calibrate U.S. military expenditures, force levels, or deployments to any oil market variable, or to some calculation of the projected economic consequences of hostilities in the Persian Gulf. Instead, changes in U.S. force levels, deployments, and thus military spending in that region have been largely governed by political events, emerging threats, and other military and political considerations, rather than by shifts in U.S. oil consumption or imports. NHTSA thus concludes that the levels of U.S. military activity and expenditures are likely to remain unaffected by even relatively large changes in light duty vehicle fuel consumption.

Nevertheless, the agency conducted a sensitivity analysis of the potential effect of assuming that some reduction military spending would result from fuel savings and reduced petroleum imports in order to investigate its impacts on the standards and fuel savings. Assuming that the preceding estimate of total U.S. military costs for securing Persian Gulf oil supplies is correct, and that approximately half of these expenses could be reduced in proportion to a reduction in U.S. oil imports from the region, the estimated savings would range from $0.02 to $0.08 (in 2007 dollars) for each gallon of fuel savings that was reflected in lower U.S. imports of petroleum from the Persian Gulf. If the Persian Gulf region is assumed to be the marginal source of supply for U.S. imports of crude petroleum and refined products, then each gallon of fuel saved might reduce U.S. military outlays by $0.05 per gallon, the midpoint of this range. NHTSA employs this estimate in its sensitivity analysis.

12. Air pollutant emissions

(a) Impacts on criteria pollutant emissions

Criteria air pollutants are common pollutants that EPA regulates under the Clean Air Act, by establishing permissible concentrations on the basis of human health-related or science-based criteria.[270] NHTSA explained in the NPRM that while reductions in domestic fuel refining and distribution that result from lower fuel consumption will reduce U.S. emissions of criteria air pollutants, additional vehicle use associated with the rebound effect from higher fuel economy will in turn increase emissions of those

[270] Criteria pollutants include ozone, particulate matter, carbon monoxide, nitrogen oxides, sulfur dioxide, and lead. For more information, see http://www.epa.gov/air/urbanair/ (last accessed October 5, 2008).

pollutants. Thus, the net effect of stricter CAFE standards on emissions of each criteria pollutant depends on the relative magnitudes of its reduced emissions in fuel refining and distribution, and increases in its emissions from vehicle use. Because the relationship between emissions rates in fuel refining[271] and in vehicle use[272] is different for each criteria pollutant, the net effect of fuel savings from the proposed standards on total emissions of each pollutant is likely to differ. Criteria air pollutants emitted by vehicles and during fuel production include carbon monoxide (CO), hydrocarbon compounds (usually referred to as "volatile organic compounds" or VOCs), nitrogen oxides (NO_x), fine particulate matter ($PM_{2.5}$) and sulfur oxides (SO_x).

For additional vehicle use due to the rebound effect, NHTSA estimates the increase in emissions of these pollutants by multiplying the increase in total miles driven by vehicles of each model year and age by age-specific emission rates per vehicle-mile for each pollutant. NHTSA developed these emission rates using EPA's MOBILE6.2 motor vehicle emissions factor model.[273] Emissions of these pollutants also occur during crude oil extraction and transportation, fuel refining, and fuel storage and distribution. The reduction in total emissions from each of these sources thus depends on the extent to which fuel savings result in lower imports of refined fuel, or in reduced domestic fuel refining. To a lesser extent, they also depend on whether any reduction in domestic gasoline refining is translated into reduced imports of crude oil or reduced domestic extraction of petroleum.

[271] That is, emissions per gallon of fuel refined.
[272] That is, emissions per mile driven.
[273] U.S. EPA, MOBILE6 Vehicle Emission Modeling Software, *available at* http://www.epa.gov/otaq/m6.htm#m60 (last accessed October 5, 2008).

Based on analysis of changes in U.S. gasoline imports and domestic gasoline consumption forecast in AEO's 2008 Early Release, NHTSA tentatively estimated in the NPRM that 50 percent of fuel savings resulting from higher CAFE standards would result in reduced imports of refined gasoline, while the remaining 50 percent would reduce domestic fuel refining.[274] The reduction in domestic refining was assumed to leave its sources of crude petroleum unchanged from the mix of 90 percent imports and 10 percent domestic production projected by AEO.

For fuel refining and distribution, NHTSA proposed to estimate criteria pollutant emission reductions using emission rates from Argonne National Laboratories' Greenhouse Gases and Regulated Emissions in Transportation (GREET) model.[275] The GREET model provides separate estimates of air pollutant emissions that occur in four phases of fuel production and distribution: crude oil extraction, crude oil transportation and storage, fuel refining, and fuel distribution and storage.[276] NHTSA tentatively assumed, for purposes of the NPRM analysis, that reductions in imports of refined fuel would reduce criteria pollutant emissions during fuel storage and distribution only. Reductions in domestic fuel refining using imported crude oil as a feedstock were tentatively assumed to reduce emissions during crude oil transportation and storage, as well as during gasoline refining, distribution, and storage, because less of each of these

[274] Estimates of the response of gasoline imports and domestic refining to fuel savings from stricter standards are variable and highly uncertain, but NHTSA's preliminary analysis as of the time the NPRM was published indicated that under any reasonable assumption about these responses, the magnitude of the net change in criteria pollutant emissions (accounting for both the rebound effect and changes in refining emissions) is extremely low relative to their current total.

[275] Argonne National Laboratories, *The Greenhouse Gas and Regulated Emissions from Transportation (GREET) Model*, Version 1.8. *Available at* http://www.transportation.anl.gov/software/GREET/index.html (last accessed October 5, 2008).

[276] Emissions that occur during vehicle refueling at service stations (primarily evaporative emissions of VOCs) are already accounted for in the "tailpipe" emission factors used to estimate the emissions generated by increased car and light truck use. GREET estimates emissions in each phase of gasoline production and distribution in mass per unit of gasoline energy content; these factors are then converted to mass per gallon of gasoline using the average energy content of gasoline.

activities would be occurring. Similarly, reduced domestic fuel refining using domestically-produced crude oil was tentatively assumed to reduce emissions during phases of gasoline production and distribution.[277]

The net changes in emissions of each criteria pollutant were calculated by adding the increases in their emissions that result from increased vehicle use and the reductions that result from lower domestic fuel refining and distribution. The net change in emissions of each criteria pollutant was converted to an economic value using estimates of the economic damage costs per ton emitted[278] developed by EPA and submitted to OMB for review. For certain criteria pollutants, EPA estimates different per-ton costs for emissions from vehicle use than for emissions of the same pollutant during fuel production, reflecting differences in their typical geographic distributions, contributions to ambient pollution levels, and resulting population exposure.

NHTSA received comments on this issue from the Alliance, NADA, the Air Improvement Resources Committee of the Alamo Area Council of Governments, and an individual, Mr. Mark Delucchi. Mr. Delucchi commented that NHTSA should clarify what kinds of damages are included in the per-ton damage cost estimates for criteria pollutants and CO_2. He suggested that if NHTSA's estimates are based on EPA's damage estimates, then they do not include health damages, visibility, crop damages, materials damages, and natural-ecosystem damages. Mr. Delucchi argued that NHTSA should include estimates for these additional categories of damage due to pollutants, and

[277] As NHTSA stated in the NPRM, in effect, this assumes that the distances crude oil travels to U.S. refineries are approximately the same whether the oil travels from domestic oilfields or import terminals, and that the distances that gasoline travels from refineries to retail stations are approximately the same as those from import terminals to retail stations.
[278] These costs result primarily from damages to human health.

that the agency "can find peer-reviewed estimates of damages in most of these categories on [his] faculty web page."

The Air Improvement Resources Committee of the Alamo Area Council of Governments (Texas) did not comment specifically on NHTSA's estimates for criteria pollutants, but simply expressed its support for the proposed standards due to the fact that they would "create net reductions in oxides of nitrogen over the lifetimes of Model Years 2011-2015 vehicles, and the San Antonio region is NO_x limited, meaning reducing NO_x emissions in the region will have a greater impact on ozone levels than would comparable volatile organic compound (VOC) reductions." The AIRC stated that "Although the proposed rulemaking would create a net increase in VOCs, the NO_x increase is of greater benefit for ozone formation in our region," and therefore the AIRC supported the proposed standards.

The Alliance commented more specifically on NHTSA's estimates for criteria pollutants, arguing that NHTSA's estimates of reductions in ozone precursors were overstated for two main reasons: first, because "NHTSA did not properly take into account the new source review standards [under the Clean Air Act], and otherwise assumed away federal (and state) laws that would have the effect of requiring offsets from the upstream refineries that NHTSA attempts to claim credit for;" and second, because "there is no indication that NHTSA has … considered the fleet turnover effect," "meaning that the significant costs NHTSA will add to the price of new vehicles will delay the transition the market would naturally make to more fuel efficient and cleaner vehicles." NADA also argued that the "Criteria pollutant reduction benefits associated with the proposed CAFE standards are overstated as the negative impact of inhibited fleet turnover was not accounted for."

As support for its comment that NHTSA had overlooked federal and state laws that would impact upstream criteria pollutant emissions, the Alliance cited both the Sierra Research and the NERA Reports it included as attachments to its comments. Sierra Research commented that "Most upstream emissions associated with the use of gasoline…in areas with air pollution problems" are already subject to air pollution control regulations, such that "changes in fuel type or the volume of fuel produced are governed by … offset requirements and credit provisions." Sierra Research argued that the GREET model used by NHTSA ignores the impacts of these regulations, by assuming that reductions in gasoline consumption translate directly into reductions in pollutant emissions. However, Sierra argued, in tightly regulated areas of the country, the air pollution control system will be much more complicated than that, such that any "give" in one part of the pollution control system will simply be absorbed by another part, and there will be no net reduction in emissions for that area. Sierra also argued that the GREET model does not properly account for "marketing" (*i.e.*, from gasoline station) emissions, which have been reduced in recent years due to proliferating vapor recovery system regulations at the state and local levels.

The NERA Report first argued that NHTSA had overestimated the amount of criteria pollutant emissions that would be reduced. It echoed Sierra Research's comment about New Source Review standards impacting criteria pollutant emissions, but argued further that their analysis of total emissions estimates for refineries in the National Emission Inventory database for 2002 suggested that NHTSA had substantially overestimated NO_x and $PM_{2.5}$ emissions, by "more than two and three times…, respectively." NERA compared NEI database refinery emissions estimates for 2002 to "estimates of refining emissions based on NHTSA's emission factors for refineries and U.S. production of gasoline and diesel fuels in that same year (EPA 2002)," assuming that NHTSA's estimates should be smaller, since "refineries produce other products besides gasoline and diesel fuel." However, NERA found that "estimates based on NHTSA's rates for only two refinery products (gasoline and diesel fuel) are larger than the NEI estimates for *all* refinery operations." NERA thus concluded that NHTSA had overestimated the benefits associated with reducing criteria pollutant emissions, because it had overestimated the amount of criteria pollutant emissions that would be reduced. NERA also stated that to the extent that fuel consumption was reduced in the long-run, refineries would be subject to more stringent emissions standards anyway, or fuel imports would be reduced, which would have no impact on U.S. emissions, although NERA did not attempt to quantify those effects.

The NERA Report next argued that NHTSA had used "ad hoc" estimates of the value per ton of criteria pollutants based on recommendations from EPA's OTAQ, which were unverifiable. NERA implied that NHTSA should instead use "values based on published EPA estimates," which it found included in a 2006 report by OMB to Congress. NERA stated that "OMB's values are slightly higher than NHTSA's for VOCs, but substantially lower for $PM_{2.5}$ and SO_x."

The NERA Report finally argued that "increasing quality-adjusted new vehicle prices will lead to an increase in the average age of the vehicle fleet, [which] will increase emissions both because older vehicles faced less stringent emission standards when sold and because the effectiveness of controls (especially those for NO_x) declines as the vehicle ages." NERA did not, however, attempt to quantify these emissions impacts. The Alliance in its comments emphasized this point about the fleet turnover effect, stating that it "shows that most criteria pollutant and air toxic levels will worsen for decades in consequence of NHTSA's proposed standards, as consumers delay purchasing new, more fuel-efficient vehicles in the current marketplace prior to an expensive new government mandate." The Alliance argued that EPCA and principles of administrative law require NHTSA to consider this effect.[279]

In response to Mr. Delucchi's comment, NHTSA is confident that the damage cost estimates it used in the NPRM to value reductions in criteria air pollutants and their chemical precursors include the full range of human health impacts known to be associated with exposure to each of these pollutants that current scientific and economic knowledge allows to be quantified and valued in economic terms. Differences between these damage costs and the estimates by OMB cited by commenters reflect the fact that the estimates provided to NHTSA by EPA apply specifically to emissions by motor vehicles, and include separate costs for emissions from stationary sources such as petroleum refineries where such differences are appropriate. The estimates provided by EPA also reflect more up-to-date knowledge about the human health impacts of exposure to criteria air pollutants and the economic costs associated with those impacts than do the estimates reported by OMB. Thus in the analysis it conducted for this Final Rule,

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[279] NHTSA notes that the Alliance also included a Sierra Research report previously submitted to EPA in connection with California's waiver application regarding the fleet-turnover effect with respect to California's proposed GHG emissions standards, as Attachment 14 to the Alliance's comments. NHTSA has not summarized the findings of that report in detail because it believes that the purpose for which the Alliance submitted the report is already captured by the NERA Report comments, and because the fleet-turnover effect due to California's proposed standards would have no direct impact on NHTSA's decision for the final rule.

NHTSA has continued to use the damage cost estimates supplied by EPA to determine the economic costs or benefits from changes in emissions of criteria air pollutants that result from higher CAFE standards.

In response to comments provided by NERA on behalf of the Alliance, NHTSA acknowledges that it may have overestimated reductions in upstream emissions of some criteria air pollutants (particularly PM and NO_x) resulting from fuel savings in the analysis it conducted for the NPRM. NHTSA has taken two steps to remedy this possible overestimation. First, the agency used updated emission factors for vehicles used to transport crude petroleum and refined fuel, including ocean tankers, railroad locomotives, barges, and heavy-duty trucks supplied by EPA to recalculate the emissions factors for each stage of fuel production and distribution in Argonne's GREET model. These updated emission factors reflect the effects of recent and pending EPA regulations on vehicle emissions and fuel composition, and result in significant reductions in the upstream emission rates for fuel production and distribution estimated using GREET. These lower upstream emission rates reduce NHTSA's estimates of emissions during fuel production and distribution under both Baseline and alternative CAFE standards, and by doing so also lower the reductions in upstream emissions projected to result from any increase in CAFE standards from their Baseline levels.

In addition, NHTSA notes that the estimates of reductions in upstream emissions it reported in the NPRM incorrectly included reductions in ocean tanker emissions for transportation of crude petroleum from overseas to ports or offshore oil terminals in the U.S. Since most of these emissions probably occur outside of the U.S., they should not be included in NHTSA's estimates of upstream emissions reductions, since those are intended to represent changes in *domestic* emissions of criteria air pollutants.[280] NHTSA has revised its analysis for this Final Rule to exclude reductions in ocean tanker emissions.

In response to comments by Sierra Research and NERA submitted by the Alliance, NHTSA notes that there are currently two cap-and-trade programs governing emissions of criteria pollutants by large stationary sources. The Acid Rain Program seeks to limit NO_x and SO_2 emissions, but applies only to electric generating facilities.[281] The NO_x Budget Trading Program is also primarily intended to reduce electric utility emissions, but does include some other large industrial sources such as refineries; however, as of 2003, refineries participating in the program accounted for less than 5 percent of total NO_x emissions by U.S. refineries.[282] In addition, some refineries could be included among the sources of NOx emissions that will be controlled under EPA's Clean Air Interstate Rule, which is scheduled to take effect beginning in 2009. However, refinery NO_x emissions could only be affected in states that specifically elect to include sources other than electric generating facilities in their plans to comply with the rule, and EPA has indicated that it expects states to achieve the emissions reductions required by the Clean Air Interstate Rule primarily from the electric power industry.[283] Thus, the

[280] Emissions from ocean tankers while in port areas, as well as pipeline or truck emissions occurring during transportation of crude petroleum from import terminals to U.S. refineries, do occur within the U.S., and reductions in these emissions should be included when estimating changes in domestic emissions. However, it is not possible to separate these emissions from those that occur in foreign ports or on the open oceans, so NHTSA's analysis does not include reductions in them. As a consequence, the analysis may underestimate reductions in upstream emissions occurring within the U.S.
[281] For a detailed description of the Acid Rain program, *see* http://www.epa.gov/airmarkt/progsregs/arp/basic.html#princips (last accessed October 6, 2008).
[282] Estimated from EPA, NO_x Budget Trading Program (SIP Call) 2003 Progress Report, Appendix A, http://www.epa.gov/airmarkets/cmprpt/nox03/NBP2003AppendixA.xls, and National Air Quality and Emissions Trends Report 2003, Table A-4, http://www.epa.gov/air/airtrends/aqtrnd03/pdfs/a4.pdf
[283] The Clean Air Interstate Rule also requires reductions in SO_2 emissions and establishes an emissions trading program to achieve them, but only electric generating facilities are included in the rule's SO_2 emissions trading program; see EPA, Clean Air Interstate Rule: Basic Information,

agency continues to assume that the reduction in domestic gasoline refining estimated to result from the adopted CAFE standard will be reflected in reduced refinery emissions of criteria pollutants.

NHTSA also notes in response to comments by Sierra Research and NERA submitted by the Alliance that emissions occurring during refueling at retail stations are included in the emissions factors estimated using EPA's MOBILE emission factor model, which also accounts for expected future reductions in these emissions. Thus, NHTSA believes that reductions in refueling emissions were correctly estimated in its NPRM analysis, and has not revised its procedures for doing so.

Finally, in response to comments by the Alliance and NERA, NHTSA acknowledges that the effect of higher prices for new vehicles on the retention and use of older vehicles is potentially significant, depending on the magnitude of expected price increases. As indicated in the discussion of the appropriate discount rate to use in analyzing the impacts of alternative CAFE standards (see Section V.B.14 below), however, NHTSA believes that manufacturers are likely to experience difficulty raising prices for new cars and light trucks sufficiently to recover all their costs for complying with higher CAFE standards. Based on a detailed econometric analysis of the effects of new vehicle prices and other variables on retirement rates for used vehicles very similar to the analysis conducted by NERA for the Alliance, NHTSA concludes that price increases for MY 2011-15 cars and light trucks likely to result from higher CAFE standards are unlikely to cause significant or lasting changes in retirement rates for older vehicles. NHTSA also notes that the vehicles whose retirement rates would be most

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http://www.epa.gov/cair/basic.html#timeline (last accessed October 6, 2008) and http://www.epa.gov/cair/pdfs/cair_final_fact.pdf (last accessed October 6, 2008).

affected by increases in prices for MY 2011-15 passenger cars and light trucks are those that will be 10-15 years of age at the time when 2011-15 vehicles are offered for sale.[284] These include cars and light trucks produced during model years 1996 through 2005, and NHTSA's analysis of their emission rates at those ages predicted using EPA's MOBILE6.2 motor vehicle emission factor model suggests that they will not be dramatically higher than emission rates for comparable new 2011-15 models. Thus the effect on total motor vehicle emissions of criteria air pollutants resulting from any reduction in new vehicle sales and accompanying increase in use of older vehicles caused by increased prices for new 2011-15 cars and light trucks is likely to be modest.

(b) Reductions in CO_2 emissions

In the NPRM, NHTSA also discussed the fact that fuel savings from stricter CAFE standards result in lower emissions of carbon dioxide (CO_2), the main greenhouse gas emitted as a result of refining, distributing, and using transportation fuels. Lower fuel consumption reduces CO_2 emissions directly, because the primary source of transportation-related CO_2 emissions is fuel combustion in internal combustion engines. NHTSA tentatively estimated reductions in carbon dioxide emissions resulting from fuel savings by assuming that the entire carbon content of gasoline, diesel, and other fuels is converted to carbon dioxide during the combustion process.[285]

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[284] This conclusion is based on unpublished econometric analysis of the effects of new vehicle prices and other variables on retirement rates for used vehicles conducted by the Volpe Center. This analysis concluded that retirement rates for 10-15 year old vehicles are most sensitive to changes in new vehicle prices.

[285] NHTSA explained that this assumption results in a slight overestimate of carbon dioxide emissions, since a small fraction of the carbon content of gasoline is emitted in the forms of carbon monoxide and unburned hydrocarbons. However, the magnitude of this overestimate is likely to be extremely small. This approach is consistent with the recommendation of the Intergovernmental Panel on Climate Change for "Tier 1" national greenhouse gas emissions inventories. *Cf.* Intergovernmental Panel on Climate Change, 2006 Guidelines for National Greenhouse Gas Inventories, Volume 2, Energy, Chapter 3, "Mobile Combustion," at 3.16. See http://www.ipcc-

Reduced fuel consumption also reduces carbon dioxide emissions that result from the use of carbon-based energy sources during fuel production and distribution.[286] For purposes of the NPRM, NHTSA estimated the reductions in CO_2 emissions during each phase on fuel production and distribution using CO_2 emission rates obtained from the GREET model discussed above, using the previous assumptions about how fuel savings are reflected in reductions in each phase. The total reduction in CO_2 emissions from the improvement in fuel economy under each alternative CAFE standard is the sum of the reductions in emissions from reduced fuel use and from lower fuel production and distribution.

NHTSA stated in the NPRM that it had not attempted to estimate changes in emissions of other GHGs, in particular methane, nitrous oxide, and hydrofluorocarbons,[287] and invited comment on the importance and potential implications of doing so under NEPA.

NHTSA received two comments on this issue. The Alliance commented that NHTSA's decision not to address other GHGs was within the agency's discretion for two

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nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf (last accessed October 6, 2008).

[286] NHTSA did not, for purposes of the NPRM, attempt to estimate changes in upstream emissions of GHGs other than CO_2. This was because carbon dioxide from final combustion itself accounts for nearly 97 percent of the total CO_2-equivalent emissions from petroleum production and use, even with other GHGs that result from those activities (principally methane and nitrous oxide) weighed by their higher global warming potentials (GWPs) relative to CO_2. Calculated from EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2006, Tables 3-3, 3-39, and 3-41, EPA 430-R-08-05, April 15, 2008. *Available at* http://www.epa.gov/climatechange/emissions/downloads/08_CR.pdf (last accessed August 15, 2008).

[287] This was because methane and nitrous oxide account for less than 3 percent of the tailpipe GHG emissions from passenger cars and light trucks, while CO_2 emissions account for the remaining 97 percent. Of the total (including non-tailpipe) GHG emissions from passenger cars and light trucks, tailpipe CO_2 represents about 93.1 percent, tailpipe methane and nitrous oxide represent about 2.4 percent, and hydrofluorocarbons (from air conditioner leaks) represent about 4.5 percent. Calculated from EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2006, Table 215, EPA 430-R-08-05, April 15, 2008. *Available at* http://www.epa.gov/climatechange/emissions/downloads/08_CR.pdf (last accessed August 15, 2008).

reasons. First, because as the Alliance stated that NHTSA suggested in the NPRM, "analyzing the emissions of GHGs other than CO_2 simply does not have a large effect on any analysis of potential GHG benefits as connected to CAFE standard setting," which the Alliance argued CARB also implicitly agreed with by denominating other GHGs in CO_2-equivalents. The Alliance stated that even though other GHGs have higher global warming potentials than CO_2, "even factoring GWP into the analysis still leaves the other GHGs with little significance to any consideration of the benefits of more-stringent CAFE standards." The Alliance further argued that the Ninth Circuit decision only concerned NHTSA's valuation of CO_2, so that NHTSA had no obligation under case law to monetize the effects of other GHGs as long as it evaluates them qualitatively.[288]

CBD, in contrast, agreed with NHTSA that other GHGs make up only a small portion of the total GHGs emitted from automobiles. However, CBD argued that these other GHG emissions "…nonetheless represent large amounts of greenhouse gases and must be included in both the economic and environmental analyses." CBD gave the example that "…nitrous oxide emissions with greenhouse gas impacts equivalent to 29 million metric tons of CO_2 are far from insignificant." NHTSA also notes that EPA's TSD on reducing GHG emissions, which was submitted as an attachment to EDF's comments, considers GHGs generally rather than focusing on CO_2.

In response to the comment from CBD, NHTSA has prepared detailed estimates of changes in emissions of certain non-CO_2 GHGs, including methane and nitrous oxide, that would result from alternative CAFE standards for 2011-15 passenger cars and light trucks. These estimates are reported in the Final Environmental Impact Statement

[288] The Alliance cited *Center for Auto Safety v. Peck*, 751 F.2d 1336, 1367, 1368 (D.C. Cir. 1985) (Scalia, J.) (upholding agency decision predicated upon weighing of non-monetized and monetized benefits against monetized costs).

accompanying this Rule.[289] Because the estimated reductions in emissions of these non-CO_2 GHGs represent a small fraction of reductions in CO_2 emissions, however, and because they are less reliable than the estimates of reductions in CO_2 itself, NHTSA has not included the economic value of reductions in non-CO_2 GHGs in its estimates of economic benefits from higher CAFE standards.[290]

(c) Economic value of reductions in CO_2 emissions

Emissions of carbon dioxide and other greenhouse gases (GHGs) occur throughout the process of producing and distributing transportation fuels, as well as from fuel combustion itself. By reducing the volume of fuel consumed by passenger cars and light trucks, higher CAFE standards will thus reduce GHG emissions generated by fuel use, as well as throughout the fuel supply cycle. Lowering these emissions is likely to slow the projected pace and reduce the ultimate extent of future changes in the global climate, thus reducing future economic damages that changes in the global climate are otherwise expected to cause. Further, by reducing the probability that climate changes with potentially catastrophic economic or environmental impacts will occur, lowering GHG emissions may also result in economic benefits that exceed the resulting reduction in the expected future economic costs caused by gradual changes in the earth's climatic systems.

[289] The FEIS is available at Docket No. NHTSA-2008-0060-0605.

[290] Expressed in CO_2-equivalent terms using global warming potentials estimated by IPCC, the reductions in methane and nitrous oxide emissions represent only about 3% of the estimated reduction in CO_2 itself. NHTSA views its estimates of non-CO_2 GHGs as less reliable than those of CO_2 itself partly because the vehicle emission factors for methane and nitrous oxide obtained from documentation for EPA's MOVES motor vehicle emission factor model assume little or no change over future model years or with vehicle age, in contrast to the pronounced declines projected for emissions of criteria air pollutants and CO_2. Similarly, the emission factors for non-CO_2 GHGs during gasoline and diesel production and distribution that are utilized in Argonne's GREET model are assumed to be fixed over the period spanned by NHTSa's analysis, again in contrast to those for criteria air pollutants and CO_2.

Quantifying and monetizing benefits from reducing GHG emissions is thus an important step in estimating the total economic benefits likely to result from establishing higher CAFE standards. Since direct estimates of the economic benefits from reducing GHG emissions are generally not reported in published literature on the impacts of climate change, these benefits are typically assumed to be the "mirror image" of the estimated incremental costs resulting from an increase in those emissions. That is, the benefits from reducing emissions are usually measured by the savings in estimated economic damages that an equivalent increase in emissions would otherwise have caused.

Researchers usually estimate the economic costs of increased GHG emissions in several steps; the first is to project future changes in the global climate and the resulting economic damages that are expected to result under a baseline projection of net global GHG emissions. These projections are usually developed using models that relate concentrations of GHGs in the earth's atmosphere to changes in summary measures of the global climate such as temperature and sea levels, and in turn estimate the reductions in global economic output that are expected to result from changes in climate. Since the effects of GHG emissions on the global climate occur decades or even centuries later, and there is considerable inertia in the earth's climate systems, changes in the global climate and the resulting economic impacts must be estimated over a comparably long future period.

Next, this same process is used to project future climate changes and resulting economic damages under the assumption that GHG emissions increase by some increment during a stated future year. The increase in projected global economic damages resulting from the assumed increase in future GHG emissions, which also occurs over a prolonged period extending into the distant future, represents the added economic costs resulting from the assumed increase in emissions. Discounted to its current value as of the year when the increase in emissions are expected to occur and expressed per unit of GHG emissions (usually per ton of carbon emissions, with non-CO_2 GHGs converted to their equivalents in terms of carbon emissions), the resulting value represents the global economic cost of increasing GHG emissions by one unit – usually a metric ton of carbon – in a stated future year. This value is often referred to in published research and debates over climate policy as the Social Cost of Carbon (SCC), and applies specifically to increased emissions during that year.

This process involves multiple sources of uncertainty, including those in scientific knowledge about the effects of varying levels of GHG emissions on the magnitude and timing of changes in the functioning of regional and global climatic and ecological systems. In addition, significant uncertainty surrounds the anticipated extent, geographic distribution, and timing of the resulting impacts on the economies of nations located in different regions of the globe. Because the climatic and economic impacts of GHG emissions are projected to occur over the distant future, uncertainty about the correct rate at which to discount these future impacts also significantly affects the estimated economic benefits of reducing GHG emissions.

Researchers have not yet been able to quantify many of the potentially significant effects of GHG emissions and their continued accumulation in the earth's atmosphere on the global climate. Nor have they developed complete models to represent the anticipated impacts of changes in the global climate on economic resources and the productivity with which they are used to generate economic output. As a consequence, the estimates of economic damages resulting from increased GHG emissions that are generated using integrated models of climate and economic activity exclude some potentially significant sources of costs that are likely to result from increased emissions. As a result, estimates of economic benefits derived from these models' estimates of the likely future climate-related economic damages caused by increased GHG emissions may underestimate the true economic value of reducing emissions, although the extent to which they are likely to do so remains unknown.

In the NPRM, NHTSA explained how it accounted for the economic benefits of reducing CO_2 emissions in this rulemaking, both in developing the proposed CAFE standards and in assessing the economic benefits of each alternative that was considered. The agency noted that the Ninth Circuit found in *CBD v. NHTSA* that NHTSA had been arbitrary and capricious in deciding not to monetize the benefit of reducing CO_2 emissions, stating that the agency had not substantiated the conclusion in its April 2006 final rule that the appropriate course was not to monetize (*i.e.*, quantify the value of) carbon emissions reduction at all. NHTSA's discussion of how it estimated the economic value of reductions in CO_2 emissions received a great deal of attention from commenters, so for the reader's benefit, it is largely reproduced below.

To that end, NHTSA reviewed published estimates of the "social cost of carbon" (SCC) emissions. The SCC refers to the marginal cost of additional damages caused by the increase in expected climate impacts resulting from the emission of each additional metric ton of carbon, which is emitted in the form of CO_2.[291] It is typically estimated as

[291] Carbon itself accounts for 12/44, or about 27 percent, of the mass of carbon dioxide (12/44 is the ratio of the molecular weight of carbon to that of carbon dioxide). Thus, each ton of carbon emitted is associated with 44/12, or 3.67, tons of carbon dioxide emissions. Estimates of the SCC are typically reported in

the net present value of the impact over some extended time period (100 years or longer) of one additional ton of carbon emitted into the atmosphere. Because atmospheric concentrations of greenhouse gases are increasing over time, and the potential damages from global climate are believed to increase with higher atmospheric GHG concentrations, the economic damages resulting from an additional ton of CO_2 emissions are expected to increase over time. Thus, estimates of the SCC are typically reported for a specific year, and these estimates are generally larger for emissions in more distant future years.

NHTSA found substantial variation among different authors' estimates of the SCC, much of which can be traced to differences in their underlying assumptions about several variables. These variables include the sensitivity of global temperatures and other climate attributes to increasing atmospheric concentrations of GHGs, discount rates applied to future economic damages from climate change, whether damages sustained by developing regions of the world should be weighted more heavily than damages to developed nations, how long climate changes persist once they occur, and the economic valuation of specific climate impacts.[292]

NHTSA explained that, taken as a whole, recent estimates of the SCC may underestimate the true damage costs of carbon emissions because they often exclude damages caused by extreme weather events or climate response scenarios with low probabilities but potentially extreme impacts, and may underestimate the climate impacts

dollars per ton of carbon, and must be divided by 3.67 to determine their equivalent value per ton of carbon dioxide emissions.

[292] For a discussion of these factors, *see* Yohe, G.W., R.D. Lasco, Q.K. Ahmad, N.W. Arnell, S.J. Cohen, C. Hope, A.C. Janetos, and R.T. Perez, "Perspectives on climate change and sustainability," 2007, in Climate Change 2007: Impacts, Adaptation and Vulnerability, Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, L.P. Palutikof, P.J. van der Linden and C.E. Hanson, eds., Cambridge University Press, 2007, at 821-824. *Available at* http://www.ipcc-wg2.org (last accessed October 7, 2008).

and damages that could result from multiple stresses on the global climatic system. At the same time, however, many studies fail to consider potentially beneficial impacts of climate change, and do not adequately account for how future development patterns and adaptations could reduce potential impacts from climate change or the economic damages they cause.

Given the uncertainty surrounding estimates of the SCC, NHTSA suggested that the use of any single study may not be advisable, since its estimate of the SCC will depend on many assumptions made by its authors. NHTSA cited the Working Group II's contribution to the Fourth Assessment Report of the United Nations Intergovernmental Panel on Climate Change (IPCC) as noting that:

> The large ranges of SCC are due in large part to differences in assumptions regarding climate sensitivity, response lags, the treatment of risk and equity, economic and non-economic impacts, the inclusion of potentially catastrophic losses, and discount rates.[293]

Although the IPCC is considered authoritative on the topic of the SCC, it did not recommend a single estimate, and NHTSA requires a single estimate for purposes of its analysis. This is because NHTSA attempts to determine the single set of passenger car and light truck CAFE standards that maximizes net social benefits arising from the fuel savings and related impacts that would result, rather than a probabilistic "expected value" of the benefit-maximizing CAFE standards. Identifying these "optimized" standards requires assigning a single value to the economic benefits resulting from each of these impacts, including the benefits from reducing CO2 emissions. The IPCC did cite the Tol (2005) study on four separate occasions as the only available survey of the peer-reviewed

[293] Climate Change 2007: Impacts, Adaptation and Vulnerability, Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, at 17. *Available at* http://www.ipcc-wg2.org (last accessed October 7, 2008).

literature that has itself been subjected to peer review.[294] Tol developed a probability function using the SCC estimates of the peer-reviewed literature and found estimate ranging from less than zero to over $200 per metric ton of carbon. In an effort to resolve some of the uncertainty in reported estimates of climate damage costs from carbon emissions, Tol (2005) reviewed and summarized 103 estimates of the SCC from 28 published studies. He concluded that when only peer-reviewed studies published in recognized journals are considered, "…climate change impacts may be very uncertainty but it is unlikely that the marginal damage costs of carbon dioxide emissions exceed $50 per [metric] ton carbon,"[295] which is about $14 per metric ton of CO_2. In the NPRM, NHTSA assumed that the summary SCC estimates reported by Tol were denominated in U.S. dollars of the year of his article's publication, 2005. Tol also concluded that the costs may be less than $50 per metric ton of carbon, or $14 per metric ton of CO_2.

NHTSA stated that because of the number of assumptions required by each study, the wide range of uncertainty surrounding these assumptions, and their critical influence on the resulting estimates of climate damage costs, some studies have undoubtedly produced estimates of the SCC that are unrealistically high, while others are likely to have estimated values that are improbably low. Using a value for the SCC that reflects the central tendency of estimates drawn from many studies reduces the changes of relying on a single estimate that subsequently proves to be biased.

It is important to note that estimates of the SCC almost invariably include the value of worldwide damages from potential climate impacts caused by carbon dioxide emissions, and are not confined to damages likely to be suffered within the U.S. In

[294] *Id.*, at 17, 65, 813, and 822.
[295] Tol, Richard S.J., "The marginal damage costs of carbon dioxide emissions: an assessment of the uncertainties," Energy Policy 33 (2005), 2064-2074, at 2072.

contrast, the other estimates of costs and benefits of raising fuel economy standards included in this proposal include only the economic values of impacts that occur within the U.S. For example, the economic value of reducing criteria air pollutant emissions from overseas oil refineries is not counted as a benefit resulting from this rule, because any reduction in damages to health and property caused by overseas emissions are unlikely to be experienced within the U.S.

In contrast, the reduced value of transfer payments from U.S. oil purchasers to foreign oil suppliers that results when lower U.S. oil demand reduces the world price of petroleum (the reduced "monopsony effect") is counted as a benefit of reducing fuel use.[296] If the agency's analysis was conducted from a worldwide rather than a U.S. perspective, however, the benefit from reducing air pollution overseas would be included, while reduced payments from U.S. oil consumers to foreign suppliers would not.

In the NPRM, NHTSA tentatively concluded that in order to be consistent with the agency's use of exclusively domestic costs and benefits in prior CAFE rulemakings, the appropriate value to be placed on climate damages caused by carbon emissions should be the one that reflects the change in damages to the U.S. alone. Accordingly, NHTSA noted that the value for the benefits of reducing CO_2 emissions might be restricted to the fraction of those benefits that are likely to be experienced within the U.S.

Although no estimates are currently available for the benefits to the U.S. itself that are likely to result from reducing CO_2 emissions, NHTSA explained that it expected that if such values were developed, the agency would employ those rather than global benefit estimates in its analysis. NHTSA also stated that it anticipated that if such values

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[296] The reduction in payments from U.S. oil purchasers to domestic petroleum producers is not included as a benefit, however, since it represents a transfer that occurs entirely within the U.S. economy.

were developed, they would be lower than comparable global values, since the U.S. is likely to sustain only a fraction of total global damages resulting from climate change.

In the meantime, NHTSA explained that it elected to use the Tol (2005) estimate of $43 per metric ton of carbon as an upper bound on the benefits resulting from reducing each metric ton of U.S. emissions.[297] This value corresponds to approximately $12 per metric ton of CO_2 when expressed in 2006 dollars. The Tol (2005) study is cited repeatedly as an authoritative survey in various IPCC reports, which are widely accepted as representing the general consensus in the scientific community on climate change science. Since Tol's estimate includes the *worldwide* costs of potential damages from carbon dioxide emissions, NHTSA elected to employ it as an upper bound on the estimate value of the reduction in U.S. domestic damage costs that is likely to result from lower CO_2 emissions.[298] NHTSA noted that Tol had a more recent (2007) and inclusive survey published online with peer-review comments. NHTSA stated that it had elected not to rely on this study, but that it would consider doing so in its analysis for the final rule if the survey had been published, and would also consider any other newly-published evidence.

NHTSA noted that the IPCC Working Group II Fourth Assessment Report (2007, at 822) further suggests that the SCC is growing at an annual rate of 2.4 percent, based on estimated increases in damages from future emissions reported in published studies. NHTSA also elected to apply this growth rate to Tol's original 2005 estimate. Thus, by

[297] $43 per ton of carbon emissions was reported by Tol (at 2070) as the mean of the "best" estimates reported in peer-reviewed studies (at the time). It thus differs from the mean of *all* estimates reported in the peer-reviewed studies surveyed by Tol. The $43 per ton value was also attributed to Tol by IPCC Working Group II (2007), at 822.
[298] For purposes of comparison, NHTSA noted that in the rulemaking to establish CAFE standards for MY 2008-11 light trucks, NRDC recommended a value of $10-$25 per ton of CO_2 emissions reduced by fuel savings, and both EDF and UCS recommended a value of $50 per ton of carbon, which is equivalent to about $14 per ton of CO_2 emissions.

2011, NHTSA estimated that the upper bound on the benefits of reducing CO_2 emissions will have reached about $14 per metric ton of CO_2, and will continue to increase by 2.4 percent annually thereafter.

In setting a lower bound, the agency agreed with the IPCC Working Group II report (2007) that "significant warming across the globe and the locations of significant observed changes in many systems consistent with warming is very unlikely to be due solely to natural variability of temperatures or natural variability of the systems." (p. 9) Although this finding suggests that the *global* value of economic benefits from reducing carbon dioxide emissions is unlikely to be zero, NHTSA stated that it does not necessarily rule out low or zero values for the benefit to the U.S. itself from reducing emissions.

For most of the analysis it performed to develop the CAFE standards, NHTSA required a single estimate for the value of reducing CO_2 emissions. The agency thus elected to use the midpoint of the range from $0 to $14, or $7.00, per metric ton of CO_2 as the initial value for the year 2011, and assumed that this value would grow at 2.4 percent annually thereafter. This estimate is employed for the analyses conducted using the Volpe model to support development of the proposed standards. The agency also conducted sensitivity analyses of the benefits from reducing CO_2 emissions using both the upper ($14/metric ton) and lower ($0/metric ton) bounds of this range.

NHTSA sought comment on its tentative conclusion for the value of the SCC, the use of a domestic versus a global value for the economic benefit of reducing CO_2 emissions, the rate at which the value of the SCC grows over time, the desirability of and procedures for incorporating benefits from reducing emissions of GHGs other than CO_2, and any other aspects of developing a reliable SCC value for purposes of establishing CAFE standards.

NHTSA received many comments on our assumptions about the SCC. The comment summaries are presented below and grouped by topic: (1) NHTSA's choice of a single value for the SCC; (2) NHTSA's choice of $7 as the value for the SCC; (3) NHTSA's choice of $0 as the lower bound estimate for the domestic U.S. value for the SCC; (4) NHTSA's choice of $14 as the upper bound estimate for the domestic U.S. value for the SCC; (5) other values that NHTSA could have chosen for the SCC; (6) NHTSA's use of a domestic versus a global value for the economic benefit of reducing CO_2 emissions; (7) the rate at which the SCC grows over time; (8) the discount rate that should be used for SCC estimates; and (9) other issues raised by commenters.

(1) NHTSA's choice of a single value for the SCC

NHTSA received a comment on its use of a single value for the SCC from Prof. Gary Yohe, an economist who has considered the SCC extensively and whom NHTSA cited in the NPRM. Prof. Yohe commented that the NPRM had stated that "Using a value for the SCC that reflects the central tendency of estimates drawn from many studies reduces the chances of relying on a single estimate that subsequently proves to be biased."[299] Prof. Yohe argued that choosing a single value for the SCC inherently creates bias, because "Any value is based on presumptions about pure rate of time preference, risk and/or inequity aversion, and climate sensitivity."

(2) NHTSA's choice of $7 as the value for the SCC

NHTSA received comments from 3 individuals, CARB, the Attorneys General, 10 U.S. Senators, 10 environmental and consumer groups, and the Alliance. Prof. Tol,

[299] 73 FR 24414 (May 2, 2008).

whose 2005 paper provided the basis for NHTSA's choice of an SCC number, commented that contrary to NHTSA's belief that the dollars used in Tol (2005) were 2005 dollars, they were in fact 1995 dollars. Prof. Tol also commented that NHTSA should "alert the reader" that although Tol (2007) was only "conditionally accepted," as NHTSA had noted in the NPRM, the newer study "finds larger estimates than the 2005 paper." Sierra Club *et al.*, in its comments, also stated that Prof. Tol had commented on the NPRM, arguing that using 1995 instead of 2005 dollars "would make his 1995 value of $14 closer to a 2005 value of $19.26."

Several commenters disputed NHTSA's choice of $7 as the midpoint between $0 and $14. UCS argued that choosing $7 puts as much weight on $0 as on $14, even though failing to assign a value was declared by the Ninth Circuit to be arbitrary and capricious. CBD commented that "NHTSA's methodology for the selection of an estimate of the value of reducing greenhouse gas emissions is arbitrary and designed to minimize the estimate." CBD argued that "…simply splitting the difference between two points is not a defensible methodology, particularly when the low point of the range is not part of a valid range but simply an arbitrary selection of zero as an endpoint."

EDF also commented NHTSA's decision to choose $7 because it is the midpoint between $0 and $14 also "lacks a reasoned basis," for which "NHTSA fails to provide any justification."

The Sierra Club *et al.* commented that NHTSA is wrong to place "equal weighting and probability" on $0 and $14 and pick the median, and that $7 is "far below current carbon estimates," citing the 2006 Stern Review which found an SCC of "on the order of" \$85/tonne CO_2. The Sierra Club argued that this shows how "misguided and unrealistic NHTSA's carbon pricing really is."

The Attorneys General commented that NHTSA's decision to simply halve Tol's estimate was "not a reasoned judgment."

Public Citizen argued that there is no justification for using the midpoint, and that NHTSA should instead "weight the credibility of each estimate," by making "apples to apples" comparisons between the studies by "looking at studies based on their assumptions." Public Citizen argued that this will help NHTSA avoid skewing the result of averaging estimates from multiple studies. NRDC similarly argued that choosing \$7 as "a simple average of its proposed upper and lower bounds….assumes a normal distribution of damages, which is decidedly *not* the distribution of social cost of carbon estimates." NRDC further argued that "…most social cost of carbon estimates are biased downwards, for the simple reason that almost all models assume perfect substitutability between normal consumption goods and environmental goods." NRDC cited 2007 research by Sterner and Persson disaggregating "goods" into "environmental goods" and "consumption goods," which found that the price of an environmental good like carbon reductions increased at a faster rate as damage progressed than consumption goods would increase. Accordingly, NRDC argued, "NHTSA's social cost of carbon is much too low."

Prof. Hanemann also commented that NHTSA did not justify its decision to pick the midpoint (between \$0 and \$14) and then project it to 2011, although he focused more particularly on NHTSA's not having applied "the escalation factor of a 2.4 percent increase in real terms beginning in 2005."

The Alliance commented that choosing \$7 as the midpoint between \$0 and \$14 is incorrect. The Alliance argued that NHTSA must try harder to estimate the purely domestic effects of CO_2 emissions reductions, and stated that NERA had found that the U.S. portion of world gross product "is a much better means of allocating the United States' share of any benefits in reduced CO2 emissions" than picking the midpoint of a range of global SCC estimates. NERA assumed that the U.S. portion is 20 percent, which "reduces NHTSA's estimate of CO2 benefits with the 'optimized standard' for MY2015 from \$869 million to \$348 million." NERA also argued that this was conservative, since the U.S., as a developed country, should be better able to adapt to negative global warming consequences.

Several commenters also criticized Tol (2005) as being out of date. Prof. Hanemann made this point, and commented that "more recent analyses show higher damage estimates." The Attorneys General similarly commented that "It seems likely that there are better estimates" than Tol's, "Since [that] article is now three years old, and it itself explains in detail the many deficiencies in the economic literature at that time." The Attorneys General stated that "NHTSA should consult with EPA on this issue, and conduct a review of the current scientific and economics literature."

Several commenters simply argued that \$7/ton is too low a value for the SCC. CARB argued that "NHTSA's assumed social cost of carbon in the future is also unreasonably low, and if set at defensible levels that also properly value cumulative impacts, could affect the stringency of the standards." Carin Skoog, an individual, similarly commented that "The arbitrary decision to use \$7/ton underestimates the economic, social, and environmental consequences of the impacts of global warming."

ACEEE similarly commented that NHTSA's use of $7/ton is both "inconsistent with current estimates" and "fails to take into account the potentially high probability of a catastrophic climate change situation." The 10 U.S. Senators who commented stated that NHTSA's value of $7 per ton is "underestimated," and "likely to be found arbitrary and capricious."

(3) NHTSA's choice of $0 as the lower bound estimate for the domestic U.S. value for the SCC

No commenters supported NHTSA's use of $0/ton as the lower bound estimate for the U.S. domestic SCC. Several commenters, including UCS, EDF, and Prof. Hanemann cited the IPCC Fourth Assessment Report as evidence that, as Prof. Hanemann stated, "there is no credible evidence of any significant net benefit to the U.S. from the climate change scenarios developed for the Fourth IPCC Report." The U.S. Senators who commented also stated that in citing the IPCC as not precluding low or zero values to the U.S., NHTSA had "fail[ed] to recognize that IPCC was looking at global estimates which are not disaggregated."

Commenters also mentioned other reports as providing evidence that there would be some net adverse impact on the U.S. from climate change, such that a lower bound value of $0 was untenable. Prof. Hanemann cited the recent USCCSP report "conclusively eliminates the notion that climate change is likely to have no net adverse impact on the United States."

UCS argued that choosing $0 as the lower bound "implies the possibility that climate change won't have any negative consequences," which "stands in stark contrast to recent government study findings on U.S. climate change effects and findings from … the Academies of Science for the G8+5."

EDF commented that "A recent review of economic studies on the predicted impacts of climate change on different economic sectors in the U.S. by the Center for Integrative Environmental Research at the University of Maryland, 'The US Economic Impacts of Climate Change and the Costs of Inaction: A Review and Assessment,' also demonstrates the range and scope of adverse impacts that climate change will have on different sectors and regions of the U.S. economy." EDF stated that "The study concluded that 'Scientific evidence is mounting that climate change will directly or indirectly affect all economic sectors and regions of the country, though not all equally. Although there may be temporary benefits from a changing climate, the costs of climate change rapidly exceed benefits and place major strains on public sector budgets, personal income and job security.'"

Sierra Club *et al.* commented that "several government reports [that] have clearly stated that CO_2 emissions do have a significant impact on our economy." NHTSA's conclusion that "it does not necessarily rule out low or zero carbon values for the benefit to the U.S. itself from reducing emissions" is arbitrary given agency's admission that "the global value of economic benefits from reducing carbon dioxide emissions is unlikely to be zero."

NRDC cited a U.S. government report that "documents that many of the projected impacts have already begun," as well as the Stern Review which "estimated that impacts could result in a loss of 5-20 percent of world GDP by 2100," and its own May 2008 report which "found U.S. damages from four impacts alone would cost 1.8 percent of GDP by 2100."

Several commenters instead raised objections to studies that may show a positive net benefit to the U.S. from climate change, such that a domestic SCC value could be $0. CBD stated that NHTSA offered "absolutely no evidence to support" choosing $0 as the lower bound, and argued that "only one study surveyed in Tol (2005) included central estimates below $0.00; and that was a non-peer-reviewed article, also authored by Tol." CBD further argued that Tol (2005) never found, nor included as a consideration in developing SCC estimates, as NHTSA suggested in the NPRM, that any studies failed "to consider potentially beneficial impacts of climate change," or to account adequately "for how future development patterns and adaptations could reduce potential impacts from climate change or the economic damages they cause."

Prof. Hanemann also argued that studies suggesting any possible positive net benefit to U.S. from global warming "have serious flaws and cannot withstand serious scrutiny," and concluded that a value of $0 per ton is "wildly unrealistic" "even [for] a sensitivity analysis."

NRDC commented that "NHTSA's lower bound seems to be based upon the fact that some estimates exist that are zero and even negative." However, NRDC argued that "These lower bound estimates are likely based on outdated science." NRDC "urge[d] NHTSA to do a rigorous re-examination of Tol's work, eliminating outdated zero estimates and adjusting for fat tailed upper distributions."

Several commenters also focused on the *CBD* decision to argue that NHTSA may not use $0 as the lower bound estimate, because as UCS stated, "the Ninth Circuit found a value of $0 to be arbitrary and capricious." EDF also commented that NHTSA's decision to pick $0 as the lower bound "lacks a reasoned basis," given the Ninth Circuit decision. Sierra Club *et al.* and the U.S. Senators similarly commented that $0 as the lower bound is contrary to *CBD*. The comment received from the U.S. Senators stated that "…we can only conclude that the purpose of this 'low bound' estimate is to cut the more accurate value in half in an arbitrary manner. We recommend NHTSA remove or justify this low bound estimate in its final CAFE regulation."

(4) NHTSA's choice of $14 as the upper bound estimate for the domestic U.S. value for the SCC

No commenters supported NHTSA's choice of $14/ton, based on Tol (2005), as the upper bound estimate for the domestic U.S. value for the SCC. ACEEE argued that "NHTSA's decision to use Tol's estimate of $14 as the upper bound based on the argument that this value includes the worldwide costs CO_2 is flawed," although the commenter did not explain why.

Some commenters argued that NHTSA should not have picked the median from Tol (2005) as its upper bound estimate.

The U.S. Senators who commented stated that NHTSA is wrong to use $14 as the upper bound because Tol's median is an average of multiple estimates, and averages should be used as averages and not as maximums. The Senators stated further that "NHTSA selected the lower of Tol's two estimates without explanation." The U.S. Senators also commented that Tol (2007) updates the previous study and finds a median of over $19/ton. NRDC also cited Tol (2007) as reflecting an increase in the median from $14 to $20 dollars per ton of CO_2.

Sierra Club *et al.* commented that $14 is an incorrect "maximum," because the maximum that Tol "states that the maximum carbon value is in the range of $55-$95 per metric ton CO2." The commenter further argued that if NHTSA could justify $0 as the lower bound, "then it should not be able to rule out the high value of $95 per ton CO_2 in the study, and the average value would be much higher."

NRDC commented that NHTSA should not have used Tol's median value of $14 as its upper bound for two reasons. First, a median value is not properly reflective of climate change damage estimate distributions, which are "asymmetric" with "fat" upper tails. And second, because of the unique aspects of climate change damage estimates, such as "nonlinearities, abrupt change, and thresholds," "a full probability density function should be estimated, using the *full range* of all [SCC] estimates from the studies, *not* simply a collection of their 'best-guesses.'" [Emphasis in original.] NRDC argued that research has shown that "When the same traditional social cost of carbon analyses are rerun incorporating the potential for nonlinear change, the resulting policy conclusions are changed considerably to greater mitigation," and that "Another recent study has shown that incorporating the potential for low-probability, high-damage events can increase the social cost of carbon by a factor of 20."

NRDC also cited Prof. Weitzman to argue that the complications of climate change damage estimates require any analysis to weigh more heavily the "low probability/high catastrophic risks," because these will otherwise be insufficiently accounted for. In discussing the uncertainties associated with climate change, NRDC cited Weitzman as stating that

> The result of this immense cascading of huge uncertainties is a "reduced form" of truly stupendous uncertainty about the aggregate-utility impacts of catastrophic

> climate change, which mathematically is represented by a very-spread-out very-fat-tailed PDF [probability density function] of what might be called (present discounted) "welfare sensitivity"…[T]he value of "welfare sensitivity" is effectively bounded only by some *very* big number representing something like the value of statistical civilization as we know it or maybe even the value of statistical life on earth as we know it.

Thus, NRDC argued, using an upper bound of $14 cannot possibly account for the uncertainties and risk of climate change. Like Sierra Club *et al*., NRDC further argued that "…for consistency with the rationale used for choosing the lower bound, NHTSA's upper bound should be based upon some function of the highest estimates in the Tol 2005 study (the very highest was $1,666)."

Some commenters argued that NHTSA had overlooked particular aspects of the Tol (2005) study, and thus arrived at $14 incorrectly.

CBD argued that NHTSA overlooked key aspects of the Tol (2005) analysis in choosing $14 per ton, including the fact that Tol included significantly higher estimates in his analysis. EDF similarly commented that NHTSA had failed to "discuss the significant gaps in the existing research reviewed in [Tol (2005)] and focuse[d] on a specific estimate of the SCC that is biased toward lower value estimates." EDF stated that NHTSA's decision to use only peer-reviewed studies from Tol (2005) introduced particular bias, because those studies "systematically used higher discount rates…which may have biased their results downward" compared to averaging all the studies together.

Some commenters argued that Tol (2005) was flawed, such that it could not provide a reliable basis for NHTSA to use its median estimate as the upper bound.

CBD commented that "the studies cited in the Tol (2005) survey dated back as much as 18 years, to 1991, and 25 of the 28 studies cited were published more than five years ago," so given that climate change science is progressing very rapidly, these studies are probably outdated.

EDF also argued that "Most of the 28 studies surveyed by Tol" are outdated and "consider only a limited number of potential impacts from climate change," as Tol recognizes by cautioning that the estimates analyzed "may understate the true cost of climate change." EDF stated that the IPCC's "most recent compilation of SCC research" agrees. EDF also commented that Tol's meta-analysis "compares studies with widely different methodologies and assumptions," particularly discount rates, which EDF stated NHTSA should have controlled for because it "can have a considerable impact on SCC estimates."

NRDC criticized Tol (2005) extensively in its comments. NRDC stated that Tol's estimate was based on studies which exclude (1) "non-market costs, such as damage to and loss of entire ecosystems and species;" and (2) "studies of national security costs caused by conflicts over stressed resources and increased migration from heavily impacted areas," which "describe global warming as a 'threat multiplier.'" NRDC recognized that Tol acknowledged that "costs such as those described above are poorly accounted for in current social cost of carbon estimates," but insisted that NHTSA must nonetheless account for them.

NRDC also argued that Tol's estimate is based on outdated studies, because "there are smaller natural sinks for carbon than Tol assumed, higher emissions than he assumed, a higher temperature response to emissions than he assumed, and faster changes in observed impacts than he assumed." NRDC commented that recent events like Hurricane Katrina are evidence that the U.S. cannot adapt to climate change-related disasters as fast as previously thought. NRDC further commented that it was unclear whether Tol's estimate "included any valuation for lost lives," suggesting that including this valuation could raise SCC considerably, and arguing that EPA accounts for it in Clean Air Act rulemakings.

(5) Other values that NHTSA could have chosen for the SCC

Many commenters suggested other SCC values that they thought NHTSA should use instead of a value based on Tol (2005).

Several commenters mentioned SCC values produced by EPA. In March 2008, EPA produced an analysis for the Senate Committee on Environment and Public Works for S. 2191, "America's Climate Security Act," also known as the Lieberman-Warner bill.[300] Public Citizen commented that NHTSA's upper bound estimate should be at least as high as EPA's estimates for the Lieberman-Warner bill, which Public Citizen said "are more recent than the Tol estimate cited in NHTSA's notice." Public Citizen commented that EPA "estimated the value of CO_2 in 2015 between \$22 and \$40 per metric ton of CO_2, and cited two other analyses with higher estimates of \$48 and \$50 per metric ton CO_2." Sierra Club *et al.* also commented that NHTSA must use a higher SCC value, and stated that "EPA's recent analysis of America's Climate Security Act of 2007 noted that the value of a ton of CO2 could be as high as \$22-\$40.28." An individual, Carin Skoog, also commented that "The US EPA recently suggested the value of a ton of CO2 could be as high as \$22-35." ACEEE appeared to refer obliquely to the EPA estimates, recommending that NHTSA use a higher CO_2 estimate. ACEEE argued that "legislative efforts to implement a carbon regime in which the projected market cost of CO_2 is

[300] *Available at* http://www.epa.gov/climatechange/downloads/s2191_EPA_Analysis.pdf (last accessed August 19, 2008).

expected to lie between $20 and $30 – significantly higher than the average damage cost assumed by NHTSA – serves as evidence that the U.S. is now beginning to contemplate the high risk of rising greenhouse gas emissions."

NRDC commented that NHTSA cited "compliance cost estimates provided by NRDC and others in the 2006 light truck rulemaking" in describing its choice of the upper bound estimate. NRDC argued that NHTSA should instead consider damage costs and not rely on compliance cost estimates. NRDC stated that "If NHTSA were to consider compliance costs it must consider current analyses, such as EPA's analysis of S.2191, which finds that CO_2 allowances would cost 19 to 67 (2005) dollars per ton of CO_2-equivalent in 2012 rising at 5 percent per year real (the range for EPA's Core Scenario is $19 to $35 in 2012, rising at 5 percent per year real)."

EPA also recently released a "Technical Support Document on the Benefits of Reducing GHG Emissions,"[301] (TSD) to accompany an Advance Notice of Proposed Rulemaking (ANPRM) on regulating GHG emissions under the Clean Air Act.[302] EDF commented in its original comments that "The higher SCC estimates contained in EPA's draft ANPR, and EPA's accompanying discussion of the remaining omissions and weaknesses in state-of-the-art SCC research, further demonstrates that NHTSA's estimates are underestimating the benefits of reducing carbon dioxide emissions, and therefore setting CAFE standards below optimal levels." After the TSD was released, EDF submitted it to NHTSA's NPRM docket, and submitted late additional comments arguing that NHTSA must "adjust its final rulemaking action in accordance with EPA's assessment and findings," because "EPA's assessment is far more rigorous than NHTSA's

[301] *Available at* Docket No. NHTSA-2008-0089-0456.2.
[302] EPA's ANPRM was signed July 11, 2008, after NHTSA's NPRM was published. *See* 73 FR 44353 (July 30, 2008).

proposal, and EPA's determinations are supported by a considerable and well-reasoned volume of information." EDF stated that EPA did its own meta-analysis "building on" Tol (2005) and (2007), but including "only recent peer reviewed studies that met a range of quality criteria in its evaluation." EDF further stated that EPA arrived at an estimate of \$40/tCO_2 (using a 3 percent discount rate), or \$60/tCO_2 (using a 2 percent discount rate). EDF commented that EPA concluded that estimates "likely underestimate costs of carbon dioxide emissions," because they do not account for all the climate change impacts identified by the IPCC, like "non-market damages, the effects of climate variability, risks of potential extreme weather, socially contingent events [(such as violent conflict)], and potential long-term catastrophic events."

The U.S. Senators who commented argued that NHTSA's use of \$14/ton based on Tol (2005) as the "high bound" estimate was incorrect because EPA had been working since 2007 "to develop more accurate, 'state-of-the-art' estimates of the benefits of reducing greenhouse gas pollution." The Senators stated that "Although EPA's estimates have not been finalized, the Agency used \$40 per ton as the value of reducing carbon dioxide emissions." The Senators further stated that "NHTSA's draft rule inexplicably makes no mention of EPA's extensive research and analysis in this area."

Other commenters argued that NHTSA should have used or considered the value at which CO_2 allowances are currently trading in the EU regulatory system. UCS stated that using \$14 as the upper end is "unacceptably low," given that "The European Climate Exchange, which provides a futures market value for global warming pollution in Europe's carbon constrained market, indicates 2011 contracts for carbon dioxide at approximately \$45 (U.S.) per metric ton—well above the figure cited by NHTSA." UCS argued that “This value represents a predicted marginal abatement cost (the cost of avoiding global warming pollution), and is likely a conservative estimate of the benefit of reducing global warming since the cost of avoiding climate change is lower than the cost of fixing the damage after it occurs.” UCS further argued that this number is also “generally consistent with other recent allowance price estimates, such as the EPA’s assessment of GHG allowance prices under Lieberman-Warner: $22-$40 in 2015 and $28-$51 in 2020 (EPA figures are in 2005 dollars per ton of CO_2-equivalent.)”

Sierra Club *et al.*, Public Citizen, and CARB all also commented that NHTSA’s value for the SCC is too low, and that NHTSA should instead use a CO_2 damage value based on the market value in the European Trading System, either the current value (which Public Citizen stated was “recently… around €30 per allowance (one metric ton CO_2 equivalent),” and CARB stated was “currently trading around $42 per ton”), or some future value. Sierra Club *et al*. argued that “the futures market value for a metric ton of CO_2 in 2011 is already up to $45,” while CARB went on to argue that “…Germany Deutsche Bank [is] forecasting EUA prices of $60 for 2008 and EUA prices as high as $100 by 2020 [citation removed].”

Other commenters suggested other SCC values different from any discussed so far. For example, Prof. Hanemann argued that, based on his own research, NHTSA use a value of “about $25 per metric ton [of CO_2] in 2005$,” and should apply a real growth rate of 2.4 percent per year to determine the value of reducing emissions in future years. CARB, in contrast, commented that “NHTSA should also consider using substantially higher estimates.” CARB stated that “the International Energy Agency (IEA) recently estimated that to limit global CO_2 emissions by the 50 percent GHG reduction that the

IPCC concluded is needed to keep global temperatures from rising more than two degrees Celcius by 2050, CO_2 offset prices will need to rise to up to $200 per ton….” CARB further argued that “…even this higher market price for carbon may not incorporate the true cost of all natural resources damages, an externality.”

Mr. Montgomery commented that NHTSA should use an SCC value of $0, because he argued that “If a comprehensive cap on [CO_2] emissions is put in place, as many commentators and policymakers predict, then the choice of policy instrument will have no effect on the overall level of emissions,” such that “Tightening a CAFE standard will only result in greater mitigation in emissions from [motor vehicles] and less mitigation in parts of the economy where decisions are made in response to carbon prices without specific regulatory mandates.” Thus, Mr. Montgomery concluded that “the damages from global warming will be the same no matter what the level of the CAFE standard, so that the SCC used should be zero.”

Mr. Montgomery also commented that an SCC based on Tol’s estimates will be too high if the “global policy objective toward greenhouse gas emissions…is a lower concentration than that on which the Tol estimates are based.” Mr. Montgomery argued that “Marginal damages depend on the level of GHG concentrations at which they are measured,” so that “If the goal for global concentrations is set at a high level (*e.g.*, 750 ppm) then damages from an additional ton of CO_2 (due to higher concentrations during the period of its residence in the atmosphere) will be higher than if the goal is set at a low level (350 ppm) at which point most of the damaging consequences have been eliminated.”

Ford redacted much of its discussion of the SCC based on confidentiality concerns, but seemed to argue generally that reducing CO_2 emissions from motor vehicles is expensive compared to reducing emissions in other sectors, and commented that "All sectors must contribute" to reducing emissions. Ford "recommended that NHTSA consider using CO_2 mitigation cost in their analysis in lieu of emission damage cost."

NADA commented that "NHTSA should consider incorporating into its analysis the $2.97 per metric ton recently paid by the U.S. House of Representatives for carbon offsets."[303]

The Alliance was the only commenter to suggest that NHTSA not quantify the SCC at all. The Alliance argued that "…given the fact that no published studies of which we are aware address the SCC apportionment issue, NHTSA would be well within its rights to decide that SCC will be considered purely in a qualitative balancing fashion and not quantified." The Alliance cited *Transmission Access Policy Study Group v. FERC*, 225 F.3d 667, 736 (D.C. Cir. 2000) ("Given that FERC's comparison of the frozen efficiency case to its base case yielded little difference, the agency had no reason to conduct further analysis. By rigorously examining the frozen efficiency case, even though it believed the case to be unreasonable, FERC ensured that its decision was 'fully informed' and 'well-considered.'").

(6) NHTSA's use of a domestic versus a global value for the economic benefit of reducing CO_2 emissions

[303] NADA cited the "Statement of Daniel P. Beard, Chief Administrative Officer, U.S. House of Representatives, Concerning the Purchase of Carbon Offsets," which does not list the specific price paid for the offsets described. *Available at* http://cao.house.gov/press/cao-20080205.shtml (last accessed August 24, 2008).

NHTSA received a number of comments on its tentative decision to employ a domestic value for the SCC instead of a global value. Several commenters supported a domestic value, while other commenters supported a global value.

The Alliance argued that NHTSA must consider only domestic impacts both because of EPCA, which refers to "the need of the *United States* to conserve energy," and because of the "extraterritoriality" or "*Aramco* canon," *see EEOC v. Arabian American Oil Co.*, 499 U.S. 244, 260 (1991) ("It is a longstanding principle of American law 'that legislation of Congress, unless a contrary intent appears, is meant to apply only within the territorial jurisdiction of the United States.') (quoting *Foley Bros. v. Filardo*, 336 U.S. 281, 285 (1949)). The Alliance further argued that because NHTSA must consider only domestic impacts, it must "develop some mechanism for scaling down the global SCC estimates produced in the published literature," besides NHTSA's proposal which just took the midpoint between $0 and $14 as the domestic SCC value. The Alliance argued that it would be inappropriate to use land mass to determine the domestic portion, since so much of the land mass on the planet is uninhabited; and also argued that it would be inappropriate to use population, since "not all human beings live in areas that are expected to be equally impacted by climate change." As discussed above, the Alliance cited to the NERA Report that it included with its comments as having found that an SCC value based on the U.S. share of world gross product was more appropriate.

NADA similarly commented that "NHTSA should account only for any *domestic* impacts of reducing the social costs of motor vehicle CO_2, given that EPCA focuses on U.S. energy security and all other costs and benefits evaluated with respect to the proposed CAFE standards are domestic only."

Mr. Delucchi agreed with NHTSA's discussion that "consistency requires" that only U.S. domestic "global warming damages" be considered if NHTSA also accounts for the monopsony effect in the reduced value of transfer payments from U.S. oil purchasers to foreign oil suppliers. Mr. Delucchi suggested that NHTSA use a procedure described in his previous research to estimate the fraction of global damages from climate change that would be borne within the U.S., and apply this fraction to the estimated global SCC to determine the value of U.S. domestic benefits from reducing emissions. This procedure adjusts the fraction of global GDP accounted for by the U.S. by the relative sensitivity of the U.S. to climate damages compared to the remainder of the world, which Delucchi measures by the ratio of U.S. dollar damages from climate change per dollar of U.S. GDP to global economic damages from climate change per dollar of global GDP. Using this method, he estimates that U.S. damages from climate change are likely to represent 0-14 percent of total global damages, and thus that the value to the U.S. of reducing carbon emissions is equal to that same percentage of the estimated global value of the SCC.[304]

Mr. Montgomery argued that a domestic SCC value was appropriate, commenting that "U.S. policy should be based on marginal damages to the U.S. from CO_2 emissions in the U.S., as stated in relevant OMB circulars on cost-benefit analysis and suggested in the draft." Mr. Montgomery further stated that "The consensus appears to be that richer countries are less vulnerable than poorer, and that temperature increases will be least in temperate regions like the U.S." Thus, Mr. Montgomery argued that a

[304] Mark A. Delucchi, Summary of the Non-Monetary Externalities of Motor Vehicle Use, UCD-ITS-RR-96-3 (9) rev.1, Institute of Transportation Studies, University of California, Davis, originally published September 1998, revised October 2004. Available at http://www.its.ucdavis.edu/publications/2004/UCD-ITS-RR-96-03(09)_rev1.pdf (last accessed October 7, 2008).

conservative estimate of U.S. damages would be a calculation "based on the ration of U.S. GDP to world GDP."

Other commenters argued that NHTSA should use a global SCC value. NRDC commented that because "Carbon dioxide is a global pollutant, and much of the damages other countries will experience *are a result* of U.S. emissions," and because "emissions in other countries will cause damages in the U.S.," that "It is fundamentally inconsistent with the global circulation of these pollutants to arbitrarily limit assessment of the benefits of reducing U.S. emissions to those accruing in our own territory." NRDC also commented that national security studies show that the global social costs of carbon will "spill over" to the U.S. and other wealthy countries. EDF also commented that NHTSA should use a global SCC number rather than a domestic one, because "Climate change is clearly a global issue," so EDF "recommend[s] that benefits of reducing CO_2 concentrations should reflect benefits to society as a whole."

EDF and the U.S. Senators commented that use of a global SCC value would be consistent with OMB guidance that international impacts of regulations may be considered if appropriate. The Senators also commented that the U.S. must consider the global climate change effects of its regulations because it ratified the United Nations Framework Convention on Climate Change in 1992. If every nation considers only domestic effects of climate change, the Senators argued, emissions reduction policies will fall "far short of the socially optimized level."

CBD similarly commented that NHTSA should use a global value for CO_2, arguing that using $7 "fails to incorporate the full economic costs of global climate change, values that are difficult to monetize, and costs to the world outside the boundaries of the United States." CBD stated that "In general, the estimate of the social costs of climate change fails to incorporate the loss of biodiversity, complex and large-scale ecosystem services, and the disproportionate impacts of global climate change on the developing world." CBD also stated that NHTSA's use of $0 as the lower bound estimate is "[p]resumably … meant to imply that the United States might benefit economically by letting other countries bear the costs of unabated American greenhouse gas emissions. Setting aside the tremendous ethical implications of such a position, NHTSA provides absolutely no evidence to support the claim."

In its late comments accompanying its submission of EPA's TSD, EDF argued that EPA's TSD concluded that a global number is correct, for several reasons. Because GHGs are global pollutants and affect everyone, using "domestic only" estimates would "omit potential impacts on the United States (*e.g,*, economic or national security impacts) resulting from climate change impacts in other countries." Consequently, a global number must be used to avoid missing any benefits and to maximize global net benefits (*i.e.*, "countries would need to mitigate up to the point where their domestic marginal cost equals the global marginal benefit." EDF stated that EPA's TSD cites Nordhaus (2006), and says that "Net present value estimates of global marginal benefits internalize the global and intergenerational externalities of reducing a unit of emissions and can therefore help guide policies towards an efficient level of provision of the public good."

(7) The rate at which the SCC grows over time

Several commenters cited the IPCC Fourth Assessment Report with regard to the rate at which the SCC should increase over time. CBD commented that as part of the Fourth Assessment Report, the IPCC "…states that 'It is virtually certain that the real social cost of carbon and other greenhouse gases will increase over time; it is very likely that the rate of increase will be 2% to 4% per year.'" The U.S. Senators commented that the 2.4 percent per year increase that NHTSA used in the NPRM is incorrect, because "the IPCC report states that 'it is very likely that the rate of increase will be 2% to 4% per year.'"

EDF stated that IPCC's recommendation of a 2.4 percent growth rate was meant to be used in combination with a low, intergenerational discount rate. EDF further argued that after the Fourth Assessment Report was released, one of the lead authors recommended using a growth rate of 3 percent, but that "The OMB equivalent guidance for the UK … recommend using a 2 percent yearly increase." EDF thus concluded that the 2.4 percent growth rate could be used, but only with a maximum 3 percent discount rate, and argued that a range of growth rates should be run in the sensitivity analysis "because of considerable uncertainty."

(8) The discount rate that should be used for SCC estimates

Commenters urged NHTSA to consider a low or even negative discount rate in choosing an estimate for the SCC. CBD, for example, stated that Stern found that "'If consumption falls along a path, the discount rate can be negative. If inequality rises over time, this would work to reduce the discount rate, for the social welfare functions typically used. If uncertainty rises as outcomes further into the future are contemplated, this would work to reduce the discount rate, with the welfare functions typically used.'" CBD then argued that "A negative discount rate would dramatically increase the cost of climate change in the cost-benefit analyses in the proposed rule."

NRDC commented that NHTSA should use a discount rate of no more than 3 percent for the entire rulemaking, and returned to this argument in its SCC discussion, criticizing Tol's estimate for relying "primarily upon estimates that did not use current accepted climate change discounting procedures of a declining discount rate over time."

In its initial comments, EDF stated that NHTSA should only consider recent studies that use a 3 percent discount rate for estimating SCC. In its late comments, EDF stated that EPA's TSD concluded that "a low discount rate is most appropriate for SCC estimation," for several reasons. First, because OMB Circular A-4 allows agencies to use a lower discount rate when there are inter-generational benefits associated with a rulemaking. Second, because "In this inter-generational context, a three percent discount rate is consistent with observed interest rates from long-term intra-generational investments (net of risk premiums) as well as interest rates relevant for monetary estimates of the impacts of climate change that are primarily consumption effects." And finally, because EPA had found that the scientific literature supports the use of a discount rate of 3 percent or lower, as being "…more consistent with conditions associated with long-run uncertainty in economic growth and interest rates, intergenerational considerations, and the risk of high impact climate damages (which could reduce or reverse economic growth)."

(9) Other issues raised by commenters

The remaining issues raised by commenters with regard to NHTSA's choice of value for the SCC were as follows:

Public Citizen commented that NHTSA should also have considered "the costs of inaction on reducing greenhouse gas emissions and the resultant consequences of global warming," including other environmental and health consequences such as those analyzed in NHTSA's DEIS. Public Citizen cited EPA's denial of California's waiver request and "a recent report from the University of Maryland" as evidence of some of these costs, and argued that NHTSA needed to estimate "the costs of inaction" in making its final decision.

NRDC commented that emissions reductions may be "greater than what CAFE accomplishes," such that the U.S. would "get…a larger social cost of carbon benefits stream," if the U.S. actions in "taking a lead in reducing emissions…[helps to] induce other countries, especially China and India, to also reduce." NRDC also argued that "Carbon dioxide has a very slow decay rate in the atmosphere, lasting hundreds of years into the future," which means that "the social costs of carbon extend well past the life time of the vehicle." Thus, "Any sensible benefits stream would extend them at *least* several decades past the lifetime of a vehicle."

In its original comments, EDF argued that NHTSA should have considered using a risk-management framework in developing an SCC estimate, because cost-benefit analysis "cannot capture the range of uncertainty and risk that characterizes climate change." EDF cited Prof. Weitzman's work as highlighting "that the expected damages of climate change may be dominated by the existence of consequences which have very low probability but very high damages (such as double-digit increases in mean global temperature), or a 'fat tail' in the distribution of possible outcomes." In its late comments, EDF added that EPA's TSD also suggested that a risk assessment framework may be more appropriate than cost-benefit analysis "in light of the ethical implications of climate change and the difficulty in valuing catastrophic risks to future generations." The

TSD went on to say that “Economics alone cannot answer the questions, policy, legal, ethical considerations are relevant too, and many cannot be quantified. When there is much uncertainty, economics recommends a risk management framework for guiding policy.”

Agency response: As indicated previously, NHTSA’s analysis of optimized CAFE standards (and the alternative standards that are established by reference to these optimized levels) requires a single value for the economic benefits from reducing CO_2 emissions. As discussed in detail below, NHTSA has elected to use a single value that is based on the mean SCC estimate reported in an updated survey of estimates of the SCC recently published by Tol. This value is the mean of estimates that use widely varying assumptions about climate sensitivity to increasing GHG concentrations, the extent of economic damages likely to result from climate change, the rate at which to discount distant future damages, the relative valuation of climate damages to nations with different income levels, and the degree of aversion to the risk of extreme climate change and damage scenarios. Thus, rather than representing particular assumptions about those parameters, it summarizes the extent of uncertainty about their values, and the effect of that uncertainty on the potential economic damages from climate change. In addition, NHTSA analyzed the sensitivity of the optimized CAFE standards and their resulting economic and environmental benefits to realistic variation about this single value, as described in detail in Section XIV.

In response to new research on the potential economic costs of climate change that has become available since the publication of the NPRM, as well as the many comments the agency received on its proposed CAFE standards and on the DEIS, NHTSA elected to revise the estimate of the value of reducing CO_2 emissions it uses to develop the CAFE standards adopted in this rule. To develop this new estimate, NHTSA relied on Tol's (2008) expanded and updated survey of 211 published estimates of the global SCC, which was published after the agency completed the analysis it conducted to develop its proposed CAFE standards.[305]

Tol's 2008 survey encompasses a significantly larger number of estimates for the global value of reducing carbon emissions than its previously-published counterpart. Like that author's earlier survey, it represents the only recent, publicly-available compendium of peer-reviewed estimates of the SCC that has been peer-reviewed and published itself. Thus, NHTSA believes that it is the most reliable source on which to base the agency's own revised estimate of the global value of reducing CO_2 emissions from fuel production and use.

Tol's updated survey reports that the mean value of the 125 estimates of the SCC published in peer-reviewed journals through the year 2006 is \$71 per ton of carbon emissions. All of these estimates represent the global value of reduced economic damages from climate change that would be likely to result from lower carbon emissions. NHTSA staff confirmed with the author that this value applies to carbon emissions occurring during the mid-1990s time frame, and is expressed in approximately 1995 dollars.[306] The \$71 per metric to estimate of the social cost of increased carbon emissions corresponds to a global value of \$19 per metric ton of CO_2 emissions reduced or avoided, also expressed in 1995 dollars. Adjusted to reflect increases since the mid-1990s in the marginal damage costs of emissions at now-higher atmospheric concentrations of GHGs

[305] Richard S.J. Tol (2008), The social cost of carbon: trends, outliers, and catastrophes, *Economics -- the Open-Access, Open-Assessment E-Journal*, **2** (25), 1-24.
[306] Tol (2008), Table 1, p. 16.

and expressed in 2007 dollars, this corresponds to a value of \$33 per ton of CO_2 emitted during the year 2007.

Many commenters noted that some estimates of the SCC are significantly higher that those reported by Tol (2005), and suggested that NHTSA employ these higher estimates of the SCC to determine the value of reducing CO_2 emissions. Specifically, the recent *Stern Review* estimates that the SCC is likely to be in excess of \$300 per metric ton of carbon, or approximately \$80 per ton of CO_2.[307] Some commenters argued that Stern's estimate should be given substantial weight in determining the value of reducing CO_2 emissions used to develop the agency's final CAFE standards. Although Stern's estimate is reported in Tol's 2008 survey, it is not included in the survey's average value for peer-reviewed estimates that forms the basis for NHTSA's revised estimate, because the study has not yet been subjected to formal peer review. However, NHTSA notes that the Stern Report's estimate of the SCC employs an unusually low value for the discount rate it applies to future economic damages from climate change, which is largely responsible for its extremely high estimate of the SCC. Although Stern makes the case for a very low discount rate on grounds of ethical treatment of future generations, the value he adopts is nevertheless outside the consensus range of estimates of this critical parameter. Hope and Newbury demonstrate that simply substituting a more conventional discount rate would reduce Stern's estimate of the benefits from reducing emissions to

[307] Stern, N.H., S.Peters, V.Bakhshi, A.Bowen, C.Cameron, S.Catovsky, D.Crane, S.Cruickshank, S.Dietz, N.Edmonson, S.-L.Garbett, L.Hamid, G.Hoffman, D.Ingram, B.Jones, N.Patmore, H.Radcliffe, R.Sathiyarajah, M.Stock, C.Taylor, T.Vernon, H.Wanjie, and D.Zenghelis (2006), *Stern Review: The Economics of Climate Change* Cambridge University Press, Cambridge, England.

the range of \$20-25 per ton of CO_2, well within the range of other estimates and significantly *below* the \$33 per ton value adopted by NHTSA.[308]

Several commenters noted that EPA has recently developed estimates of the value of reducing CO_2 emissions, and recommended that NHTSA employ these values in its analysis of alternative CAFE standards. EPA's estimates are reported in that agency's Technical Support Document accompanying its advance notice of proposed rulemaking on motor vehicle CO_2 emissions.[309] In that Document, EPA derives estimates of the SCC using the subset of estimates included in Tol's 2008 survey drawn from peer-reviewed studies published after 1995 that do not employ so-called equity weighting.[310] Updated from their original mid-1990s values to reflect increases in the marginal damage costs of emissions at growing atmospheric concentrations of CO_2 and expressed in 2006 dollars, EPA reports average values of \$40 per ton of CO_2 for studies using a 3 percent discount rate, and \$68 per ton for studies using a 2 percent discount rate.[311] These estimates compare to NHTSA's revised 2007 estimate of \$33 per ton of CO_2, which is based on estimates of the SCC that employ discount rates ranging from 1 percent to 5 percent.

NHTSA's view is that the mean value of all 125 SCC estimates from peer-reviewed studies reported by Tol provides a more appropriate basis for valuing reductions

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[308] See Hope, Chris, and David Newbery, "Calculating the Social Cost of Carbon," unpublished paper, Cambridge University, May 2006, p. 15.

[309] U.S. EPA, Technical Support Document on Benefits of Reducing GHG Emissions, EPA-HQ-OAR-2008-318-0078.pdf, June 12, 2008.

[310] Equity weighting assigns higher weights per dollar of economic damage from climate change that are expected to be borne by lower-income regions of the globe, in an attempt to make the welfare changes corresponding to those damages more comparable to the damages expected to be sustained by higher-income world regions.

[311] These values are reported in EPA, Table 1. p. 12. Using the original estimates included in Tol's 2008 survey, which were supplied to NHTSA by the author, the agency calculates these values at \$38 per ton and \$62 per ton for 3% and 2% discount rates, slightly below the estimates reported by EPA. These differences may be attributable to the two agencies' use of different measures of inflation to update the original estimates from mid-1990s to 2007 price levels (NHTSA employs the Implicit Price Deflator for U.S. GDP, generally considered to be an accurate index of economy-wide price inflation).

in CO_2 emissions than does the more limited subset of these estimates relied upon by EPA. Although the agency is aware that advances in modeling climate change and its potential economic damages have occurred over the past decade, NHTSA believes that excluding pre-1995 studies and those that employ equity weighting (which would eliminate a total of 58 of the 125 estimates) is not only arbitrary, but would eliminate many studies that produced sound, defensible estimates of the SCC, particularly recognizing that those studies have been published in peer-reviewed journals.[312] Including them thus improves the reliability of the resulting average value, by reducing the uncertainty surrounding it.

NHTSA also believes that the value of reducing CO_2 emissions should not be based solely on those estimates that reflect a single discount rate. NHTSA acknowledges that the varying discount rates employed by different researchers are an important source of variation in their resulting estimates of the SCC, but recognizes that the discount rate is a parameter about which there is legitimate disagreement, analogous to the uncertainty surrounding the other parameters involved in modeling future climate change and the resulting economic damages.

NHTSA believes that incorporating estimates of the SCC based on varying discount rates in its estimate of the benefits from reducing CO_2 emissions increases the extent to which that estimate accurately reflects legitimate sources of uncertainty, including that surrounding the correct discount rate. In the agency's view, this is

[312] Again using the original estimates from Tol's 2008 survey supplied by the author, NHTSA estimates that excluding the 18 pre-1995 estimates from the 125 used to develop the agency's $33 per ton estimate would increase this figure to $36 per ton, while excluding the 40 estimates that employ equity weighting would *reduce* the agency's estimate to $23 per ton. Excluding both pre-1995 estimates and those that employ equity weighting would eliminate a total of 58 of the 125 peer-reviewed estimates included in developing NHTSA's estimate of $33 per ton, and reduce it to $20 per ton.

preferable to attempting to resolve this uncertainty by limiting the sample of estimates to those that employ the discount rate it regards as most appropriate. Another more practical reason for not restricting the sample of estimates to those using a specific discount rate is that this would drastically reduce the number of estimates on which the agency's estimate of the value of reducing CO_2 emissions is based, thus increasing significantly the uncertainty that surrounds it. As an illustration, EPA's previously-reported estimate of the value of reducing CO_2 emissions for a 3 percent discount rate ($40 per ton) is based on only 10 of the 125 peer-reviewed estimates included in Tol's recent survey, while its estimate corresponding to a 2 percent discount rate ($68 per ton) is based on only 13 of those 125 estimates.[313]

In a recent rulemaking, DOE used a range of values from $0 to $20 (in 2007 dollars) per ton to estimate the benefits of reductions in CO_2 emissions resulting from new energy conservation standards for commercial air conditioning equipment.[314] DOE derived the upper bound of this range from the mean of published estimates of the SCC reported in the same earlier survey by Tol (2005) that NHTSA relied upon for the value it used to analyze the CAFE standards proposed in the NPRM, and the lower bound from the assumption that reducing CO_2 emissions would produce no economic benefit. However, NHTSA believes that the $33 per ton estimate it has developed using Tol's more recent (2008) and comprehensive survey of published estimates of the SCC provides a more up-to-date basis for valuing reductions in CO_2 emissions resulting from higher CAFE standards, primarily because Tol's 2008 survey includes a larger number of

[313] Based on Tol 2008, Table 1, p. 16.
[314] Department of Energy, 10 CFR Part 431, Energy Conservation Program for Commercial and Industrial Equipment: Packaged Terminal Air Conditioner and Packaged Terminal Heat Pump Energy Conservation Standards: Final Rule, *Federal Register*, October 7, 2008, pp. 58813-58814.

published estimates of the SCC, as well as more recently-published estimates. In all analyses that employ this estimated global value of the benefits from reducing CO_2 emissions, NHTSA reduces the value of the savings in monopsony costs from lower U.S. petroleum consumption and imports to zero. This is consistent with the fact that monopsony payments are a transfer rather than a real economic benefit when viewed from the same global perspective that justifies the use of a global value for reducing emissions.

As some commenters pointed out, another approach NHTSA could rely on to estimate the value of reducing GHG emissions would be to use actual or projected prices for CO_2 emission permits in nations that have adopted or proposed GHG emission cap and trade systems. In theory, permit prices would reflect the incremental costs for achieving the last emissions reductions necessary to comply with the overall emissions cap. If this cap is based on an estimate of the level of global emissions required to prevent an unacceptable degree of climate change, permit prices could provide an estimate of the benefits of reducing GHG emissions to a level that forestalls unacceptable climate change. A related approach would be to use estimates of the cost of reducing emissions from specific sources *other than* passenger cars or light trucks to estimate the value of reducing CO_2 emissions via higher CAFE standards, under the reasoning that requiring higher fuel economy for cars and light trucks would allow these costs to be avoided or saved.

NHTSA considered the use of CO_2 permit prices to measure the benefits from reducing emissions via higher CAFE standards, but rejected this approach primarily because of the difficulty and arbitrariness in deciding what is considered an “acceptable” degree of climate change. The agency also notes that there is considerable scientific uncertainty in determining the level of emissions reduction that would be necessary to limit climate change to any degree that was deemed acceptable. Since permit prices will depend on the level of emission reduction that is required, they are likely to reflect this arbitrariness and uncertainty. The difficulty in establishing emissions caps that lead to optimal reductions in CO_2 emissions means that prices for emission permits under cap-and-trade systems are unlikely to provide an accurate measure of global benefits from reducing emissions. Similar objections also apply to using the costs of reducing emissions from non-transportation sources to estimate the benefits from reducing car and light truck emissions, since both the source and level of emissions reductions are likely to affect critically the value of these cost savings. In addition, OMB guidance also advises against using the avoided costs of not having to undertake other, unrelated regulatory actions as estimates of the benefits of the action in question.[315] Both permit prices and cost savings from avoiding the necessity of emissions reductions in other sectors represent exactly such avoided costs of unrelated regulatory actions, and are thus inappropriate measures of benefits from reducing CO2 emisisons from passenger cars and light trucks.

Finally, still other comments urged the agency to take into account the resulting reduction in the risk of catastrophic climate events when estimating the benefits from reducing GHG emissions. Most of the estimates of the SCC that are included in Tol's updated review treat the risks and potential damages from catastrophic events using conventional probabilistic methods, but very few attempt to include explicit premiums

[315] Office of Management and Budget, Circular A-4, "Regulatory Analysis," September 17, 2003, at 19. *Available at* http://www.whitehouse.gov/omb/circulars/a004/a-4.pdf (last accessed November 13, 2008).

reflecting the population's aversion to accepting those risks. Further, most published studies of climate damages report insufficiently detailed results to allow appropriate risk premiums to be calculated, and in any event such calculations require arbitrary and controversial assumptions about the relationship between consumption levels and social welfare. Thus, while NHTSA acknowledges that including an appropriate premium to reflect the value of reducing the risks of catastrophic climate events could significantly increase its estimate of the value of reducing CO_2 emissions, it has not attempted to do so. For discussion of NHTSA's consideration of abrupt climate change, see § 3.4.3.2.4 of the FEIS.

The environmental impacts of GHG emissions differ in several important ways from those of conventional air pollutants. Most important, as the IPCC has noted, CO_2 and other GHGs are chemically stable, and thus remain in the atmosphere for periods of a decade to centuries or even longer, becoming well-mixed throughout the earth's atmosphere. As a consequence, current emissions of these gases have extremely long-term effects on the global climate, and emissions from the U.S. are expected to contribute to changes in the global climate that will affect many other nations. Similarly, emissions occurring in other countries will contribute to changes in the earth's future climate that are expected to affect the well-being of the U.S. The long-lived nature of atmospheric GHGs means that emissions of these gases from any location or source can affect the global climate over a prolonged period, and can thus result in economic damages to many other nations as well as over subsequent generations.

Some analysts argue that reducing GHG emissions to an economically efficient level, or one that maximizes the difference between the benefits from limiting the extent of climate change and the costs of achieving the necessary emissions reductions, would require individual nations to limit their own domestic emissions to the point where their *domestic* costs for further reducing emissions equal the *global* value of reduced economic damages that result from limiting climate change. If individual nations consider only the domestic benefits they each receive from limiting the pace or extent of climate change, they will each reduce their emissions only to the point where their respective domestic costs for achieving further reductions equal the benefits from limiting the impacts of climate change on to their own domestic economies. Because no individual nation is likely to experience a large share of total global damages from climate change, however, none will capture a significant share of the benefits from limiting it. Thus the combined global reduction in emissions resulting from individual nations' comparisons of their domestic benefits from limiting climate change to their domestic costs for reducing emissions may be inadequate to slow or limit the progress of climate change.

Nevertheless, NHTSA notes that there are serious risks that nations unilaterally attempting to reduce emissions by adopting policies or regulations that reflect the global economic benefits from reducing the threat of climate change will economically disadvantage the domestic industries those policies affect. By doing so, they may induce economic activity – particularly production by emissions-intensive industries – to shift to nations that adopt less stringent regulations or lower economic penalties on emissions. These shifts could take either the form of industries relocating production capacity to other nations, or the loss of market share by domestic producers to foreign suppliers located in nations without equally strict policies to limit emissions. In either case, significant reductions in domestic economic activity within nations that establish policies on the basis of global value of reducing emissions would result, while the anticipated reductions in emission would not occur. Achieving an efficient level of emissions reductions would require all nations to agree to reduce emissions until the costs they would incur for further reducing emissions equal the global benefits from doing so. In the absence of such agreements and detailed monitoring of international compliance, nations that reduce emissions beyond the extent justified by domestic benefits are likely to bear significant costs without resulting in comparably valuable reductions in the potential economic damages they face from climate change.

NHTSA is not alone or unique in this concern. In comments on EPA's recent advance notice of proposed rulemaking to regulate greenhouse gas emissions under the Clean Air Act, several federal agencies noted that unilateral regulation of GHG emissions by the U.S. could impose significant costs on domestic industries, thus causing economic activity and GHG emissions to shift to nations where such regulations have not been adopted. As a consequence, they argued, unilateral U.S. regulation of GHG emissions in the absence of an international framework for regulating global emissions could significantly harm the U.S. economy without generating a net reduction in worldwide GHG emissions. Agencies expressing these concerns included the U.S. Departments of Agriculture, Commerce, Energy, and Transportation, the President's Council of Economic Advisors, Office of Science and Technology Policy, and Council on Environmental Quality, and the Small Business Administration.[316] EPA itself also acknowledged the possibility that unilateral attempts by the U.S to regulate GHG emissions could adversely affect the competitiveness of energy-intensive domestic

[316] Environmental Protection Agency, 40 CFR Chapter I, Regulating Greenhouse Gas Emissions Under the Clean Air Act; Proposed Rule, *Federal Register*, July 30, 2008, pp. 44354-44396.

industries, thus shifting economic activity and emissions outside the U.S. and minimizing the net reduction in global GHG emissions.[317]

In the specific context of this rulemaking, establishing CAFE standards on the basis of the global benefits projected to result from lower GHG emissions would impose higher costs on automobile production to serve the U.S. market, regardless of where it occurs. If vehicle manufacturers located in the U.S. (regardless of whether they are U.S. or foreign-owned) respond by reducing production to serve the U.S. market without comparably increasing production volumes to serve foreign markets, the U.S. economy may bear significant costs without resulting in a significant net reduction in global GHG emissions.

Recognizing this prospect, NHTSA has attempted to estimate the fraction of global economic damages from climate change that are likely to be borne within the U.S., and used this value to estimate the U.S. domestic benefits from reducing GHG emissions. The agency notes that including only the domestic component of benefits is consistent with its past and current treatment of other global impacts resulting from higher CAFE standards. Specifically, NHTA includes only the net reduction in monopsony costs to the U.S. economy in its estimate of the reduction in economic externalities resulting from lower U.S. petroleum consumption and imports. No commenters have objected to this practice in past CAFE rulemakings, and the only comment received on this issue in the current rulemaking noted that NHTSA's use of a domestic value for reducing CO_2 emissions was consistent with its treatment of petroleum import externalities. The agency also notes that NRDC's assertion that unilateral U.S. action to reduce CO_2 emissions might produce indirect benefits to the U.S. by leading other nations to do so is

[317] EPA, pp. 44413-44414.

purely speculative, and largely at odds with historical experience on other initiatives that require international cooperation to realize their full potential benefits.

The agency constructed one estimate of the U.S. domestic benefits from reducing CO_2 emissions using estimates of U.S. domestic and global benefits from reducing greenhouse gas emissions developed by EPA and reported in that agency's Technical Support Document accompanying its advance notice of proposed rulemaking on motor vehicle CO_2 emissions.[318] Specifically, NHTSA calculated the ratio of domestic to global values of reducing CO_2 emissions estimated by EPA using its Climate Framework for Uncertainty, Negotiation, and Distribution (FUND) integrated assessment model.

EPA's central estimates of domestic and global values for reducing GHG emissions during 2007 using the FUND model using a 3 percent discount rate are $1 and $17 per metric ton (in 2006$), which suggests that benefits to the U.S. from reducing CO2 emissions are likely to represent about 6 percent of their global total. The comparable figures derived using a 2 percent discount rate are $4 and $88 for 2007, suggesting that U.S. domestic benefits from reductions in CO_2 emissions will amount to less than 5 percent of their global total. EPA's results also suggest that these fractions are likely to remain roughly constant over future decades.[319] Although EPA cautions that these estimates are preliminary and subject to further development, it also describes them as having the advantage of being "fully consistent," because they are produced using the same model with identical inputs and parameter values. Applying the 5-6 percent figure to the agency's $33 per metric ton estimate of the global value of reducing CO_2

[318] U.S. EPA, Technical Support Document on Benefits of Reducing GHG Emissions, June 12, 2008.
[319] These values are reported in EPA, Table 1. p. 12.

emissions, developed as described above, yields an estimate of approximately $2 per metric ton for the domestic benefit from reducing U.S. CO_2 emissions in 2007.

NHTSA also constructed a second estimate of the fraction of global economic damages from climate change likely to be borne by the U.S. using the procedure described by Delucchi in his comments on the NPRM.[320] Delucchi notes that the fraction of global damages from climate change can be estimated by adjusting the U.S. share of global economic output, measured by the ratio of U.S. GDP to gross world product, by the relative sensitivity of U.S. and world economic output to damages resulting from climate change. Using data on the U.S. share of world economic output (which ranges from 20-28 percent) and published estimates of the relative sensitivity of the U.S. economy to climate damages compared to the world economy as a whole, Delucchi estimates that the U.S. fraction of global economic damages from climate change is likely to range from 0-14 percent. Applying the midpoint of this range (7 percent) to the agency's $33 per ton estimate of the global value of reducing CO_2 emissions also yields an estimate of approximately $2 per metric ton for the domestic benefit from reducing U.S. CO_2 emissions in 2007.

NHTSA has elected to employ the value of benefits from reducing CO_2 emissions that are likely to occur within the U.S. in developing the CAFE adopted in this Final Rule.[321] Based on the preceding discussion, the agency estimates this value at $2 per metric ton of CO_2 emissions that are eliminated as a consequence of reduced fuel

[320] Mark A. Delucchi, Summary of the Non-Monetary Externalities of Motor Vehicle Use, UCD-ITS-RR-96-3 (9) rev.1, Institute of Transportation Studies, University of California, Davis, originally published September 1998, revised October 2004, pp. 49-51. Available at http://www.its.ucdavis.edu/publications/2004/UCD-ITS-RR-96-03(09)_rev1.pdf (last accessed October 7, 2008).

[321] NHTSA notes the Alliance's suggestion that the "*Aramco* canon" applies to NHTSA's decision with regard to whether to use a domestic or global value for the SCC. NHTSA need take no position with respect to this issue in this rulemaking, as it has chosen to use a domestic value for the SCC.

production and consumption resulting from higher CAFE standards. This value applies to emission reductions occurring in 2007, and as described in the following section, is assumed to increase over the future to reflect the rising marginal cost of additional emissions as atmospheric CO_2 concentrations continue to increase.

The marginal cost per ton of additional CO_2 emissions is generally expected to rise over time, because the increased pace and degree of climate change – and thus the resulting economic damages – caused by additional emissions are both expected to rise in proportion to the *existing* concentration of CO_2 in the earth's atmosphere. The IPCC Fourth Assessment Report variously reports that the climate-related economic damages resulting from an additional ton of carbon emissions are likely to grow at a rate of 2.4 percent annually, and at a rate of 2-4 percent annually.[322] Virtually all commenters who addressed this issue asserted that the IPCC intended the 2.4 percent growth rate it reports for the SCC in one passage to instead read "2-4 percent," and many urged NHTSA to apply a 3 percent or higher growth rate to determine the future value of the SCC.

NHTSA staff reviewed the underlying references from which the disputed figure was derived, and those sources clearly report the growth rate implied by their estimates of the future value of the SCC for different future years as 2.4 percent, rather than the 2-4 percent asserted by commenters.[323] Although most studies that estimate economic damages caused by increased GHG emissions in future years produce an implied growth rate in the SCC, neither the rate itself nor the information required to derive its implied

[322] Yohe et al. (2007), p. 13 reports that "…it is very likely that the rate of increase [in the social cost of carbon] will be 2% to 4% per year." However, p. 822 states that "…the SCC will increase over time; current knowledge suggests a 2.4% per year rate of growth."

[323] Hope, C.W. (2006), The Marginal Impact of CO2 from PAGE2002: An Integrated Assessment Model Incorporating the IPCC's Five Reasons for Concern, *Integrated Assessment Journal*, 6, (1), 19-56; and Hope, Chris, and David Newbery (2006), Calculating the social cost of carbon, University of Cambridge, May 2, 2006.

value is commonly reported. NHTSA has been unable to locate other published research that reports the likely future rate of growth in damage costs from CO_2 emissions or the information required to derive it.

NHTSA used the 2.4 percent annual growth rate to calculate the future increases in its estimates of both the domestic ($2/metric ton in 2007) and global ($33/metric ton in 2007) values of reducing CO_2 emissions. Over the lifetimes of cars and light trucks subject to the CAFE standards it is establishing for model years 2011-15, these values average $4 and $66 per ton of CO_2 emissions, exactly twice their estimated values during 2007. The agency also notes that EDF's assertion that the 2.4 percent growth rate could be used only in conjunction with an intergenerational discount rate with a maximum of 3 percent has no apparent basis. Although the agency's analysis did comply with EDF's suggestion in any case, NHTSA selected the growth rate in the future value of reducing CO_2 emissions and the discount rate applied to these benefits for separate reasons, as discussed in detail previously.

Recognizing the uncertainty surrounding current estimates of the economic damages likely to result from increased GHG emissions, NHTSA also conducted sensitivity analysis using $80 per ton as an estimate of the global value for reducing CO_2 emissions. In his updated survey of SCC estimates, Tol reports that the standard deviation associated with the mean value from 125 peer-reviewed estimates of the global SCC of $71 per ton of carbon emissions is $98 per ton. Like Tol's original $71 estimate, this value applies to mid-1990s emissions of carbon (rather than carbon dioxide), and is expressed in approximately 1995 dollars. A range of one standard deviation above and below the $71 mean value extends from minus $27 (*i.e.*, $27 per ton benefit for each ton of carbon emitted) to $169 per ton of carbon. Converting this range to 2007 dollars per ton of CO_2 and applying the same 2.4-percent annual growth rate to these values produces a range of minus $13 to $80 around the $33 per ton mean estimate of the global benefit from reducing CO_2 emissions in 2007.[324]

While NHTSA uses the $80 per ton benefit of reducing CO_2 emissions in its sensitivity analysis, the agency has elected not to employ the minus $13 per ton figure, in part because, based on information from the U.S. Climate Change Science Program and the IPCC, it views the implication that there are likely to be significant net economic benefits from climate change as implausible. In addition, the agency notes that extending the upper limit of the range of values to two standard deviations above the mean estimate, while continuing to truncate the distribution at $0 on its lower end, would have produced a misleading analysis of the sensitivity of the optimized CAFE standards (and their economic and environmental impacts) to the range of uncertainty surrounding the value of benefits from reducing CO_2 emissions. NHTSA believes that the range extending from the $2 per ton estimate of the domestic value of reducing CO_2 emissions to the $80 per ton upper estimate of the global value is sufficiently broad to illustrate the sensitivity of fuel savings and resulting environmental impacts to plausible differences in the SCC.

In all of the sensitivity analyses that employ the $80 per ton global value of the benefits from reducing CO_2 emissions, NHTSA reduces the savings in monopsony costs from lower U.S. petroleum consumption and imports to zero, in order to be consistent with the fact that monopsony payments are a transfer rather than a real economic benefit

[324] A two-standard deviation range around the agency's $33 per ton central estimate would extend from minus $59 to $126 per ton of CO_2 emissions. The agency regards this range as encompassing implausibly wide values, as its lower end implies economic *benefits* of $59 for each additional ton of CO_2 emissions during 2007, while its upper end significantly exceeds all but two of the 125 peer-reviewed estimates included in Tol's 2008 survey.

when viewed from the same global perspective. This reduction partly offsets the effect of the higher CO_2 value on the optimized CAFE standards and resulting benefits, although the extent to which it does so is limited by the fact that the value of reducing CO_2 emissions continues to grow at the assumed 2.4 percent rate over the period spanned by the analysis.

13. The value of increased driving range

NHTSA also considered the fact that improving vehicles' fuel economy may increase their driving range before they require refueling. By reducing the frequency with which drivers typically refuel their vehicles, and by extending the upper limit of the range they can travel before requiring refueling, improving fuel economy provides some additional benefits to drivers. Alternatively, if manufacturers respond to improved fuel economy by reducing the size of fuel tanks to maintain a constant driving range, the resulting savings in manufacturing costs will presumably be reflected in lower vehicle sales prices.

NHTSA stated in the NPRM that no direct estimates of the value of extended vehicle range are readily available, so NHTSA's analysis calculates the reduction in the annual number of refueling cycles that results from improved fuel economy, and applies DOT-recommended values of travel time savings to convert the resulting time savings to their economic value.[325] The NPRM provided the following illustration of how the value of extended refueling range is estimated: a typical small light truck model has an average fuel tank size of approximately 20 gallons. Assuming that drivers typically refuel when

[325] *See* Department of Transportation, Guidance Memorandum, "The Value of Saving Travel Time: Departmental Guidance for Conducting Economic Evaluations," Apr. 9, 1997. *Available at* http://ostpxweb.dot.gov/policy/Data/VOT97guid.pdf (last accessed August 20, 2008); update *available at* http://ostpxweb.dot.gov/policy/Data/VOTrevision1_2-11-03.pdf (last accessed August 20, 2008).

their tanks are 20 percent full (*i.e.*, 4 gallons in reserve), increasing this model's actual on-road fuel economy from 24 to 25 mpg would extend its driving range from 384 miles (16 gallons X 24 mpg = 384 miles) to 400 miles (16 gallons X 25 mpg = 400 miles). Assuming that the truck is driven 12,000 miles per year, this reduces the number of times it needs to be refueled from 31.3 (12,000 miles per year ÷ 384 miles per refueling) to 30.0 (12,000 miles per year ÷ 400 miles per refueling), or by 1.3 refuelings per year.

Weighted by the nationwide mix of urban (about 2/3) and rural (about 1/3) driving and average vehicle occupancy for all driving trips (1.6 persons), the DOT-recommended value of travel time per vehicle-hour is slightly below $24.00 (in 2006 dollars).[326] Assuming that locating a station and filling up requires ten minutes, the annual value of time saved as a result of less frequent refueling amounts to $5.20 (calculated as 1.3 refuelings/year x 10/60 hours/refueling x $24.00/hour). This calculation is repeated for each future calendar year that vehicles affected by the alternative CAFE standards evaluated in this rule would remain in service. Like fuel savings and other benefits, however, the total value of this benefit for vehicles produced during a model year declines over their expected lifetime, because a smaller number of those vehicles remain in service each year, and those remaining in service are driven fewer miles.

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[326] The average hourly wage rate during 2006 was estimated to be approximately $25.00 per hour. For urban travel, the DOT guidance recommends that personal travel (which accounts for 94.4 percent of urban automobile travel) be valued at 50 percent of the hourly wage rate, while business travel (5.6 percent of urban auto travel) should be valued at 100 percent of the hourly wage rate. For intercity travel, personal travel (which represents 87 percent of intercity automobile travel) is valued at 70 percent of the wage rate, while business travel (the remaining 13 percent) is valued at 100 percent of the wage rate. The resulting average values of travel time are $13.20 for urban travel and $18.48 for intercity travel. Multiplying these by average vehicle occupancy (1.6) produces estimates of $21.12 and $29.56 for the value of time per vehicle-hour in urban and rural travel. Using the fractions of urban and rural travel reported above, the weighted average of these values is $23.91 per hour. Departmental Guidance for Valuation of Travel Time in Economic Analysis, 1997. *Available at* http://ostpxweb.dot.gov/policy/Data/VOT97guid.pdf (last accessed Nov. 2, 2008).

NHTSA received comments only from the Alliance regarding the benefits that drivers receive from increased driving range. The Alliance stated that "NHTSA incorrectly assumes that its new fuel economy standards will improve vehicle range and thus reduce the number of times a vehicle owner would have to refill the tank (creating consumer benefits)." The Alliance comments focused on two points: one, that analysis by Sierra Research demonstrates "the complete absence of any relationship between fuel economy and range in the light truck fleet," and two, that manufacturers "design fuel-storage capacity to achieve the basic range requirements consumers demand," and will reduce the space necessary for fuel tanks in order to devote it to other uses (such as increasing cargo space) if fuel economy levels rise. The Alliance argued that NHTSA's assumption that raising fuel economy levels will improve vehicle range and thus result in more miles driven (*i.e.*, the rebound effect) are "not supported by existing data" and contradicted by the Sierra Research analysis. For example, Sierra Research found that the driving range for the Chevrolet Suburban has decreased from 588 to 527 miles as its fuel economy has improved from 1992 to 1999, because the gas tank capacity was decreased in the new body from 42 gallons to 31 gallons.

In response to the Alliance's comments, NHTSA notes that the most likely explanation for the absence of a relationship between fuel economy and refueling range is that manufacturers adjust fuel tank size to achieve some target level of refueling range. If by doing so, manufacturers are able to reduce the space occupied by fuel tanks and devote it to increased passenger or cargo carrying capacity, as the Alliance asserts, this presumably reflects manufacturers' view that those attributes are more valuable to vehicle owners than increased refueling range, or that the resulting savings in vehicle production costs are more valuable to buyers than extended refueling range. If manufacturers respond in either of these ways, they apparently estimate that the resulting increase in the vehicle's utility to potential buyers is more valuable than the increase in refueling range that would result from holding tank size fixed. Thus, NHTSA's estimate of the value of increased refueling range will underestimate the true benefits from the resulting changes in vehicle attributes or prices.

14. Discounting future benefits and costs

The discount rate applied to future benefits and costs of reduced fuel consumption has a significant effect on the stringency of the final standards. Discounting converts the economic values of benefits and costs that are expected to occur in the future to their equivalent values today (or present values), to account for the reduction in their value when they are deferred until some later date rather than received immediately. Discounting reflects the fact that most people view economic outcomes that are not expected to occur until some future date as less valuable than equivalent outcomes that occur sooner. Discounting is particularly important to enable consistent comparison of costs and benefits that are expected to occur in the future to those occurring in the present, or when the future time profiles of benefits and costs are not expected to be similar. The discount rate expresses the percent decline in the value of future benefits or costs—as viewed from today's perspective—for each year they are deferred into the future.

In the NPRM, NHTSA proposed to use a rate of 7 percent per year to discount the value of future fuel savings and other benefits when analyzing the potential impacts of alternative CAFE standards. NHTSA relied primarily on the 7 percent discount rate for two reasons. First, OMB guidance states that 7 percent reflects the economy-wide opportunity cost of capital, and that it "is the appropriate discount rate whenever the main effect of a regulation is to displace or alter the use of capital in the private sector."[327] NHTSA believes that much of the cost of CAFE compliance to manufacturers is likely to come at the expense of other investments the auto manufacturers might otherwise make, for example, in research and development of new technologies. Second, NHTSA's analysis in the NPRM determined that 7 percent is a reasonable estimate of the interest rate that vehicle buyers who finance their purchases are currently willing to pay to defer the added costs of purchasing vehicles with higher fuel economy.[328]

However, the agency also performed an analysis of benefits from alternative increases in CAFE standards using a 3 percent discount rate, and sought comment on whether the MY 2011-2015 CAFE standards should be set using a 3 percent rate instead of a 7 percent rate. OMB guidance also states that when a regulation primarily and directly affects private consumption (*e.g.*, through higher consumer prices for goods and services), instead of primarily affecting the allocation of capital, a lower discount rate may be more appropriate. OMB argues that the consumption rate of time preference would be the most appropriate discount rate in this situation, since it reflects the rate at which consumers discount future consumption to determine its value at the present time. One measure of the consumption rate of time preference is the rate at which savers are willing to defer consumption into the future when there is no risk that the borrower will fail to repay them, and a readily available source of this measure is the real rate of return

[327] Office of Management and Budget, Circular A-4, "Regulatory Analysis," September 17, 2003, at 33. *Available at* http://www.whitehouse.gov/omb/circulars/a004/a-4.pdf (last accessed November 13, 2008).
[328] *See* NPRM discussion at 73 FR 24415-16 (May 2, 2008).

on long-term government debt. After adjusting to remove the effect of inflation, OMB reports that this rate has averaged about 3 percent over the past 30 years.

The NPRM analyzed and sought comment on both the 7 percent and 3 percent discount rates because in the context of CAFE standards for motor vehicles, the appropriate discount rate depends on one's view of how the costs of complying with more stringent standards are ultimately distributed between vehicle manufacturers and consumers. Compared to the proposed standards set with the 7 percent discount rate, NHTSA determined that using a 3 percent discount rate would raise the combined passenger car and light truck standards by about 2 mpg in MY 2015 (to 33.6 mpg from 31.6 mpg), and would reduce lifetime CO_2 emissions of the vehicles affected by the proposed standards for MY 2011-15 by an additional 29 percent (to 672 mmt, instead of 521 mmt). However, NHTSA estimated that complying with the higher standards would cost an additional 89 percent more in technology outlays over the five model years ($85 billion versus of $45 billion).

***Commenters calling for NHTSA to use a lower discount rate*:**

Several commenters, including environmental and consumer groups, state agencies and attorneys general, and three individuals, called for lower discount rates than 7 percent. The commenters' argument for lower discount rates is essentially two-fold. First, commenters argued that the proposed CAFE standards actually affect private consumption and not capital investments, so consistency with OMB guidance requires NHTSA to use a discount rate lower than 7 percent. Second, commenters argued that because reducing CO_2 emissions and thus the pace or degree of climate change is an important component of the benefits from higher CAFE standards, the fact that these benefits are likely to occur in the distant future – and thus to be experienced by future generations – requires NHTSA to apply a lower "intergenerational" discount rate. Commenters were unclear about whether this lower discount rate should also be applied to the other components of benefits resulting from higher CAFE standards, which are expected to occur within 25-35 years.

UCS, EDF, NRDC, CARB, and the Attorneys General commented that NHTSA should use a discount rate of 3 percent or less for setting the CAFE standards. Some commenters, like UCS, based their comments on OMB Circular A-4. UCS commented that although manufacturers will absorb some of the costs of the standards by reallocating capital from other potential uses, "the amounts involved will be markedly smaller than the benefits realized by private consumers," specifically, the benefits due to reduced "private consumption of vehicle fuels." Thus, UCS argued, the standards "primarily and directly affect private consumption" much more than the allocation of capital, so a discount rate of 3 percent should be used. CARB similarly stated that the fuel economy standards will affect private consumption over the long-term, so OMB guidance indicates that 3 percent is a more appropriate discount rate. EDF also drew on OMB guidance, but emphasized the increased costs to consumers of more-expensive passenger cars and light trucks as justification for using a 3 percent discount rate, rather than the benefits from reduced fuel consumption. Comments from the Attorneys General included both points in favor of a 3 percent discount rate according to OMB guidance—that consumers would face higher vehicle costs, but also gain benefits like reduced fuel consumption, a better environment, and a more secure energy future.

Other comments made in favor of a 3 percent discount rate focused on the "intergenerational benefits" of reducing climate change by raising fuel economy standards. OMB Circular A-4 suggests that it may be appropriate to use a lower discount rate than those used for intra-generational analysis when comparing costs and benefits that are likely to be experienced by different generations. Specifically, Circular A-4 notes that "Special ethical considerations arise when comparing benefits and costs across generations. Although most people demonstrate time preference in their own consumption behavior, it may not be appropriate for society to demonstrate a similar preference when deciding between the well-being of current and future generations." (p. 35) On this basis, OMB advises that "If your rule will have important intergenerational benefits or costs you might consider a further sensitivity analysis using a lower but positive discount rate in addition to calculating net benefits using discount rates of 3 and 7 percent." (p. 36)

EDF commented that "The benefits from mitigating climate change will occur over decades or even centuries; as a result, CAFE's implications for carbon dioxide emissions should trigger EPA and OMB guidelines for estimating costs or benefits that affect multiple generations." EDF cited EPA's draft ANPRM on greenhouse gas regulation under the Clean Air Act as stating that "[w]hen there are important benefits or costs that affect multiple generations of the population, EPA and the Office of Management and Budget (OMB) allow for low but positive discount rates (e.g. 0.5-3 percent noted by US EPA, 1-3 percent by OMB). Rates of three percent or lower are consistent with long-run uncertainty in economic growth and interest rates, considerations of issues associated with the transfer of wealth between generations, and the risk of high impact climate damages."[329] EDF also stated that using a discount rate of 3 percent or lower "is also in full agreement with the guidance with the blue ribbon panel of economists, including a Nobel laureate, who recommended that the rate at which future benefits and costs should be discounted to present values will generally not equal the rate of return on private investment."[330] Thus, EDF argued that NHTSA should use a 3 percent discount rate, with a sensitivity analysis using 0.5 and 1 percent.

NRDC offered a similar comment, arguing that this is a multi-generational rulemaking because it impacts climate change, and that therefore an "intergenerational discount rate" must be used of not more than 3 percent. NRDC argued that "The discount rate is often the single most important parameter in benefit cost analyses of environmental regulations, due to the fact that high discount rates disadvantage projects whose benefits accrue in the future but whose costs are borne up front." NRDC's comment included four reasons why the intergenerational discount rate must be 3 percent or less. First, NRDC argued that a "social" discount rate must be used when there are "social (i.e., non-private) costs and benefits." The CAFE standards will reduce fuel consumption, which means that society will experience the benefits of reduced global warming and other air pollution. Second, NRDC stated that the proper rate is the "net national welfare" or NNW, which represents "the real rate of growth in the economy, which takes GDP and subtracts from it depreciation of natural and man made capital, pollution abatement expenses, and negative externalities, and then adds to it the value of non-market goods, such as household labor." NRDC asserted that this rate is likely to

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[329] EPA's ANPRM is available at 73 FR 44354 (July 30, 2008). EDF also cited OMB Circular A-4 and EPA "Guidelines for Preparing Economic Analyses," EPA 240-R-00-003 (2000), *available at* http://yosemite.epa.gov/EE/epa/eed.nsf/pages/Guidelines.html (last accessed August 6, 2008).
[330] EDF cited Kenneth J. Arrow et al., Is there a Role for Benefit-Cost Analysis in Environmental, Health, and Safety Regulation?, 272 Science 173, 221-222 (12 April 1996).

range from 0 to 1 percent. Third, NRDC argued that because CAFE standards are "precautionary" in nature and "reduce the likelihood of potentially catastrophic climate change or serious military security costs," society may be willing to pay more to avoid these extreme risks, such that a negative social discount rate may be appropriate. And finally, NRDC argued that "the use of a declining discount rate is the newly supported method for climate damages." For these reasons, NRDC argued that NHTSA should use a discount rate no higher than 3 percent for setting CAFE standards, and should conduct a sensitivity analysis using lower rates.

An individual commenter, Mark Eads, also stated that the choices made primarily involve long-term inter-generational environmental benefits and costs rather than intra-generational benefits and costs. Mr. Eads presented his summary and comparison of a number of scholarly papers considering discount rate over the past several years, and suggested that NHTSA apply a declining discount rate that begins at 2.6 percent in year one and declines to 0.6 percent in year 300.

UCS, EDF, NRDC, CARB, the Attorneys General, and Mr. Eads did not address the issue of whether a lower intergenerational discount rate should also be applied to the other components of benefits resulting from higher CAFE standards, which are likely to be experienced by current generations.

Other commenters urged NHTSA to use discount rates besides 7 or 3 percent. CBD commented that both 7 percent and 3 percent are too high, arguing that they "artificially reduce" the value of future benefits from improved fuel efficiency, and that using a lower discount rate will result in higher standards. Although CBD did not specify what discount rate would be preferable, other than to recommend a lower one, CBD appeared to approve of Stern's use of a discount rate below 1 percent. CFA and NESCAUM, in contrast, both supported NHTSA's use of a 5 percent discount rate. CFA argued that NHTSA should have "picked the middle road" between 3 percent and 7 percent, to avoid "emphasizing the importance of economic factors and capital goods at the expense of the need to conserve energy," and used 3 and 7 percent for sensitivity analyses. NESCAUM argued that a 7 percent discount rate "inappropriately devalues the technologies designed to achieve increased fuel economy," and stated that EPA had used a 5 percent discount rate in its 2000 rulemaking on Tier 2 emissions standards.[331]

Professor Michael Hanemann commented that NHTSA's decision to use a discount rate of 7 percent was "utterly unfounded in the climate change context," and that NHTSA should use a discount rate of no higher than 4 percent, although even 4 percent had been criticized in recent articles on climate change economics. Thus, Prof. Hanemann argued, NHTSA should use a discount rate of no higher than 4 percent, and conduct sensitivity analyses with lower numbers, like 2 percent. The Attorneys General commented that NHTSA should take account of Professor Hanemann's suggestion of 4 percent as an example of "the discount rates that scholars and economists are using to evaluate the costs and benefits related to global warming."

Professor Gary Yohe commented that the appropriate discount rate for benefits from public investments in an economy where returns to private capital investment are taxed should be *lower* than the rate of return on private capital, in order to reflect the fact that public investment can increase returns to private investment by reducing distortions

[331] EPA calculated the value of a statistical life year for the Tier 2 benefits analysis by amortizing the $5.9 million mean value of a statistical life (VSL) estimate over the 35 years of life expectancy associated with subjects in the labor market studies, discounting it at 5 percent to get $360,000 per life-year saved in 1999 dollars. *See* 68 FR 6698, 6784, fn. 107 (Feb. 10, 2000).

caused by the corporate profits tax. Although they are not specifically public investments, Prof. Yohe noted that investments that reduce GHG emissions by improving vehicle fuel economy are likely to increase returns to a broad range of private investments, including investments in mechanisms that facilitate adaptation to climate change. Although he did not recommend a specific discount rate, Prof. Yohe clearly suggested that the appropriate rate should be below 7 percent. He also noted that OMB's definition and 3 percent estimate of the social rate of time preference did not correspond to the conventional definition of that concept, which is a constant-utility rather than a constant-consumption discount rate.

***Commenters calling for NHTSA to use a 7 percent or higher discount rate*:**

Other commenters, including manufacturers and dealers, as well as one individual, called for NHTSA to use a discount rate of 7 percent or higher. AIAM commented simply that it "support[s] the discount rates used by NHTSA as reasonable for analytical purposes." David Montgomery of CRA International also commented that NHTSA's use of a 7 percent discount rate was reasonable, arguing that "the correct discount rate to use [for CAFE purposes] is the marginal social return on investment, which measures what society would have earned on other investment foregone in order to make the investment in more costly motor vehicles with higher fuel economy." Mr. Montgomery stated that "The chosen 7% real discount is a reasonable, and probably conservative, estimate of the long run, real, pre-tax return on investment in the U.S."

Ford commented that the discount rate "should represent society's opportunity cost of money, which should be close to a 'risk-free' rate such as that of the U.S. Treasury." However, Ford then argued that the short-term costs to invest in technology are very high for domestic manufacturers, and that manufacturers must "borrow the necessary capital for such investment." Thus, Ford stated, it did not support the use of a 3 percent discount rate, although it did not recommend an alternative discount rate.

NADA commented that NHTSA should use a discount rate of at least 7 percent or higher to estimate the future costs and benefits of the proposed standards. NADA stated that "financing rates on motor vehicle loans are indicative of appropriate discount rates since they reflect the real-world opportunity costs faced by consumers when buying vehicles" with higher fuel economy, but argued that NHTSA had not "generated accurate historical loan rates, let alone justified projections for what those rates will be in MY 2015." NADA further stated that a too-low discount rate "will result in overly costly CAFE standards, decreased new motor vehicle sales, and lower than projected fuel savings and greenhouse gas reduction benefits."

The Alliance commented that NHTSA should use a discount rate closer to 12 percent, although it urged NHTSA to rely on a "nested logit" model developed by NERA for "modeling consumer behavior instead of the *ad hoc* analysis NHTSA performs of private benefits without attempting to explain whether there is a market failure." The Alliance argued that OMB Circular A-4 allows the use of a higher discount rate than 7 percent in certain cases if appropriate, and that "other prominent studies relevant to this issue have settled on much higher interest rates than seven percent," including the Congressional Budget Office, which "discounts consumers' fuel savings at a rate of 12 percent per year," and Sierra Research's study submitted by the Alliance in support of its comments, which used a rate of 12.4 percent. A discount rate of 12 percent makes sense, the Alliance argued, because "Consumers can be expected to discount the value of future fuel savings at a rate at least as high as their cost of borrowing funds," so they "would be unwilling to spend an extra dollar on fuel economy improvements that would lower their fuel costs by ten cents per year because the cost savings would be less than the annual interest on that dollar."

Responding to the Alliance's assertion that rates as high as 12 percent might be appropriate for discounting future benefits from fuel savings, the Attorneys General noted in a supplemental comment that a more recent study of vehicle buyer's tradeoffs between higher purchase prices and savings in operating expenses than that relied upon by NERA estimates that buyers discount future fuel savings using nominal rates that average 9 percent. After adjusting it to remove the effect of expected future inflation, the Attorneys General estimated that the corresponding real discount rate was 5.4 percent, and urged NHTSA to use this rate in its analysis of future benefits from fuel savings and other consequences of higher CAFE standards.[332]

In response to the extensive comments it received to the NPRM and the DEIS on this issue, NHTSA has carefully reviewed published research and OMB guidance on appropriate discount rates, including discount rates that should be applied to benefits that are expected to occur in the distant future and thus be experienced mainly by future generations. On the basis of this review, the agency has elected to apply separate discount rates to the benefits resulting from reduced CO_2 emissions, which are expected to reduce the rate or intensity of climate change that will occur in the distant future, and

[332] The agency has reviewed the study relied upon by the Attorneys General in its comment recommending a 5.4 percent discount rate, and notes that the estimates of vehicle buyers' implicit discount rates it reports average 10.2 percent before adjusting for inflation, rather than the 9 percent reported by the Attorneys General. Adjusting this average rate to remove the effects of actual inflation over the most recent decade produced a value of 7.5 percent, rather than the 5.4 percent reported in the recent comment by the Attorneys General.

the economic value of fuel savings and other benefits resulting from lower fuel consumption, which will be experienced in the comparatively near future. Specifically, NHTSA discounts future benefits from reducing CO_2 emissions using a 3 percent rate, but discounts all other benefits resulting from higher CAFE standards at 7 percent.

As some commenters pointed out, OMB guidance on discounting permits the use of lower rates to discount benefits that are expected to occur in the distant future, and will thus be experienced by future generations.[333] The main rationale for doing so is that although most individuals demonstrate a clear preference for current consumption over consumption they expect to occur later within their *own* lifetimes, it may not be appropriate for society to exercise a similar preference for consumption by current generations versus consumption opportunities for future generations when developing actions that affect their relative income levels. In addition, while market interest rates provide useful guidance about the rates that should be used to discount future benefits that will be experienced by current generations, no comparable market rates are available to guide the choice of rates for discounting benefits to be received by future generations.

NHTSA has elected to use a rate of 3 percent to discount the future economic benefits from reduced emissions of CO_2 that are projected to result from decreased fuel production and consumption. These benefits, which include reductions in the expected future economic damages caused by increased global temperatures, a rise in sea levels, and other projected impacts of climate change, are anticipated to extend over a period from approximately fifty to two hundred or more years in the future, and will thus be experienced primarily by generations that are not now living. The 3 percent rate is consistent with OMB guidance on appropriate discount rates for benefits experienced by

[333] White House Office of Management and Budget, Circular A-4, September 17, 2003, pp. 35-36.

future generations, as well as with those used to develop many of the estimates of the economic costs of future climate change that form the basis for NHTSA's estimate of economic value of reducing CO_2 emissions.[334] Of the 125 peer-reviewed estimates of the social cost of carbon included in Tol's 2008 survey, which provides the basis for NHTSA's estimated value of reducing CO_2 emissions, 83 used assumptions that imply discount rates of 3 percent or higher.

Moreover, the 3 percent rate is consistent with widely-used estimates in economic analysis of climate change of the appropriate rate of time preference for current versus distant future consumption, expected future growth in real incomes, and the rate at which the additional utility provided by increased consumption declines as income increases.[335] The Ramsey discounting rule is widely employed in studies of potential economic damages from climate changes in the distant future. The Ramsey rule states that $-r = \delta + \eta g$, where r is the consumption discount rate, δ is the pure rate of time preference (or the marginal rate of substitution between current and future consumption under the assumption that they are initially equal), g is the expected (percentage) rate of growth in future consumption, and η is the elasticity of the marginal utility of consumption with respect to changes in the level of consumption itself. Commonly used values of these parameters in climate studies appear to be δ = -1 percent per year, $\eta = -1$, and g = 2 percent per year, which yield a value for r of 3 percent per year.[336]

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334 Richard S.J. Tol, The social cost of carbon: trends, outliers, and catastrophes, *Economics Discussion Papers*, July 23, 2008.

335 EPA notes that "In this inter-generational context, a three percent discount rate is consistent with observed interest rates from long-term intra-generational investments (net of risk premiums) as well as interest rates relevant for monetary estimates of the impacts of climate change that are primarily consumption effects." See U.S. EPA, Technical Support Document on Benefits of Reducing GHG Emissions, June 12, 2008, p. 9.

336 See Tol (2008), p. 3.

The remaining future benefits and costs anticipated to result from higher fuel economy are projected to occur within the lifetimes of vehicles affected by the CAFE standards for MY 2011-20 vehicles, which extend up to a maximum of 35 years from the dates those vehicles that are produced and sold. Because the vehicles originally produced during these model years will gradually be retired from service as they age, and those that remain in service will be driven progressively less, most of these benefits will actually occur over the period from 2011 through approximately 2025. Thus, a conventional or "intra-generational" discount rate is appropriate to use in discounting these benefits and costs to their present value when analyzing the economic impacts of establishing higher CAFE standards.[337]

The correct discount rate to apply to these nearer-term benefits and costs depends on how the costs to vehicle manufacturers of improving the fuel economy of their vehicle models to comply with higher CAFE standards will ultimately be distributed. If manufacturers are unable to recover their costs for increasing fuel economy in the form of higher selling prices for new vehicles, those outlays will displace or alter other productive investments that manufacturers could make, and the appropriate discount rate is their opportunity cost of capital investment. In contrast, if manufacturers are able to raise selling prices for new vehicles sufficiently to recover all their costs for improving fuel economy, those costs will ultimately affect private consumption decisions rather than capital investment opportunities. Under this assumption, economic theory and OMB

[337] NHTSA acknowledges that using different rates to discount the distant and nearer-term future benefits from higher CFAE standards presents a potential problem of time inconsistency, which arises from the much greater uncertainty that surrounds long-term future rates of growth in investment, economic output, and consumption than is associated with near-term estimates of these variables. However, the agency believes that this problem is less serious than those that would result from using a single rate to discount benefits that occur over the next 25-35 year sand those that are likely to occur over a 100-200 year time frame.

guidance suggest that a consumption discount rate, which reflects the time preferences of consumers rather than those of lenders or investors, is appropriate for discounting future benefits. Consumption discount rates are generally thought to be lower than the opportunity cost of investment capital in the presence of income taxation. Finally, if competitive conditions in the new vehicle market manufacturers and potential buyers' valuation of higher fuel economy permit manufacturers to recover only part of their costs for meeting higher CAFE standards through higher prices for new vehicles, a rate between an investment discount rate and the lower consumption discount rate is appropriate, with the exact rate depending on the distribution of compliance costs between vehicle manufacturers and buyers.

OMB estimates that the real before-tax rate of return on private capital investment in the U.S. economy averages approximately 7 percent per year, and generally recommends this figure for use as a real discount rate in cases where the primary effect of a regulation is to displace private capital investment.[338] However, this figure represents an economy-wide average estimate that incorporates no risk premium other than that associated with uncertainty about future growth in total economic output. As a consequence, it may understate the opportunity cost of capital for corporations facing firm- or market-specific risks on future investment returns. In addition, domestic motor vehicle manufacturers currently have little or no accumulated earnings available to re-invest, and may be required to enter private capital markets to finance the investments necessary to allow them to comply with higher CAFE standards. In doing so they are likely to face real interest rates well above the 7 percent opportunity cost of capital

[338] White House Office of Management and Budget, Circular A-4, September 17, 2003, p. 33.

estimated by OMB, which may provide a more accurate estimate of the appropriate investment rate for discounting future benefits resulting from increased fuel economy.

OMB guidance estimates that an appropriate current value for the consumer rate of time preference – and thus the discount rate that should be used if the costs of complying with a regulation are borne by consumers – is approximately 3 percent. However, this estimate is derived from rates of return demanded by consumers on highly liquid investments, and is intended to apply to situations where there is little or no risk that consumers will actually realize the future benefits resulting from a proposed regulation. In the case of CAFE standards, buyers face considerable uncertainty about future fuel prices and thus the value of fuel savings resulting from higher fuel economy, their future levels of vehicle use, and the actual lifetimes of new vehicles. In addition, buyers initial investments in higher fuel economy are illiquid, and their extent to which they can recover the remaining value of higher fuel economy in the used vehicle market is uncertain. Finally, unlike most of the regulations that OMB Circular A-4 is intended to address, most (75-80 percent) of the benefits from higher CAFE standards accrue directly to the parties they affect – vehicle buyers – rather than to society at large. Taken together, these circumstances make the use of a riskless consumption discount rate, which is intended for use in discounting the economy-wide effects on consumption, inappropriate for discounting the future benefits that result from requiring higher fuel economy.

Recent empirical studies of the discount rates that new vehicle buyers reveal by trading off the higher purchase prices for more fuel-efficient vehicles against future savings in fuel costs resulting from higher fuel economy, which capture the effects of these uncertainties, conclude that buyers apply real discount rates well above the 3 percent rate recommended by OMB for riskless situations. Dreyfus and Viscusi estimate that, when adjusted to reflect differences between the current interest rate environment and rates at the time the data for their study were drawn, U.S. buyers apply real discount rates in the range of 12 percent when weighing expected future fuel savings against higher purchase prices.[339] Verboven estimates that European buyers' nominal discount rates range from 5 to 13 percent, with an average estimate of slightly above 10 percent, which corresponds to a real discount rate of approximately 7 percent when adjusted to reflect current and recent U.S. inflation rates.[340] These studies are likely to provide more reliable estimates of the appropriate consumption rate for discounting benefits from higher fuel economy than the 3 percent figure recommended in OMB guidance.

Uncertainty about future developments in the international oil market, the U.S. economy, and the U.S. market for new cars and light trucks make it extremely difficult to anticipate the extent to which vehicle manufacturers will be able to recover costs for complying with higher CAFE standards in the form of higher selling prices for new vehicles. If new vehicle buyers expect fuel prices to remain higher than those used by NHTSA to establish CAFE standards for MY 2011-15, they may be willing to pay the higher prices necessary for manufacturers to recover their costs for complying with those

[339] See Dreyfus, Mark K. and W. Kip Viscusi. 1995. "Rates of Time Preference and Consumer Valuations of Automobile Safety and Fuel Efficiency." Journal of Law and Economics. 38: 79 – 98; and the adjustment of discount rates reported in that source discussed in NERA, "Discount Rates for Private Costs," pp. 4-5, attachment to Alliance of Automobile Manufacturers comment on NPRM, Docket Item NHTSA-2008-0089-50.

[340] See Verboven, Frank, "Implicit Interest Rates in Consumer Durables Purchasing Decisions – Evidence for Automobiles," p. 22, attachment to California Department of Justice, comment on NPRM, Docket Item NHTSA-2008-0089-0495.

standards.[341] However, potential buyers who expect future fuel prices to be lower than these levels are likely to resist manufacturers' efforts to raise new vehicle prices sufficiently to recover all of their CAFE compliance costs, since buyers' assessment of the value of higher fuel economy will be lower than that reflected in the CAFE standards NHTSA establishes.

From the manufacturer perspective, the current financial condition of some car and light truck producers suggests that they are likely to find it difficult to absorb the full cost of complying with higher CAFE standards. Because CAFE standards apply to all manufacturers, establishing higher standards may provide a ready opportunity for all producers to raise car and light truck prices. However, this opportunity may be restricted if producers that face very low incremental costs for complying with higher CAFE standards because of higher fuel economy levels in their planned model offerings compete aggressively with others that face significant costs for increasing fuel economy levels in their product plans to comply with higher CAFE standards.

After considering the comments received and various arguments about the ultimate incidence of manufacturers' costs for complying with higher CAFE standards, NHTSA has concluded that the costs for complying with higher CAFE standards are likely to be shared by manufacturers and purchasers of new vehicles, but that the exact distribution fraction of these costs between manufacturers and buyers is extremely difficult to anticipate. Generally, NHTSA believes that manufacturers are likely to be able to raise prices only to the extent justified by potential buyers' assessments of the

[341] Whether they will be willing to do so, however, depends partly on how the combined value of the economic and environmental externalities used to determine CAFE standards compares to current fuel taxes. It also depends on whether new vehicle buyers take account of the value of fuel savings resulting from higher fuel economy over the entire expected lifetimes of the vehicles they purchase, or over only some part of that lifetime (such as the period they expect to own new vehicles).

value of future fuel savings that will result from higher fuel economy, but the agency recognizes that buyers' valuations of fuel savings are inherently uncertain and undoubtedly vary widely. Price increases for new cars and light trucks are likely to allow manufacturers to recoup some fraction of their costs for complying with higher CAFE standards, while the remainder of those costs are likely to displace other investment opportunities that would otherwise be available to them.

Regardless of the ultimate incidence of costs for complying with higher CAFE standards, however, both manufacturers' opportunity costs for capital investment and empirical estimates of the discount rates that buyers of new vehicles apply to future fuel savings indicate that a rate of 7 percent is an appropriate rate for discounting the nearer-term benefits from increased fuel economy that will occur over the lifetimes of model year 2011-15 cars and light trucks.

Thus for purposes of establishing the CAFE standards adopted in this Final Rule and estimating their economic benefits, NHTSA has continued to employ a 7 percent rate to discount future benefits from higher CAFE standards *other than those resulting from reduced CO_2 emissions*. Recognizing the uncertainty surrounding this assumption, NHTSA has also tested the sensitivity of the level of the optimized CAFE standards and their resulting economic benefits to the use of a 3 percent discount rate for all categories of benefits.

15. Accounting for uncertainty in benefits and costs

NHTSA explained in the NPRM that in analyzing the uncertainty surrounding its estimates of benefits and costs from alternative CAFE standards, NHTSA considered alternative estimates of those assumptions and parameters likely to have the largest effect. NHTSA stated that these include the projected costs of fuel economy-improving technologies and their expected effectiveness in reducing vehicle fuel consumption, forecasts of future fuel prices, the magnitude of the rebound effect, the reduction in external economic costs resulting from lower U.S. oil imports, the value to the U.S. economy of reducing carbon dioxide emissions, and the discount rate applied to future benefits and costs. The range for each of these variables employed in the agency's uncertainty analysis is presented in the section of the NPRM discussing each variable.

NHTSA explained that the uncertainty analysis was conducted by assuming independent normal probability distributions for each of these variables, using the low and high estimates for each variable as the values below which 5 percent and 95 percent of observed values are believed to fall. Each trial of the uncertainty analysis employed a set of values randomly drawn from each of these probability distributions, assuming that the value of each variable is independent of the others. Benefits and costs of each alternative standard were estimated using each combination of variables. A total of 1,000 trials were used to establish the likely probability distributions of estimated benefits and costs for each alternative standard.

NHTSA received only one comment on its methodology for accounting for uncertainty in benefits and costs. The Alliance commented that the results presented by NHTSA of its sensitivity analysis indicated increasing levels of certainty in the ability of the proposed standards to create net benefits—specifically, NHTSA concluded that there was at least a 99.3 percent certainty that changes made to MY 2011 vehicles to achieve the higher CAFE standards would produce a net benefit; at least a 99.6 percent certainty for MY 2012 vehicles; and 100 percent certainty for MY 2014-15 vehicles. The Alliance argued that “Traditional discounting analysis indicates that the effects of policy changes are more uncertain at points far into the future,” and that “NHTSA should recognize that its predictive abilities in the area of automotive technology dim the farther it attempts to peer out into the future.” The Alliance commented that NHTSA should “reevaluate its statistical model in this light.”

Agency response: NHTSA agrees that uncertainty regarding both costs and benefits from fuel enhancing technologies increases at points farther into the future. The Alliance comment seems to suggest the application of an increasingly wide spread of high and low value parameters for technology costs and effectiveness rates for each successive model year. However, recognizing this increasing uncertainty could either increase or decrease the probability that increases in CAFE standards will produce net benefits. The agency has no basis for determining whether this increased uncertainty would be likely to result in a higher probability of net benefits or a higher probability of net costs. A variety of factors such as unforeseen technology breakthroughs or fluctuations in energy and materials prices could influence benefits and costs in the distant future, and we see little merit in adding additional assumptions about conditions distant in time without a reasonably solid basis for selecting such assumptions.

We could simply increase the range symmetrically by some arbitrary factor, but, assuming the same normal distribution that is employed for most of the variables in our uncertainty analysis, increasing the range of both costs and benefits proportionally would be unlikely to significantly impact the conclusions of the uncertainty analysis. Thus, the agency has not increased this range of uncertainty by progressively more for each successive model year. We also note that the increased level of certainty that net benefits will occur over the lifetime of the later model years covered by the standard is a result of the relatively higher ratio of benefits to costs estimated for those later model years, rather than of a higher degree of certainty about those estimates.

VI. How NHTSA sets the CAFE standards

A. Which attributes does NHTSA use to determine the standards?

NHTSA explained in the NPRM that it had taken a fresh look for purposes of this rulemaking at the question of which attribute or attributes would be most appropriate for setting CAFE standards. NHTSA preliminarily concluded that a footprint-based function would be the most effective and efficient for both passenger car and light truck standards. NHTSA explained that unlike a weight-based function, a footprint-based function helps achieve greater fuel economy/emissions reductions without having a potentially negative impact on safety and is more difficult to modify than other attributes because it cannot be easily altered outside the design cycle in order to move a vehicle to a point at which it is subject to a lower fuel economy target. NHTSA also discussed other attributes on which functions could be based, including curb weight, engine displacement, interior volume, passenger capacity, and towing or cargo-hauling capability, but tentatively rejected those other attributes as being generally easier to game than footprint. NHTSA nevertheless sought comment on whether the proposed standard should be based on vehicle footprint alone, or whether other attributes such as the ones described above should be considered. NHTSA requested that if any commenters advocate one or more additional attributes, that they supply a specific, objective measure for each attribute that is accepted within the industry and that can be applied to the full range of light-duty vehicles covered by this rulemaking. NHTSA noted that in addition to being able to be objectively measured on all light-duty vehicles, any attribute-based system needs to (1) minimize the potential for gaming (artificial manipulation of the attribute(s) to achieve a more favorable fuel economy target), (2) have an observable relationship to fuel economy, and (3) avoid adverse safety consequences and undue relative burden on full-line manufacturers.

The agency received many comments on its choice of attribute. The Aluminum Association, Honda, IIHS, and UCS supported NHTSA's proposal of attribute-based standards depending upon footprint, alone. Honda cited the use of footprint as a means of maintaining consumer choice and maintaining an incentive to make use of lightweight materials. The Aluminum Association indicated that footprint-based standards would assure stability between model years. UCS claimed the footprint compared favorably to other attributes. Honda, the Aluminum Association, and IIHS all argued that footprint-based standards would provide incentives well-aligned with highway safety objectives. Honda commented that incentives provided by a footprint-based system are such that footprint-based standards would be, from a public policy perspective, preferable to weight-based standards, even though fuel economy is more strongly related to weight.

On the other hand, some organizations questioned the agency's proposal to continue basing light truck CAFE standards on footprint and to adopt new footprint-based standards for passenger cars. Subaru (a subsidiary of Fuji Heavy Industries) and BMW expressed concern that footprint-based standards discourage the introduction of new "small vehicle concepts" encouraged by weight-based standards under development in Europe and Japan. Porsche suggested that rapid changes in the light vehicle fleet call into question the use of footprint as the basis for CAFE standards. Porsche also argued that footprint is not an ideal attribute for passenger car standards because passenger cars are less prone to rollover than light trucks and the steepness of the curves NHTSA proposed for passenger cars would provide an incentive for gaming. Ferrari also expressed concern regarding the potential to increase footprint by mounting larger wheels, but did not compare this risk to the risk of, for example, increasing vehicle weight under a weight-based standard. Wenzel and Ross questioned the agency's judgment regarding the safety benefits of discouraging manufacturers from responding to CAFE standards by selling smaller vehicles. Cummins argued that other attributes, in particular weight, would provide a better engineering relationship to fuel economy, but acknowledged that NHTSA proposed to rely on footprint as a means to best "balance public policy concerns."

GM expressed general support for footprint-based standards, but also proposed that the agency adopt a two-attribute system that would adjust targets applicable to vehicles capable of towing heavy loads. The Alliance, which also supported this concept, indicated that such vehicles "generally achieve about five percent lower fuel economy than similar vehicles not designed for such duty cycles." Other commenters supporting adjustments for "tow-capable" vehicles included Chrysler, Cummins, Ford, NADA, RVIA, and several members of Congress. RVIA suggested that without such an adjustment, RV owners will "have no choice but to attempt to pull travel trailers with undersize vehicles," thereby compromising highway safety. Honda and Toyota both opposed the concept based on concerns that such adjustments would compromise progress toward EISA's requirement that NHTSA ensure the new vehicle fleet reaches an average of at least 35 mpg by MY 2020.

Similarly, the Alliance, Chrysler, and NADA proposed that the agency adjust targets for "off-road capable" vehicles including, but not limited to vehicles with four-wheel drive. The Alliance and Chrysler proposed downward adjustments of 10 percent and 1 mpg, respectively, based on past performance of such vehicles. Toyota expressed concern regarding competitive effects of such an adjustment.

In addition to these two-attribute proposals, the agency also received a proposal from Porsche for a three-attribute concept under which vehicle targets would depend on footprint, weight, and maximum torque. Subaru and Volkswagen expressed support for this concept. Porsche and Subaru argued that this three-attribute concept would provide provide a better statistical relationship to fuel economy and would help to reduce the steepness of the curves NHTSA proposed for passenger cars. Volkswagen indicated that the concept would be less burdensome for manufacturers with fleet mix "challenged by" a footprint-based system. Ferrari also commented that, considering the characteristics and fuel economy of performance vehicles, the agency should adopt a two- or three-attribute system that also incorporates curb weight, maximum power, maximum torque, and/or engine displacement.

Conversely, some organizations expressed strong opposition regarding standards that would rely on more than one attribute. UCS questioned whether any dual-attribute approach could "deliver the benefits" of a system based on footprint, alone. Honda argued that NHTSA should "automatically reject" the inclusion of any additional attribute that could decrease overall fuel savings achieved by CAFE standards. Similarly, as mentioned above, Toyota expressed concern that inclusion of additional attributes could compromise progress toward EISA's requirements.

Agency response: Having considered comments on what attribute(s) should be included in attribute-based CAFE standards for passenger cars and light trucks, NHTSA is promulgating standards that depend on vehicle footprint.

As discussed in Section VIII, in the agency's judgment, from the standpoint of highway safety, it is important that the agency promulgate CAFE standards that discourage manufacturers from responding by selling smaller vehicles. While the agency's research also indicates that reductions in vehicle mass tend to compromise highway safety, footprint-based standards provide an incentive to use advanced lightweight materials and structures that would be discouraged by weight-based standards.

Also, although NHTSA recognizes that weight is better correlated with fuel economy than is footprint, the agency has concluded that there is less risk of "gaming" by increasing footprint under footprint-based CAFE standards than by increasing vehicle mass under weight-based CAFE standards. The agency also agrees with concerns raised by some commenters that there would be greater potential for gaming under multi-attribute CAFE standards, such as standards under which targets would also depend on attributes such as weight, torque, power, towing capabilitiy, and/or off-road capability. Standards that incorpororate such attributes in conjunction with footprint would not only be significantly more complex, they would make it less certain that the future fleet would actually achieve the average fuel economy levels projected by the agency.

Although NHTSA recognizes that any change in the structure of CAFE standard changes the relative challenge those standards pose to each manufacturer, the agency notes that compliance with CAFE standards is determined based on average performance, such that no specific vehicle model need necessarily achieve its fuel economy target. This means, for example, that RV owners will not, as suggested by RVIA, be forced to use "undersize" vehicles; rather, the agency expects that manufacturers will continue to provide a range of vehicles with capabilities sought by vehicle buyers.[342]

Furthermore, changes—discussed below—to the NHTSA's procedure for determining the shape and stringency of CAFE standards more fully incorporate the capabilities of, for example, high-performance vehicles, tow-capable vehicles, and offroad-capable vehicles. In developing the CAFE standards promulgated today, the agency has included <u>all</u> vehicles produced by <u>all</u> manufacturers, including the high-performance vehicles produced by companies such as Ferrari and Porsche. Also, as discussed in Section IV, for purposes of estimating potential fuel economy improvements to specific vehicle models, the agency has developed estimates specific to performance vehicles of the availability, cost, and effectiveness of different fuel-saving technologies. Therefore, the final passenger car standards give appropriate weight to the capabilities of these vehicles.

Also, as discussed below and in sections III and XI, the Agency is tightening its definition of "nonpassenger automobile" such that many vehicles will be newly classified as passenger cars. Most of these changes involve two-wheel drive vehicles with relatively modest towing capacity, such that vehicles with off-road capabilities and/or more substantial towing capacity comprise an even greater share of the vehicles that will still be classified as light trucks. Therefore, NHTSA has established final light truck CAFE standards that appropriately account for the capabilities of such vehicles.

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[342] In any event, the agency doubts that RV owners would, as asserted by RVIA, be likely to violate guidelines and laws concerning towing capacity.

B. Which mathematical function does NHTSA use to set the standards?

As discussed above, Congress also recently mandated that NHTSA set attribute-based fuel economy standards "and express each standard in the form of a mathematical function."[343] NHTSA uses a continuous, constrained logistic function for expressing the passenger car and light truck standards, which takes the form of an S-curve, and is defined according to the following formula:

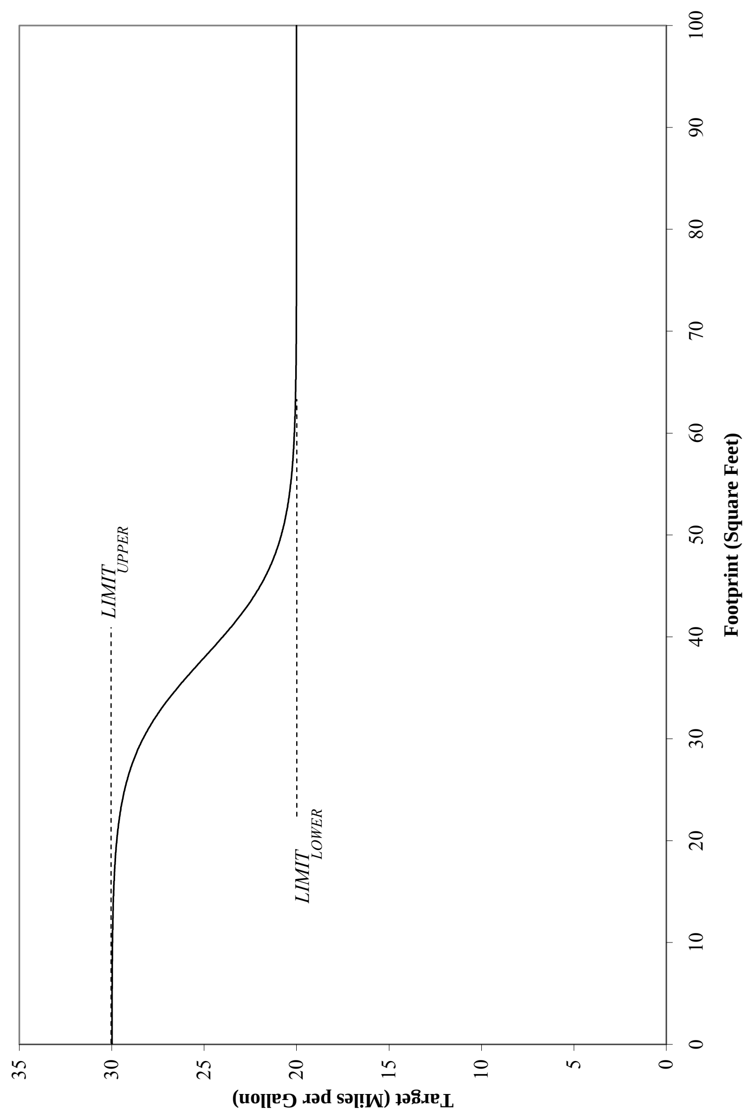
$$TARGET = \frac{1}{\frac{1}{a} + \left(\frac{1}{b} - \frac{1}{a}\right)\frac{e^{(FOOTPRINT-c)/d}}{1+e^{(FOOTPRINT-c)/d}}}$$

Here, *TARGET* is the fuel economy target (in mpg) applicable to vehicles of a given footprint (*FOOTPRINT*, in square feet), *b* and *a* are the function's lower and upper asymptotes (also in mpg), *e* is approximately equal to 2.718,[344] *c* is the footprint (in square feet) at which the inverse of the fuel economy target falls halfway between the inverses of the lower and upper asymptotes, and *d* is a parameter (in square feet) that determines how gradually the fuel economy target transitions from the upper toward the lower asymptote as the footprint increases. Figure VI-1 below shows an example of a logistic target function, where *b* = 20 mpg, *a*= 30 mpg, *c* = 40 square feet, and *d* = 5 square feet:

[343] 49 U.S.C. § 32902(a)(3)(A).

[344] *e* is the irrational *number* for which the slope of the function $y = number^x$ is equal to 1 when *x* is equal to zero. The first 8 digits of *e* are 2.7182818.

Figure VI-1. Sample Logistic Curve



***Continuous function*:**

NHTSA explained in the NPRM that it examined the relative merits of both step functions and continuous functions in its rulemaking for MY 2008-2011 light trucks, and described the agency's rationale for choosing a continuous function for the CAFE program. A step function, in the CAFE context, would separate the vehicle models along the spectrum of attribute magnitudes into discrete groups, and each group would be assigned a single fuel economy target, so that the average of the groups would be the average fleet fuel economy. A continuous function, in contrast, would assign each vehicle model (and indeed, any vehicle model at any point along the spectrum) its own unique fuel economy target, based on its particular attribute magnitude. Thus, two vehicles models built by different manufacturers could have the same fuel economy target, but only if they had identical magnitudes of the attribute. In other words, a continuous function is a mathematical function that defines attribute-based targets across the entire range of possible attribute values, and then applies them through a harmonically weighted formula to derive regulatory obligations for fleet averages.

NHTSA decided against a step function for several reasons. First, because of the strong incentive of manufacturers to game the system at the "edges" of the steps, by increasing the magnitude of a vehicle model's attribute only slightly in order to receive the lower target of the next step. A continuous function tends to reduce this incentive because on an uninterrupted spectrum, the vehicle model's magnitude of the attribute must be increased much more in order to gain a significantly lower fuel economy target—*i.e.*, the necessary change in the vehicle model must be greater in order to receive the same level of benefit. Second, the continuous function minimizes the incentive to downsize a vehicle, since any downsizing would result in higher targets being applicable. And finally, the continuous function provides manufacturers with greater regulatory certainty, since under a step function, the boundaries of categories (*i.e.*, the size of the steps) could be redefined in future rulemakings. Thus, NHTSA tentatively concluded that a continuous function was the best choice for setting CAFE standards.

NHTSA received only three comments regarding its use of the continuous function. Ferrari commented that it supports "the choice to use a continuous function instead of a step function, because for each vehicle model is associated the corresponding fuel economy target, regardless of whether the attribute is the footprint alone or another one or a combination of two or more."

Fuji/Subaru commented that "In general, Subaru conceptually supports the NHTSA proposal to carryover the attribute and continuous logistic function structure from the prior 2008-2011 light truck fuel economy rulemaking."

IIHS commented that it "strongly supports the extension of an attribute-based system to cars and the agency's proposal to index fuel economy to a continuous function." IIHS stated that a step function gives manufacturers an incentive "to redesign vehicles with minimally larger footprints to achieve lower fuel economy targets or to downsize vehicles to achieve weight reductions within footprint categories." This incentive exists, IIHS argued, because of the fact that "By minimally boosting the footprint of a vehicle near an upper boundary, an automaker can gain a large benefit in meeting fuel economy targets," and that "By the same token, an automaker can significantly decrease a vehicle's size and weight as long as the changes do not place the vehicle below the lower boundary of its current step," which IIHS argued presented significant safety concerns. IIHS further stated that the continuous function presented an added benefit over a step function insofar as "car buyers would be more likely to notice design changes incorporated to achieve a substantial CAFE benefit in a continuous function system."

Agency response: Notwithstanding concerns regarding the steepness of an attribute-based function—concerns that are addressed below in Section VI.E—these comments support the agency's decision to promulgate a final rule that uses a continuous function to specify fuel economy targets that depend on a vehicle attribute.

***Constrained logistic function*:**

NHTSA explained in the NPRM that there are a variety of mathematical forms available to estimate the relationship between an attribute and fuel economy that could be used as a continuous function, including simple linear (straight-line) functions, quadratic (U-shaped) functions, exponential (curves that continuously become steeper or shallower) functions, and unconstrained logistic (S-shaped) functions. NHTSA examined these alternative mathematical forms in the MY 2008-2011 light truck CAFE rulemaking,[345] but concluded that none of those functional forms as presented would be appropriate for the CAFE program because they tended toward excessively high stringency levels at the smaller end of the footprint range, excessively low stringency levels at the larger end of the footprint range, or both. Too high stringency levels for smaller vehicles could potentially result in target values beyond the technological capabilities of manufacturers, while too low levels for larger vehicles would reduce fuel savings below that of the optimized fleet. NHTSA determined that a constrained logistic function, shaped like an S-curve with plateaus at the top and bottom rather than increasing/decreasing to infinity, provided a relatively good fit to the data points without creating problems associated with some or all of the other forms. The constrained logistic function also limited the potential for the curve to be disproportionately influenced by outlier vehicles.

[345] *See* 71 FR 17600-17607 (Apr. 6, 2007) for a fuller discussion of the agency's analysis in that rule.

NHTSA defined the constrained logistic functions for the CAFE standards using four parameters. Two parameters, *a* and *b*, established the function's upper and lower bounds (asymptotes), respectively. A third parameter, *c*, specified the footprint at which the function was halfway between the upper and lower bounds. The last parameter, *d*, established the rate or "steepness" of the function's transition between the upper (at low footprint) and lower (at high footprint) boundaries. The resulting curve was an elongated reverse "S" shape, with fuel economy targets decreasing as footprint increased. The definitions of the constrained logistic functions and NHTSA's process for fitting the curves is described in much more detail in Section VI.E below.

NHTSA tentatively concluded in the NPRM that a constrained logistic function was appropriate for setting CAFE standards for both passenger cars and light trucks, but sought comment on whether another mathematical function might result in improved standards consistent with EPCA and EISA.

Although NHTSA received a number of comments requesting alternative standards for certain manufacturers, which are discussed in Section VI.D, only Ferrari commented specifically regarding the constrained logistic function. Ferrari stated that it agreed with NHTSA "about the use of a constrained logistic function to avoid a too high standard for smaller vehicles, and too low for larger vehicles, being the attribute the footprint." Ferrari further stated that "the almost flattened tails of the curve (i.e. asymptotes) are helpful to avoid either vehicle downsizing or over sizing which could produce negative effects for safety and vehicle compatibility in case of accidents."

Agency response: As a potential alternative to the constrained logistic function, NHTSA did also present information regarding a constrained linear function. The agency did not receive comments on this option, and remains concerned about possible unintended consequences of the "corners" in such a function. Therefore, the agency is promulgating a standard that, as proposed in the NPRM, uses a constrained logistic function to specify attribute-based fuel economy targets.

C. What other types of standards did commenters propose?

In the NPRM, NHTSA explained that it is obligated under 49 U.S.C. 32902(a)(3)(A), recently added by Congress, to set attribute-based fuel economy standards for passenger cars and light trucks.[346] NHTSA stated that it welcomed Congress' affirmation through EISA of the value of setting attribute-based fuel economy standards, because the agency believes that an attribute-based structure is preferable to a single-industry-wide average standard for several reasons. First, attribute-based standards increase fuel savings and reduce emissions when compared to an equivalent industry-wide standard under which each manufacturer is subject to the same numerical requirement. Under such a single industry-wide average standard, there are always some manufacturers that are not required to make any improvements for the given year because they already exceed the standard. Under an attribute-based system, in contrast, every manufacturer can potentially be required to continue improving each year. Because each manufacturer produces a different mix of vehicles, attribute-based standards are individualized for each manufacturer's different product mix. All manufacturers must ensure they have used available technologies to enhance fuel economy levels of the

[346] The statutory section states as follows:

> **(3) Authority of the Secretary.**—The Secretary shall—
>
> > **(A)** prescribe by regulation separate average fuel economy standards for passenger and non-passenger automobiles based on 1 or more vehicle attributes related to fuel economy and express each standard in the form of a mathematical function ….

vehicles they sell. Therefore, fuel savings and CO_2 emissions reductions will always be higher under an attribute-based system than under a comparable industry-wide standard.

Second, attribute-based standards eliminate the incentive for manufacturers to respond to CAFE standards in ways harmful to safety.[347] Because each vehicle model has its own target (based on the attribute chosen), attribute-based standards provide no incentive to build smaller vehicles simply to meet a fleet-wide average, because the smaller vehicles will be subject to more stringent fuel economy targets.

Third, attribute-based standards provide a more equitable regulatory framework for different vehicle manufacturers.[348] A single industry-wide average standard imposes disproportionate cost burdens and compliance difficulties on the manufacturers that need to change their product plans and no obligation on those manufacturers that have no need to change their plans. Attribute-based standards spread the regulatory cost burden for fuel economy more broadly across all of the vehicle manufacturers within the industry.

And fourth, attribute-based standards respect economic conditions and consumer choice, instead of having the government mandate a certain fleet mix. Manufacturers are required to invest in technologies that improve the fuel economy of the vehicles they sell, regardless of size.

All commenters recognized that NHTSA must set attribute-based standards per Congress' mandate in EISA, but several commenters, mostly small and limited-line manufacturers, requested that NHTSA develop some kind of alternative standard besides

[347] The 2002 NAS Report described at length and quantified the potential safety problem with average fuel economy standards that specify a single numerical requirement for the entire industry. *See* NAS Report at 5, finding 12.
[348] *Id*. at 4-5, finding 10.

the attribute-based passenger car and light truck standards proposed in the NPRM.[349] These manufacturers generally argued that the proposed passenger car standards were set without regard to 15 percent of the passenger car market and were disproportionately burdensome to them (NHTSA notes, however, that full-line manufacturers argued to the contrary that the proposed standards were disproportionately burdensome to *them*). Most requested that the agency set an alternative standard that required them to raise their CAFE levels by a certain set percentage each year, rather than at the rate required by the proposed standards. Commenters generally reasoned that these alternative standards would improve fuel savings, because otherwise small and limited-line manufacturers will be unable to meet the proposed standards and will just pay fines.

Several manufacturers suggested alternative standards that increase at set percentages each year. BMW suggested, and Mitsubishi supported, an alternative passenger car standard under which manufacturers for which the ratio of the fleet standard to the manufacturer's average footprint is higher than average would have the option of using a flat standard. This flat standard would increase at 4.5 percent per year, which was the same annualized increase as NHTSA's proposed passenger car standards. BMW argued that the suggested approach would be consistent with EISA because it would be derived from the attribute-based standards.

Ferrari also suggested that small manufacturers (which it argued should be re-defined as either producing less than 5,000 vehicles annually for sale in the U.S. or selling less than 15,000 vehicles annually in the U.S.) should be provided an option to

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[349] The Alliance comment on this issue simply stated that "For some manufacturers, whose model proliferation may not correlate well with footprint-based CAFE standards, the burden of required fuel economy increases is particularly high," and suggested that "NHTSA should consider the appropriateness of implementing an alternative fuel economy standard option" for those manufacturers, but left it to the individual manufacturers to comment further.

improve their fuel economy by a certain percentage each year. Ferrari did not suggest a particular percentage by which standards should increase. At the very least, Ferrari argued that small manufacturers should be given more lead-time than full-line manufacturers for making CAFE improvements.

Volkswagen also commented that NHTSA should consider a percent increase option for the manufacturers (like Volkswagen) with fleets that "exhibit an unbalanced correlation to the footprint attribute," a concept which Volkswagen suggested could be applied to both passenger cars and light trucks. If NHTSA declined to adopt such a suggestion, Volkswagen requested that manufacturers be allowed to comply with the industry average target for each model year.

Ford also argued in favor of passenger car and light truck standards that increase at a set percentage each year, specifically at 3.8 percent per year, which Ford estimated would achieve similar CAFE levels by MY 2015. Ford's comment was based on its construction of the EISA requirement that standards "increase ratably" between MY 2011 and MY 2020, and was discussed in the section above addressing other comments made regarding that requirement.

Fuji/Subaru suggested that smaller-volume manufacturers should have the option of either meeting the average on the proposed passenger car curve for the fleet as a whole, or paying civil penalties based on the target assigned through the proposed passenger car curve. These alternative options would be available in the early years of the rulemaking for manufacturers not able to meet rapidly-increasing standards. Fuji/Subaru argued that smaller manufacturers could not feasibly meet the proposed standards and that an alternative option would be consistent with EISA, because the fleet average would be derived from the attribute-based standards.

Similar to Fuji/Subaru, Porsche argued that smaller limited-line manufacturers should be allowed the option to meet a fleet average equivalent to the midpoint of the compliance curve for the overall fleet in a given model year, "rather than being forced to leave the market, restrict product or pay exorbitant civil penalties." Porsche argued that such a CAFE obligation would be "challenging but achievable," and given the rate of increase in passenger car CAFE standards between 2007 and 2011, would be preferable to paying "skyrocketing civil penalties." Porsche additionally argued that EPCA/EISA prohibits NHTSA from excluding manufacturers in setting the CAFE standards, because NHTSA must "prescribe by regulation average fuel economy standards for automobiles manufactured by a manufacturer in that model year" according to 49 U.S.C. § 32902(a). Porsche argued that NHTSA cannot set standards without reference to a manufacturer's fleet, and then subject that manufacturer to enforcement penalties under those standards.

Mercedes Benz also argued that "manufacturers not included in the analysis" for passenger car standards, *i.e.*, limited-line manufacturers, should be allowed either to meet the average fuel economy specified for the vehicle fleet, or "to improve their fleet fuel economy by a percentage equal to the percentage improvement NHTSA estimates for the fleet as a whole." Mercedes Benz suggested that NHTSA could require manufacturers to comply with the higher of the two options. The commenter further argued that such an approach would be legal under EPCA/EISA because it "would be based on the attribute based continuous function curve," and would be fairer because the proposed attribute-based standards did not take into account what the fleet as a whole could achieve in terms of fuel economy.

NHTSA disagrees that it has the authority to set flat average or fixed-increase standards for any manufacturers under EPCA and EISA. An average standard that is "based on" an attribute-based standard is not itself attribute-based, as required by EISA. Many of the manufacturers arguing for an alternative standard were concerned that the agency had excluded them from consideration in developing the proposed standards. In response, the agency included all manufacturers subject to the standards (excluding low-volume manufacturers), to ensure that the curves reflected the capabilities of the entire fleet, and not just the seven largest manufacturers. NHTSA believes that this addresses many of the commenters' concerns.

D. How does NHTSA fit the curve and estimate the stringency that maximizes net benefits to society?

In the NPRM, NHTSA proposed attribute-based passenger car and light truck CAFE standards under which each vehicle model has a fuel economy target that is based on the vehicle model's footprint, and the CAFE levels required of each manufacturer's passenger car and light truck fleets are determined by calculating the sales-weighted harmonic averages of those targets. NHTSA proposed the following mathematical function relating fuel economy targets to footprint:

$$T(x) = \frac{1}{f(x)}$$

where

$$f(x) = \frac{1}{A} + \left(\frac{1}{B} - \frac{1}{A}\right)\frac{e^{(x-C)/D}}{1 + e^{(x-C)/D}}$$

and

$T(x)$ = fuel economy target (mpg)

x = footprint (square feet)

A = highest mpg value of fuel economy target

B = lowest mpg value of fuel economy target

C = coefficient (in square feet) determining horizontal midpoint of $f(x)$

D = coefficient (in square feet) determining width of transition between A and B.

In the NPRM, NHTSA determined the curves relating footprint to fuel economy for a given model year and vehicle type (passenger car or light truck) for which the harmonic average of the functional values are the manufacturers' fuel economy targets, using the following five-step process. (In the discussion below, we shall refer to these ten curves – one for each model year and vehicle type - as the "fuel economy curves.")

In Step 1, NHTSA determined the "manufacturer-optimized" fuel economies for each vehicle in the MY 2011–2015 product plans, submitted to NHTSA prior to the NPRM, of the seven largest manufacturers (Chrysler, Ford, General Motors, Honda, Hyundai, Nissan, Toyota). The "manufacturer-optimized" fuel economies were obtained by applying fuel economy technologies to a given manufacturer's fleet of a given vehicle type (cars or trucks) and model year, until the incremental benefits are equal to the incremental costs. The resulting fuel economies were "manufacturer-optimized" in the sense that they maximize societal net benefits at the level of the manufacturer, model year, and vehicle type. This approach was used to push each manufacturer's fleet to a point of equal effort. NHTSA restricted data to the seven largest manufacturers because those manufacturers accounted for most of the market and because a number of other manufacturers did not submit product plan data and/or had histories of paying civil penalties rather than complying with CAFE standards.

In Step 2, NHTSA determined initial values for parameters *A* and *B* (values revised in steps 4 and 5, described below) for each vehicle class (passenger car and light truck) and model year as follows. For passenger cars (and light trucks, respectively) in a given model year, NHTSA set the initial value of the parameter *A* to be the harmonic average fuel economy among the vehicles of the given model year and vehicle type (produced by the seven largest manufacturers) comprising the lower third (respectively, eleventh) percentile of footprint values. NHTSA set the initial value of *B* to be the harmonic average fuel economy among the vehicles of the given model year and vehicle type (produced by the seven largest manufacturers) comprising the upper fourth (respectively, sixth) percentile of footprint values. NHTSA set *A* and *B* in this manner, rather than fitting them, for example, through regression, in order to ensure that the upper and lower fuel economy values reflect the smallest and largest models in the fleet. NHTSA chose the percentile values it used by examining the fuel economies of the largest and smallest car and truck models, and determining its best assessment of appropriate cohorts, acknowledging that there are no canonical choices for the cohorts.

In Step 3, NHTSA determined initial values for parameters *C* and *D* for each vehicle type and model year as follows. (Their values were revised for model year 2012-2014 in Step 5.) For a given model year and vehicle type, NHTSA set the initial values of *C* and *D* to be the values for which the average (equivalently, sum) of the absolute values of the differences between the manufacturer-optimized fuel consumptions for the given model year and vehicle type and the values obtained by applying the function *f(x)* (defined above) to the corresponding vehicle footprints is minimal, where the values of *A* and *B* are taken from those determined in Step 2 and where *e* denotes the base of the natural logarithm (which is approximately equal to 2.71828). That is, NHTSA determined *C* and *D* by minimizing the average absolute residual, commonly known as the MAD (Mean Absolute Deviation) approach, of the corresponding constrained logistic curve. NHTSA fit the curve in fuel consumption space rather than fuel economy space because the manufacturer targets are in terms of the harmonic average fuel economy, and so it is more important that the curve fit the fuel consumption data well than that it fit the fuel economy data well. NHTSA also explained in the NPRM that it chose to use MAD in this Step instead of minimizing the sum of the square errors ("least squares," another common approach in curve fitting) in order to lessen the influence of outliers. NHTSA believed that it was more appropriate to use unweighted data in fitting the curve rather than weighting the data by sales because of large variations in model sales.

In Step 4, NHTSA determined for each model year and vehicle class the integer value of *t* that maximized the societal net benefits (considering the seven largest manufacturers) achieved by a fuel economy standard under which fuel consumption targets were defined by the function

$$g(x) = \frac{1}{A} + \left(\frac{1}{B} - \frac{1}{A}\right)\frac{e^{(x-C)/D}}{1+e^{(x-C)/D}} + 0.0001t$$

using the values of *A* and *B* determined in Step 2, and the values of *C* and *D* determined in Step 3.[350] NHTSA reset the values of $1/A$ and $1/B$ to be $1/A + 0.0001t$ and $1/B + 0.0001t$, respectively. (These were not the final values of *A* and *B* for model years 2012-2014, which were further adjusted in Step 5.) That is, NHTSA initially set the stringency of the curves to maximize societal net benefits.

In Step 5, NHTSA adjusted the values of *A*, *B*, *C*, and *D* for passenger cars and light trucks in model years 2012-2014 as follows. NHTSA replaced the values of *A*, *B*, *C*, *D* for passenger cars (respectively, light trucks) in model years 2012-2014 with the values obtained by making even annual steps between the values obtained for model years 2011 and 2015 under Step 4. For *A* and *B*, these steps were made evenly on a gallon per mile basis. For *C* and *D*, these steps were made evenly on a square foot basis. Having done so, NHTSA then repeated Step 4 beginning with these adjusted coefficients.

NHTSA explained in the NPRM that it performed Step 5 because the model year 2011 car curve crossed the model year 2012 car curve and the model year 2011 truck curve crossed the model year 2012 truck curve. This is undesirable because it implies that the fuel economy target for a model year 2012 car in a certain range of footprint values is lower than that for a model year 2011 car of the same size (and likewise with trucks). We note that no further curve crossings occurred. That is, the passenger car (respectively, light truck) curves for model years 2011 – 2015 that resulted upon the completion of Step 5 were mutually non-intersecting.

NHTSA thus set the fuel economy curve for a given model year and vehicle type to be

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[350] This procedure uniformly shifts the upward and downward (depending on whether *t* is positive or negative), but on the same gallon per mile basis corresponding to the harmonic averaging of fuel economy values.

$$T(x)=\frac{1}{f(x)}=\frac{1}{\frac{1}{A}+\left(\frac{1}{B}-\frac{1}{A}\right)\frac{e^{(x-C)/D}}{1+e^{(x-C)/D}}}$$

where *A*, *B*, *C*, and *D* assume the final values determined in Steps 1-5. (Recall that the function *f(x)* above is in fuel consumption space, not fuel economy space.) The values of *A*, *B*, *C*, and *D* in the NPRM for each vehicle type and model year were as follows.

Parameter Values of the Fuel Economy Curves in the NPRM

	Parameter Values for Passenger Cars				Parameter Values for Light Trucks			
	A	B	C	D	A	B	C	D
2011	38.20	25.80	45.88	1.60	30.90	21.50	51.94	3.80
2012	40.00	27.40	45.79	1.54	32.70	22.80	51.98	3.82
2013	40.80	28.70	45.70	1.48	34.10	23.80	52.02	3.84
2014	41.20	29.90	45.61	1.42	34.10	24.30	52.06	3.86
2015	41.70	31.20	45.51	1.36	34.30	24.80	52.11	3.87

NHTSA noted in the NPRM that a manufacturer's CAFE standard may decrease in some year, compared to the prior year, even though the passenger car (respectively, light truck) fuel economy curves increase in functional values with increasing model year. A manufacturer's standard may decrease as a result of increasing the footprints of the vehicles it produces in the later of the two years by a sufficiently large amount. (In the NPRM, NHTSA referred to the decrease in vehicle or manufacturer fuel economy targets from one year to the next as "backsliding".) However, as explained in the NPRM, NHTSA believes it is unlikely that any manufacturer would take such a step in the MY 2011-2015 timeframe, given growing consumer preference for smaller, higher-fuel economy vehicles.

NHTSA noted in the NPRM that the curves obtained for passenger cars might be undesirably steep near the inflection point, where small changes in footprint can lead to not so small changes in target fuel economy. NHTSA requested particular comment on this issue and a number of other issues, including the determination of cohorts used to set values for the asymptotes *A* and *B*, the manner in which *C* and *D* are determined, the treatment of outliers, and curve crossing.

NHTSA received several comments concerning the manner in which it fit the fuel economy curves.

Comments regarding that the car and truck curves are set independently

Three commenters (Honda, Wenzel and Ross, and Public Citizen) stated it would or might be better if rather than setting the car and truck curves independently, the car and truck fuel consumption data were pooled and a single curve fit to the pooled data. Honda commented that this would result in standards that treat cars and trucks more equally and could fix the steepness problem with the car curve. Wenzel and Ross argued that setting the same standards for passenger cars and light trucks would lead to manufacturers producing relatively fewer pickups and truck-based SUVs, compared to cars and crossover SUVs, and this would result in fewer deaths and injuries resulting from crashes of incompatibly-sized vehicles and greater fuel savings. Public Citizen simply stated that NHTSA failed to set "one continuous standard for passenger cars and light trucks."

Agency response: In the NPRM, NHTSA did examine the standards that would result from pooling the data in this manner. However, NHTSA is required by statute to set separate curves for cars and trucks, and upon further reflection we believe this requirement extends to how the agency develops the curves. Pooling data for both fleets would mean applying to passenger cars a standard based, in part, on the technological capabilities of light trucks, and vice versa. NHTSA is promulgating final standards that, as proposed, base the curve applied to each fleet only on the capabilities of vehicles that would be covered the curve.

Comments concerning the manufacturers whose data to which the curves were fit

BMW, Mercedes, Mitsubishi, Porsche, Subaru, and the Alliance commented that the fuel economy curves should be fit to data from all manufacturers to which the fuel economy standards apply, and not just to data from the seven largest manufacturers. Some commenters (BMW, Mercedes, Mitsubishi, Porsche) argued that limiting to data from the seven largest manufacturers results in disproportionate burdens to other manufacturers subject to the standards. Mitsubishi stated that all manufacturers need to be included in setting the standards in order for the standards to comprehensively reflect the technological and economic feasibility for the U.S. auto industry.

Agency response: Upon further consideration, NHTSA agrees with the commenters and has revised its methodology to include all manufacturers to which the standards apply: BMW, Chrysler, Daimler, Ferrari, Ford, General Motors, Honda, Hyundai, Maserati, Mitsubishi, Nissan, Porsche, Subaru, Suzuki, Tata, Toyota, Volkswagen. That is, NHTSA has revised Step 1 above to include the vehicles of the given model year and vehicle type for all 17 of these manufacturers.[351]

In developing the standards promulgated today, NHTSA included all manufacturers both in the curve fitting process and in the process by which the agency determined the final stringency of the standards. In addition, NHTSA has used the

[351] However, Ferrari and Maserati are not expected to manufacturer light trucks for sale in the United States in the model years covered by this final rule.

manufacturers' updated product plan submissions in Step 1 for the final rule, as opposed to the 2007 product plans used in the NPRM.

Comments concerning the steepness of the car curve

Several commenters (Chrysler, Honda, Nissan, Ferrari, Porsche, Subaru, Toyota, Volkswagen, the Union of Concerned Scientists, AIAM, ACEEE) expressed concern that the car curve was too steep and that this could lead to manufacturers to artificially increase the footprint of car models they produce near the point of inflection in order to reduce their fuel economy targets. In addition, Volkswagen and AIAM commented that the steepness of the car curve could pose inequitable burdens to manufacturers. ACEEE stated that the steepness of the car curve could lead to gaming of the classification of vehicles as passenger cars or light trucks. Chrysler argued that the steepness problem could become more serious in the face of changing consumer preferences.

Conversely, the Alliance expressed concern that flattening the curves might unjustifiably lower the fuel economy targets for the smallest vehicles and raise the targets for the largest vehicles.

ACEEE suggested that the steepness of the car curve is explained largely by the fact that larger cars have more horsepower on average than smaller cars, over and above what is needed for comparable performance. ACEEE argued that excessive horsepower has adverse effects on safety and that NHTSA should consider ways to discourage the continued growth in horsepower in the US car market.

Commenters suggested a number of potential solutions to flatten the car curve. Honda suggested pooling the car and truck data when fitting the curves. Nissan suggested increasing *D* by a factor between 0.6 and 0.9. Ferrari suggested employing additional attributes besides footprint to set the curves. AIAM suggested using a variant of "shadow size" instead of footprint, changing the methodology used to determine the value of the parameter *D*, adding data from more companies, using additional attributes, or adding an alternative compliance option. ACEEE suggested revisiting the idea of normalizing car footprint to reduce the steepness of the car curve. Toyota suggested determining the value of the parameter *D* before determining the values of *A* and *B*. Chrysler suggested reducing the value of *A* or increasing the value of *D*.

Agency response: NHTSA is incorporating AIAM's suggestion to include data from more manufacturers, as discussed in the section "Comments concerning the manufacturers whose data to which the curves were fit" above. NHTSA reviewed the methods it presented in the NPRM for flattening the curve and the commenters' response to these methods. NHTSA has substantially revised its approach to mitigating the curve steepness issue, and believes that this revised approach provides a more rational solution than those presented either by NHTSA in the NPRM or by commenters in response to the NPRM.

Specifically, for the final rule, NHTSA has revised Step 1 as follows: First, rather than limiting this Step solely to the seven largest manufacturers, NHTSA included all manufacturers. Second, rather than identifying CAFE levels that maximized net societal benefits attributable (separately) to each individual manufacturer, that agency identified CAFE levels that cause each manufacturer to exhaust available technologies. In doing so, the agency has focused this Step on the engineering aspects of available technologies, essentially setting aside economic considerations.

The agency believes that using this technology exhaustion approach and pooling product plan data from all model years better equalizes the effort, or fuel saving potential for each manufacturer's fleet and provides a better estimation of the statistical relationship between vehicle size and fuel economy.

Comments concerning the determination of the asymptotes (A and B)

Chrysler, GM, Honda, and Toyota expressed a variety of concerns about the manner in which the values of the parameters A and B were determined.

GM commented that the values of *A* and *B* in the NPRM could discourage the production of larger vehicles. In addition, GM argued that the cohort used to determine the value of A for cars did not contain sufficiently many domestic cars to provide a value for A that reflects small cars as a whole (both foreign and domestic). GM suggested increasing *A* by 10 percent and decreasing *B* by 5 percent.

Chrysler suggested reducing the value of *A* in a manner that reflects lower consumer tolerance for fuel economy technologies on the least expensive vehicles.

Honda and Toyota argued that *A* and *B* should not be set as the average fuel economies of cohort sets of vehicles, but rather be determined in a metric-optimizing way similar to the determination of *C* and *D*. Both manufacturers suggested setting *D* first through some means, followed by determining *A*, *B*, and *C* by optimizing a curve-fitting metric. Toyota suggested this would help with the steepness problem for cars. In addition, Toyota stated that the process used to select the cohorts in the NPRM appeared to lack a clear technical or empirical basis.

Agency response: NHTSA believes that the values of *A* and *B* should be set as the average values of cohorts, rather than to optimize a curve-fitting metric. NHTSA believes that it is more important that the largest and smallest target values for the fuel economies of individual vehicle models reflect the smallest and largest vehicles in the fleet, and do so in a manner that is relatively stable, than that their values freely optimize a curve-fitting metric. The analysis presented in NHTSA's 2006 Final Rule establishing standards for MY 2008-MY 2011 light trucks demonstrated that freely fitting all four constants of the logistic curve produces unstable and potentially extreme functional limits.[352] As the agency explained in that notice, such results can produce impossibly stringent standards for manufacturers that only produce small vehicles, and/or unduly low targets for large vehicles. These problems led the agency to conclude then, as it concludes today, that the limits of the logistic curve must be constrained, and that the constraints should be based on the potential performance of identified cohorts of vehicles with the smallest and largest footprints.

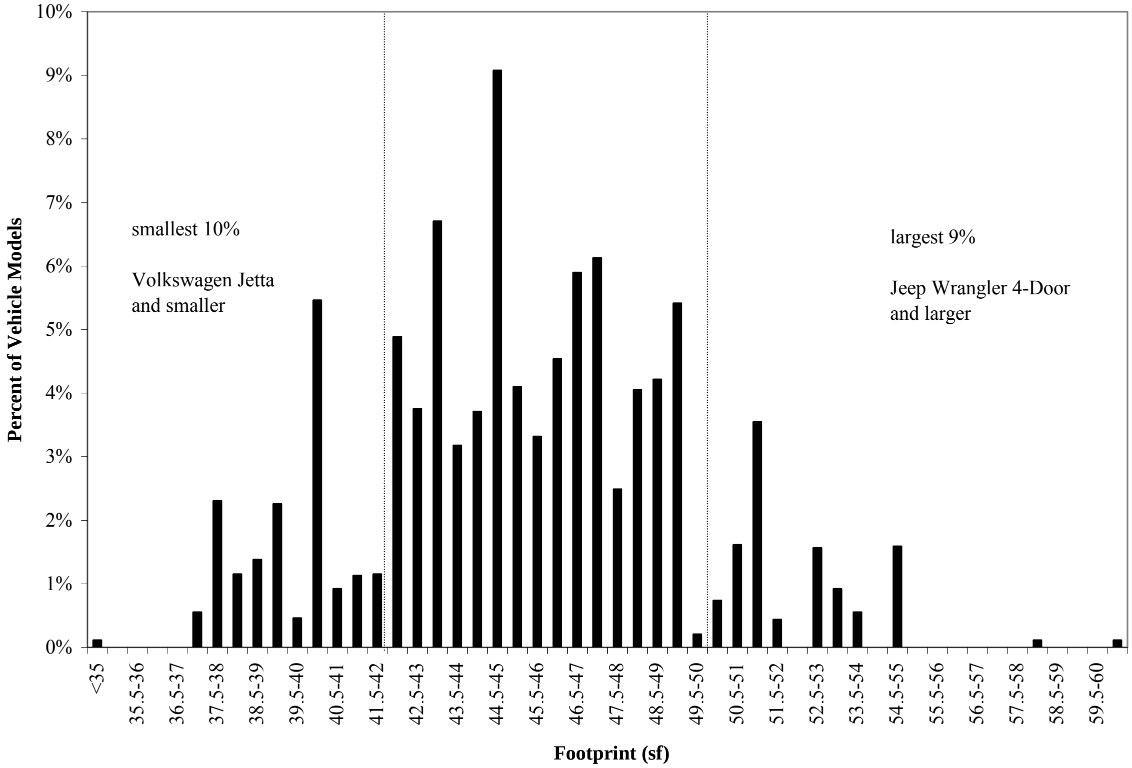
Given a cohort setting approach, NHTSA agrees with GM's comment to enlarge the cohort used to determine the value of *A* for cars to include more domestic small cars. NHTSA enlarged this cohort to comprise the lower tenth percentile of footprints (based now on the data from the seventeen manufacturers to which the standards apply). In addition, upon reviewing the updated product plans from the seventeen manufacturers, all of whose product plans we now use to determine cohorts, NHTSA has slightly changed the percentiles used to determine the remaining cohorts as follows: The percentile used to determine the value of *A* for light trucks was changed to 10 from 11, while that used to determine *B* for passenger cars (respectively, light trucks) was changed from 4 (respectively, 6) to 9 (respectively, 6). The agency continues to recognize that there are no canonical choices for the percentiles used to determine the cohorts. The cohorts

[352] 71 FR 17600-06 (Apr. 6, 2006).

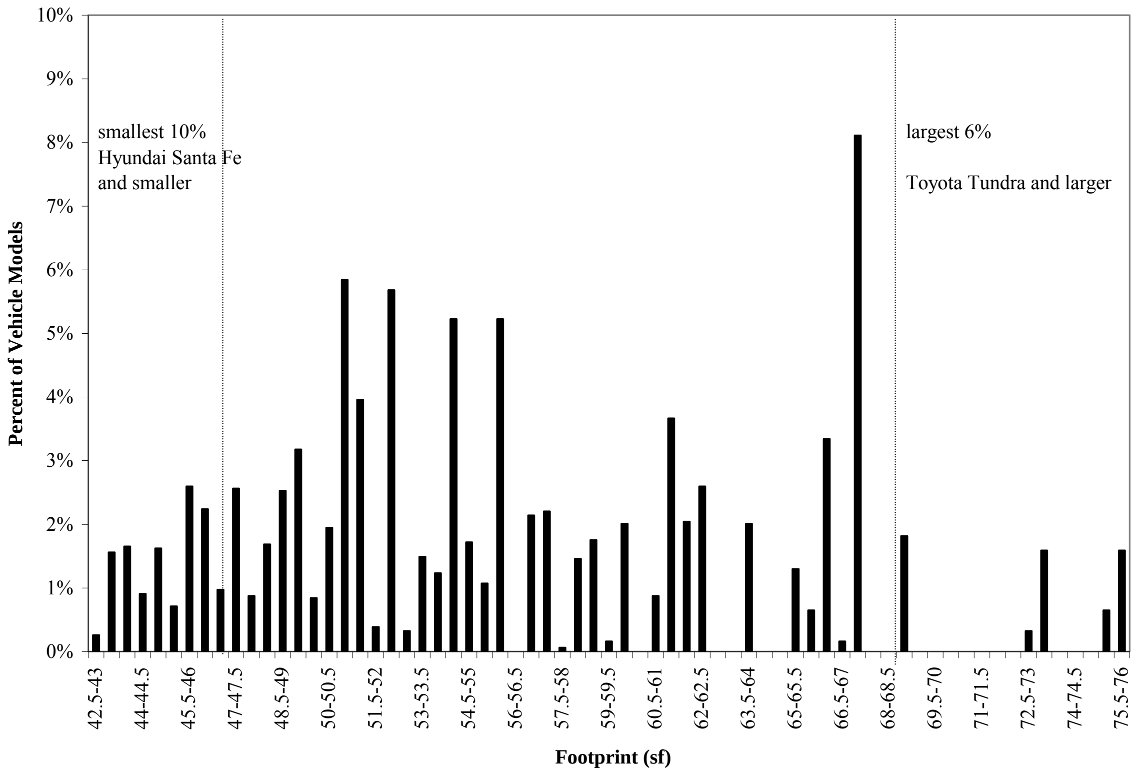
NHTSA has set for the final rule reflect the agency's best assessment of the passenger car and light truck fleets. Also, because the agency is now pooling data from the five model years when fitting the fuel economy curves, as described below in "Comments concerning curve crossing", these percentiles are applied to the pooled model year data, rather than to each model year's dataset.

That is, for the final rule, NHTSA has revised Step 2 as follows. For passenger cars (respectively, light trucks), NHTSA set the initial value of the parameter *A* to be the harmonic average fuel economy among the vehicles of the given vehicle type (produced by the seventeen manufacturers used in Step 1) comprising the lower tenth (respectively, tenth) percentile of footprint values. NHTSA set the initial value of *B* to be the harmonic average fuel economy among the vehicles of the given vehicle type (produced by the seventeen manufacturers) comprising the upper ninth (respectively, sixth) percentile of footprint values. (As with the NPRM, these harmonic averages constitute the initial values of *A* and *B*, which will later be revised in Step 4.) Note that the revised Step 2 fits only two values for *A* (one for cars and one for trucks), and likewise two values for *B*, whereas the version of Step 2 applied in the NPRM fitted 10 values for each (one for each vehicle type and model year).

Distribution of Passenger Car Footprint Values in the Final Rule



Distribution of Light Truck Footprint Values in the Final Rule



Comments concerning the curve-fitting metric and treatment of outliers

Honda expressed concern about NHTSA's use of unweighted data (*i.e.*, data not weighted by sales) in the curve-fitting metric, stating that vehicle models that are similar to a number of other vehicle models would have an undue influence on the curve under an unweighted curve-fitting metric.

Subaru suggested that the initial curves should be fit to each manufacturer separately and then the results pooled in some fashion.

Commenters expressed differing views regarding how outliers should be treated. Public Citizen stated that removing outliers has the effect of reducing the stringency of the standards, and so all outliers should be included when fitting the curve. Conversely, Honda stated that outliers should be eliminated, presumably because of a concern that they have an undue influence on the standards.

Agency response: NHTSA further considered the potential to exclude outliers from the curve fitting and/or stringency determination processes. However, even considering all related comments, the agency has been unable to arrive at a definition of "outlier" as it would apply to these processes. Even after the maximal application of technology (described above) to manufacturers' fleets, some vehicle models have fuel economy values well below or well above those of other vehicle models with similar footprint. However, these vehicles contain information about the capability of some types of vehicles. Similarly, some vehicles with considerable quantities of technology do not achieve unusually high fuel economy values. Therefore, NHTSA finds that neither performance- nor technology-based outliers can be definitively, objectively identified. Furthermore, because NHTSA is using the minimization of mean absolute deviation (MAD) for curve fitting, outliers have far less influence on the solution than they would had the agency relied on conventional least-square regression

NHTSA has also continued to use an unweighted curve-fitting metric, rather than weighting the data by sales. Each vehicle model provides an equal amount of information concerning the underlying relationship between footprint and fuel economy. As explained in the NPRM, sales-weighted regression would give some vehicle models vastly more emphasis than other vehicle models. On the other hand, Honda expressed concern that, under unweighted regression, vehicle models that have been disaggregated into multiple virtually identical "models." To address this concern, the agency has attempted to identify such models (*e.g.*, vehicle models that appear to differ only in trim level), and to consolidate them into single entries. Even so, the potential distortions by such disaggregation are far smaller than the potential distortions associated with sales-weighted analysis.

In response to Subaru's suggestion, NHTSA believes that there is an insufficient amount of data at the manufacturer level (particularly in light of NHTSA's decision to use data from all manufacturers, including a number of smaller manufacturers) to generate reliable curves at an individual-manufacturer level.

As explained above, NHTSA has concluded, based on further analysis and taking into account all related comments, that unweighted MAD provides a better approach. However we note that because we pool the model year data when fitting the curve in the final rule, for reasons described in "Comments concerning curve crossing" below, unweighted MAD will be applied to the pooled model year data for a given vehicle type, as opposed to fitting the fuel economy curve for each model year and vehicle type to the data from vehicles of that model year and vehicle type.

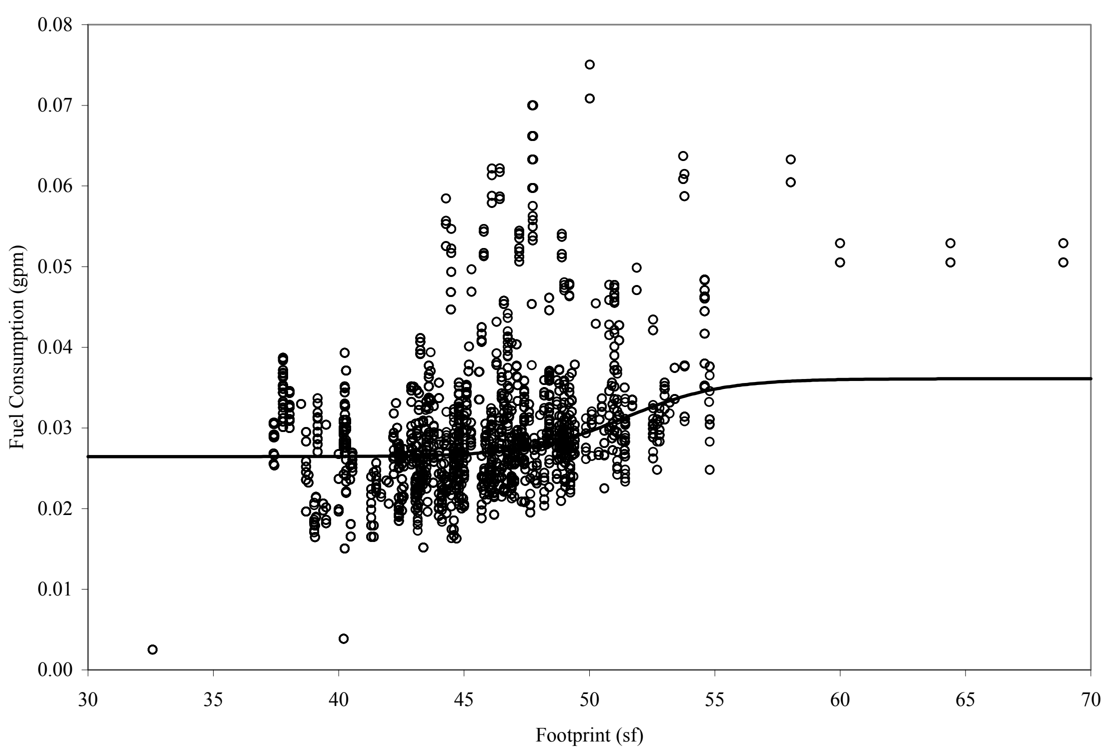
That is, for the final rule, NHTSA has revised Step 3 as follows: NHTSA determined values for parameters *C* and *D* for each vehicle type as follows. For a given vehicle type, NHTSA set the initial values of *C* and *D* to be the values for which the average (equivalently, sum) of the absolute values of the differences between the optimized fuel consumption from Step 1 for the given vehicle type (all model years) and the values obtained by applying the following function

$$f(x) = \frac{1}{A} + \left(\frac{1}{B} - \frac{1}{A}\right)\frac{e^{(x-C)/D}}{1+e^{(x-C)/D}}$$

to the corresponding vehicle footprints is minimal, where the values of *A* and *B* are taken from those determined in Step 2 and where *e* denotes the base of the natural logarithm (which is approximately equal to 2.71828). That is, NHTSA determined *C* and *D* by minimizing the average absolute residual of the *pooled* MY 2011-2015 data under the corresponding constrained logistic curve. Note that the revised Step 3 fits only two values for *C* (one for cars and one for trucks), and likewise two values for *D*, whereas the version of Step 3 applied in the NPRM fitted 10 values for each (one for each vehicle type and model year). We also note that because Step 5 has been eliminated in this final rule, for reasons described in "Comments concerning curve crossing" below, the values of *C* and *D* determined in Step 3 are the final values of these parameters.

For passenger cars, this procedure yielded a curve with the following coefficients: *A* = 37.82 mpg, *B* = 27.70 mpg, *C* = 51.41 square feet, *D* = 1.91 square feet. This curve, shown below on a fuel consumption (*i.e.*, gpm) basis, produced an average absolute difference of 18 percent.

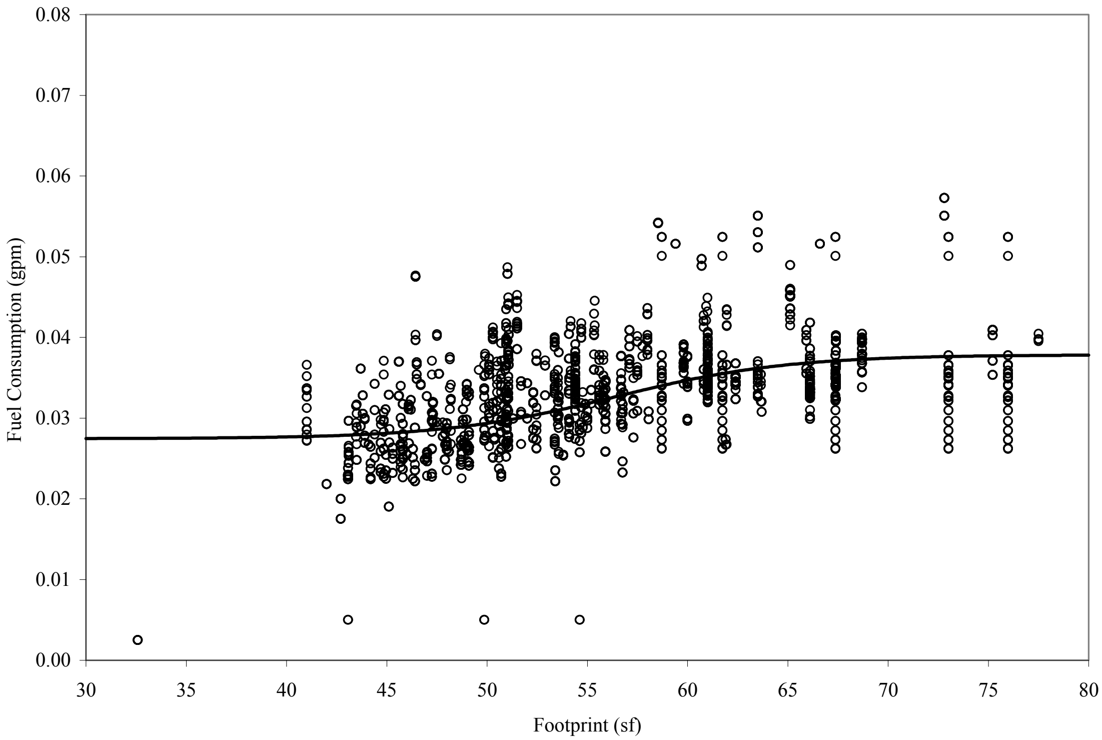
Fitted Curve for Passenger Cars in the Final Rule



Each data point in this graph represents a car model in the updated MY 2011-2015 product plans, and the fuel consumption values for these data points reflect the "technology exhaustion" fuel consumption (*i.e.*, the lowest fuel consumption achievable using technologies known about today). The curve in this graph is the constrained logistic curve defined by the parameters determined in Step 3. Step 4 has not yet been applied. Note that the corresponding chart in the NPRM (Figure V-7 in the NPRM) presented five curves, instead of one, since Steps 2 and 3 in the NPRM fit five car curves (one for each model year) instead of one. The sole curve in the above chart reflects the underlying relationship between the footprint of cars and the fuel economy achievable in them using technologies we know of today.

For light trucks, the same procedure yielded a curve with the following coefficients: A = 36.43 mpg, B = 26.43 mpg, C = 56.41 square feet, and D = 4.28 square feet. This curve, shown below on a fuel consumption (*i.e.*, gpm) basis, produced an average absolute difference of 14 percent.

Fitted Curve for Light Trucks in the Final Rule



Comments concerning curve-crossing

NHTSA received comments on both sides of the curve-crossing issue. While Nissan shared NHTSA's concern about curve crossing, Toyota commented that curve crossing did not necessarily pose a problem because it believed that manufacturers were not likely to reduce a vehicle's fuel economy in a year in which its target fuel economy declined from the previous year. Additionally, Toyota argued that NHTSA's means of addressing curve crossing lacked an empirical basis and clear objective factors.

Nissan and Toyota proposed different solutions to address the curve crossing issue: Nissan suggested increasing *D* by a factor between 0.6 and 0.9. Although it did not feel that curve crossing was necessarily problematic, Toyota presented an alternative methodology for addressing the curve crossing issue by smoothing the rate of increase between model years.

Agency response: NHTSA agrees with Nissan that curve crossing is problematic, since it makes little sense for a vehicle's fuel economy target to decrease from one model year to the next. However, NHTSA disagrees with the solutions proposed to address curve crossing for the following reasons. Nissan's suggestion to increase *D* by a factor between 0.6 and 0.9 appears to have no rational basis for choosing such a factor. Toyota's proposed alternative methodology, on the other hand, is designed to produce standards that align with historic planning cycles and allocation of engineering resources. While it is desirable for the fuel economy standards to be consistent with historic planning cycles and resource allocation, NHTSA believes that it is more important that the standards are the maximum feasible, and artificially "smoothing" the rate of increase could not guarantee that standards are the maximum feasible in each model year.

Given that NHTSA is now applying maximized fuel economies in Step 1, NHTSA has concluded that it is beneficial to include data from all model years (for the given vehicle type) in fitting the curve, as the underlying relationship between fuel economy and footprint should not change from one year to the next. (However, the relationship can change as new technologies develop to improve fuel economy.) That is, we now determine *A* and *B* using pooled model year data in Step 2, and fit *C* and *D* using pooled model year data in Step 3. As a consequence of eliminating Step 5, the values of *C* and *D* for cars (and likewise trucks) agree in each model year. (Step 4 remains unchanged in this final rule.) The inclusion of data from all model years eliminates the possibility of curve crossing, and so NHTSA is eliminating Step 5 in this final rule.

With regard to Toyota's comment, the agency believes that the revised approach to curve fitting significantly improves the objectivity of the process for determining maximum feasible standards.

The parameter values in this final rule are as follows.

Parameter Values of the Fuel Economy Curves in This Final Rule

Model Year	Parameter Values for Passenger Cars				Parameter Values for Light Trucks			
	A	B	C	D	A	B	C	D
2011	31.20	24.00	51.41	1.91	27.10	21.10	56.41	4.28
2012	33.30	25.20	51.41	1.91	28.10	21.70	56.41	4.28
2013	35.80	26.60	51.41	1.91	29.50	22.60	56.41	4.28
2014	36.80	27.20	51.41	1.91	30.30	23.00	56.41	4.28
2015	38.70	28.20	51.41	1.91	30.50	23.20	56.41	4.28

E. Why has NHTSA used the Volpe model to support its analysis?

In developing today's final CAFE standards, NHTSA has made significant use of results produced by the CAFE Compliance and Effects Model (commonly referred to as the Volpe model), which DOT's Volpe National Transportation Systems Center developed specifically to support NHTSA's CAFE rulemakings.

As discussed above, the agency uses the Volpe model to estimate the extent to which manufacturers could attempt to comply with a given CAFE standard by adding technology to fleets that the agency anticipates they will produce in future model years. This exercise constitutes a simulation of manufacturers' decisions regarding compliance with CAFE standards.

The model also calculates the costs, effects, and benefits of technologies it estimates could be added in response to a given CAFE standard. It calculates costs by applying the cost estimation techniques discussed above in Section IV and by accounting for the number of affected vehicles. It accounts for effects such as changes in vehicle travel, changes in fuel consumption, and changes in greenhouse gas and criteria pollutant emissions. It does so by applying the fuel consumption estimation techniques also discussed in Section IV, and the vehicle survival and mileage accumulation forecasts, the rebound effect estimate and the fuel properties and emission factors discussed in discussed in Section V. Considering changes in travel demand and fuel consumption, the model estimates the monetized value of accompanying benefits to society, as discussed in Section V. The model calculates both the current (*i.e.*, undiscounted) and present (*i.e.*, discounted) value of these benefits.

The Volpe model has other capabilities that facilitate the development of a CAFE standard. It can be used to fit a mathematical function forming the basis for an attribute-based CAFE standard, following the steps described below. It can also be used to evaluate many *(e.g.*, 200 per model year) potential levels of stringency sequentially, and identify the stringency at which specific criteria are met. For example, it can identify the stringency at which net benefits to society are maximized, the stringency at which a specified total cost is reached, or the stringency at which a given average required fuel economy level is attained. The model can also be used to perform uncertainty analysis (*i.e.*, Monte Carlo simulation), in which input estimates are varied randomly according to specified probability distributions, such that the uncertainty of key measures (*e.g.*, fuel consumption, costs, benefits) can be evaluated.

In principle, NHTSA could perform all of these tasks through other means. For example, in developing the standards promulgated today, the agency did not use the

Volpe model's curve fitting routines, because they could not be modified in time to implement the changes discussed below to this aspect of the agency's analysis. In general, though, these model capabilities greatly increase the agency's ability to rapidly, systematically, and reproducibly conduct key analyses relevant to the formulation and evaluation of new CAFE standards.

NHTSA received comments from the Alliance and CARB encouraging NHTSA to examine the usefulness of other models. Examples of other models and analyses that NHTSA and Volpe Center staff have considered for the final rule include DOE's NEMS, Oak Ridge National Laboratory's (ORNL) Transitional Alternative Fuels and Vehicles (TAFV) model, Sierra Research's VEHSIM model and the California Air Resources Board's (CARB) analysis supporting California's adopted greenhouse gas emissions standards for light vehicles.

DOE's NEMS represents the light-duty fleet in terms of four "manufacturers" (domestic cars, imported cars, domestic light trucks, and imported light trucks), twelve vehicle market classes (*e.g.*, "standard pickup"), and sixteen powertrain/fuel combinations (*e.g.*, methanol fuel-cell vehicle). Therefore, as currently structured, NEMS is unable to estimate manufacturer-specific implications of attribute-based CAFE standards. The analysis of manufacturer-specific implications is essential to setting the standard, because any given standard will have differential impacts on individual manufacturers, depending on the composition of their vehicle fleets. A particular standard could impose uneconomic costs on some manufacturers while leaving other manufacturers unaffected. In order to balance national-level costs and benefits, assessment of individual manufacturer's costs and compliance strategies is required.[353]

TAFV accounts for many powertrain/fuel combinations, having been originally designed to aid understanding of possible transitions to alternative fueled vehicles, but it also represents the light duty fleet as four aggregated (*i.e.*, industry-wide) categories of vehicles: small cars, large cars, small light trucks, and large light trucks. Thus, again, as currently structured, TAFV is unable to estimate manufacturer-specific implications of attribute-based CAFE standards.

Sierra Research's vehicle simulation model, VEHSIM, which was originally developed by General Motors, calculates the fuel economy for a specified vehicle design over a specified driving cycle. Despite theoretical advantages in terms of explicit representation of physical phenomena underlying fuel consumption, VEHSIM has significant shortcomings as a tool for model-by-model evaluation of the *entire* future light vehicle fleet. At least in principle, the Volpe model could be modified to use VEHSIM or any other vehicle simulation tool to estimate fuel consumption. However, in practice, NHTSA and Volpe Center staff are skeptical that doing so will be either feasible or meaningful as long as CAFE analysis continues to be informed by forecasts of the future vehicle market—forecasts that, though detailed, will not foreseeably contain the extensive information needed to perform full vehicle simulation. The information required for full vehicle simulation is not only exponentially greater than NHTSA currently requests of manufacturers, but for future vehicles, the information may not yet

[353] In principle, if all manufacturers freely traded fuel economy credits among themselves, fleetwide estimates of compliance costs and benefits would approximate the sum of individual manufacturer costs and benefits. However, major manufacturers have repeatedly indicated that they do not intend to trade credits, and statutory language prohibits NHTSA from considering the benefits of trading in setting standards.

exist, as manufacturers may not have completed the design of future vehicles. See Section IV.C.8 for a fuller discussion of full vehicle simulation in the context of CAFE.

CARB's analysis of light vehicle GHG emissions standards uses two levels of accounting. First, based on a report prepared for NESCCAF, CARB represents the light-duty fleet in terms of only five "representative" vehicles. Use of these "representative" vehicles ignores the fact that the engineering characteristics of individual vehicle models vary widely both among manufacturers and within manufacturers' individual fleets. This shortcoming was also pointed out by the Alliance. For each of these five vehicles, NESCCAF's report contains the results of full vehicle simulation given several pre-specified technology "packages." Second, to evaluate manufacturer-specific regulatory costs, CARB essentially reduces each manufacturer's fleet to only two average test weights, one for each of California's two proposed regulatory classes. Even for a flat standard such as considered by California, NHTSA would not base its analysis of manufacturer-level costs on such a high level of aggregation. Further, use of CARB's methods would not enable NHTSA to estimate manufacturer-specific implications of the attribute-based CAFE standards. As noted above, it is impossible to meaningfully estimate national level costs and benefits of a standard applied at the level of individual manufacturer's fleets without assessing individual manufacturer's costs and compliance strategies.

Although the Volpe model has known (and likely unknown) limitations, having considered other tools and analytical approaches, NHTSA has concluded that the Volpe model is the best available option for the development and evaluation of potential CAFE standards, and NHTSA and Volpe Center staff will continue to collaborate on improvements to the model.

NHTSA notes that some commenters questioned the transparency of the Volpe model, which Public Citizen and the Center for Biological Diversity (CBD) referred to as a "black box." In response to these claims, the agency notes that model documentation, publicly available in the rulemaking docket, explains how the model is installed, how the model inputs (all of which, except for manufacturers' confidential product plans, are available to the public) and outputs are structured, and how the model is used. The model can be used on any Windows-based personal computer with Microsoft Office 2003 and the Microsoft .NET framework installed (the latter available without charge from Microsoft). The executable version of the model is available upon request, and has been provided to manufacturers, consulting firms, academic institutions, nongovernmental organizations, research institutes, foreign government officials, and other organizations. The current version of the model was developed using Microsoft Development Environment 2003, and every line of computer code (primarily in C#.NET) has been made available to individuals who have requested the code. Many of these individuals have run the model using market forecast data that they estimated on their own. Given the comprehensive disclosure of information about the Volpe model and the fact that many entities and individuals have made use of it, the characterization of the Volpe model as a "black box" is not accurate.

Although NHTSA uses the Volpe model as a tool to inform its consideration of potential CAFE standards, unlike what some commenters asserted, the Volpe model does not determine the CAFE standards NHTSA proposes or promulgates as final regulations.

The results it produces are completely dependent on inputs selected by NHTSA, based on best available information and data available at the time standards are set. In addition to identifying the input assumptions underlying its decisions, NHTSA provides the rationale and justification for selecting those inputs as described in Sections III through V of this notice. NHTSA also determines whether to use the model to estimate at what stringency net benefits are maximized, or to estimate other stringency levels, such as the point where total costs equal total benefits. NHTSA also determines whether to use the model to evaluate the costs and effects of stringencies that fall outside of the scope of maximum feasible. For example, the standards for the "Technology Exhaustion" Alternative examined by NHTSA and discussed later in this section, were estimated outside the model, which was subsequently used to estimate corresponding costs and effects.[354] Finally, NHTSA is guided by the statutory requirements of EPCA as amended by EISA in the ultimate selection of a CAFE standard.

NHTSA does not agree with Public Citizen that the agency "does not establish what is technologically feasible and economically practicable based on an independent assessment of the current vehicle fleet and the available technology to improve the fleet, but rather accepts industry inputs, which are run through the black box of the Volpe model and a variety of 'optimization' factors, which are tied to maximizing industry-wide benefits." The manufacturers' plans are only the starting point for the agency's determination of how much technology can and should be required consistent with the statutory factors. NHTSA considers the results of analyses conducted by the Volpe model and analyses conducted outside of the Volpe model, including analysis of the impacts of carbon dioxide and criteria pollutant emissions, analysis of technologies that

[354] By definition, the "maximum technology" scenario far exceeds the maximum feasible CAFE standard.

may be available in the long term and whether NHTSA could expedite their entry into the market through these standards, and analysis of the extent to which changes in vehicle prices and fuel economy might affect vehicle production and sales. Using all of this information—not solely that from the Volpe model—the agency considers the governing statutory factors, along with environmental issues and other relevant societal issues such as safety, and promulgates the maximum feasible standards based on its best judgment on how to balance these factors.

This is why the agency considered seven regulatory alternatives, only one of which maximizes net benefits. The others assess alternative standards that in many cases exceed the point at which net benefits are maximized. These comprehensive analyses, which also included scenarios with different economic input assumptions as presented in the FEIS and FRIA, are intended to inform and contribute to the agency's consideration of the "need of the United States to conserve energy," as well as the other statutory factors. 49 U.S.C. § 32902(f). Additionally, within the model the agency considers the need of the nation to conserve energy by accounting for economic externalities of petroleum consumption and monetizing the economic costs of incremental CO_2 emissions in the social cost of carbon.

VII. Determining the appropriate level of the standards

A. Analyzing the preferred alternative

As discussed above, EPCA requires the agency to determine what level of CAFE stringency would be "maximum feasible" for each model year by considering the four competing factors of technological feasibility, economic practicability, the effect of other motor vehicle standards of the Government on fuel economy, and the need of the United

States to conserve energy. NEPA directs that environmental considerations be integrated into that process. To accomplish that purpose, NEPA requires an agency to compare the potential environmental impacts of its proposed action to those of a reasonable range of alternatives. NHTSA compared and analyzed these impacts in the DEIS and the FEIS. The proposed standards for MY 2011-2015 passenger cars and light trucks were set at the point where societal net benefits were maximized. NHTSA referred to those standards as the "Optimized" Alternative in the NPRM, DEIS, and FEIS. In the DEIS and the FEIS, the agency identified the Optimized Alternative (maximizing societal net benefits) as NHTSA's Preferred Alternative. The agency carefully considered and analyzed each of the individual economic assumptions to determine which assumptions most accurately represent future economic conditions. For a discussion of the economic assumptions relied on by the agency in this final rule, see Section V. The economic assumptions used by the agency in this final rule correspond to the "Mid-2 Scenario" set of assumptions identified in the FEIS. *See* FEIS § 2.2. The Optimized Alternative utilizing the Mid-2 Scenario economic assumptions, which were prompted in part by public comments, is squarely within the spectrum of alternatives set forth in the DEIS and the FEIS, and all relevant environmental impacts associated with the Optimized Alternative have been presented in the DEIS and FEIS, and considered by NHTSA.

B. Alternative levels of stringency considered for establishment as the maximum feasible level of average fuel economy

NHTSA recognizes that alternative stringencies are possible, depending on how the agency balances the four factors underlying the selection of maximum feasible level of average fuel economy and the attendant environmental concerns. To aid it in determining the maximum feasible level, NHTSA chose six alternative regulatory actions. Each alternative reflects a balancing of the four factors that differs from the balancing on which the agency's Preferred Alternative is based. In *CBD v. NHTSA*, the Ninth Circuit recognized that EPCA gives "NHTSA discretion to decide how to balance the statutory factors—as long as NHTSA's balancing does not undermine the fundamental purpose of EPCA: energy conservation." 538 F.3d 1172, 1195 (9th Cir. 2008). The Court also raised the possibility that NHTSA's current balancing of the statutory factors might be different from the agency's balancing in the past, given the greater importance today of the need to conserve energy and the more advanced understanding of climate change. *Id.* at 1197-98.

An infinite number of alternatives could theoretically have been defined along a continuum from the least to the most stringent levels of CAFE standards. In the interest of practicality, the agency examined the six specific alternatives, described below, to illustrate the effect of balancing the four factors differently on the range of potential stringency levels, the relationship of economic benefits to compliance costs, and the resulting environmental impacts. The fuel economy levels associated with the alternatives encompass a reasonable range to evaluate potential alternative balancings of the four EPCA factors, as well as the potential environmental impacts of the CAFE standards and alternatives under NEPA.

Pursuant to Section 1502.2(d) of the Council on Environmental Quality (CEQ) regulations, this section discusses how the alternatives considered in NHTSA's Environmental Impact Statement, and the agency's decision to select the Optimized

Alternative,[355] which results in the CAFE standards codified in this final rule ("NHTSA's Decision"), will achieve the objectives of sections 101 and 102(1) of the National Environmental Policy Act (NEPA) and other environmental laws and policies. *See* 40 CFR § 1502.2.

The six alternatives are described as follows:

- The "no increase" or "baseline" alternative assumes that NHTSA would not issue a rule regarding CAFE standards, or alternatively, that NHTSA would issue a rule continuing current standards through 2015. Either way, the "baseline" alternative thus assumes that average fuel economy levels in the absence of CAFE standards beyond 2010 would equal the higher of a manufacturer's product plans or the manufacturer's required level of average fuel economy for MY 2010. The MY 2010 fuel economy in mpg (27.5 mpg for cars and 23.3 mpg for light trucks) represents the average fuel economy levels the agency believes manufacturers would continue to achieve, assuming the agency does not issue a rule.[356] The baseline alternative provides a useful reference point for measuring the impact of the new authorities granted to NHTSA under EISA. The agency uses this baseline in both its NEPA analysis and as part of its baseline market forecast as a Volpe model input.
- The "25 percent below optimized" alternative reflects standards that are more stringent than the "baseline" alternative, but less stringent than the "optimized" alternative. The required average CAFE levels under this alternative are less

[355] For a discussion of NHTSA's decision to select the Optimized Alternative utilizing the Mid-2 Scenario economic assumptions, see Section VII.E.2 below.
[356] In the FEIS, NHTSA refers to this alternative as the "No Action" alternative. CEQ regulations require agencies to consider a no action alternative as part of their NEPA analysis. *See* 40 CFR §§ 1502.2(e) and 1502.14(d).

stringent than those under the optimized alternative by 25 percent of the difference in required fuel economy between the optimized alternative and the "total costs equal total benefits" alternative. For purposes of comparison, we note that the average fuel economy levels required by this alternative fall below those under the optimized alternative by the same absolute amount by which the levels under the "25 percent above optimized" alternative exceed those under the optimized alternative.

- The "25 percent above optimized" alternative reflects standards that exceed the required average fuel economy levels of the optimized alternative by 25 percent of the difference between the average fuel economy levels required by the optimized alternative and those required by the total costs equal total benefits alternative.
- The "50 percent above optimized" alternative reflects standards that exceed the required average fuel economy levels of the optimized alternative by 50 percent of the difference between the average fuel economy levels required by the optimized alternative and those required by the total costs equal total benefits alternative.
- The "total costs equal total benefits" alternative requires average fuel economy levels that result from increasing fuel economy targets until the total cost of all applied technologies equals the total benefits of all applied technologies. Adopting this alternative would result in zero net benefits because the benefits to society are completely offset by the costs.[357]

[357] This analysis produced stringencies at which benefits were approximately equal to costs. The precision of this exercise is limited by several factors, including (1) the discrete amounts by which NHTSA varied

- The "technology exhaustion" alternative reflects standards that are based on progressively increasing stringency in MYs 2011-2015 until every manufacturer without a history of paying civil penalties has exhausted all technologies estimated to be available during each model year. Except for phase-in constraints, this analysis was performed using the same technology-related estimates (*e.g.*, incremental costs, incremental fuel savings, availability, applicability, and dependency on vehicle redesign and refresh cycles) as used for the other alternatives. For the technology exhaustion alternative, NHTSA removed phase-in constraints in order to develop an estimate of the effects of fuel economy increases that might be achieved if manufacturers could apply as much technology as theoretically possible, while recognizing that some technologies require major changes to vehicle architecture and can thus be applied only as part of a redesign or refresh. Thus, in each year, NHTSA increased the stringency until the first manufacturer exhausted available technologies; beyond this stringency, NHTSA estimated that the manufacturer would be unable to comply (NHTSA is precluded from considering manufacturers' ability to use CAFE credits) and would be forced to pay civil penalties. NHTSA then increased the stringency until the next manufacturer was unable to comply, and continued to increase the stringency of the standard until every manufacturer was unable to apply enough technology to comply.

C. EPCA provisions relevant to the selection of the final standards

1. 35 in 2020

stringency levels under consideration, (2) "carrying over" of technologies between model years, and (3) rounding of fuel economy levels, CAFE levels, and required CAFE levels.

Section 102(a)(2) of EISA adds to 49 U.S.C. § 32902(b) a requirement that states as follows:

> (A) AUTOMOBILE FUEL ECONOMY AVERAGE FOR MODEL YEARS 2011 THROUGH 2020—The Secretary shall prescribe a separate fuel economy standard for passenger automobiles and a separate average fuel economy standard for non-passenger automobiles for each model year beginning with model year 2011 to achieve a combined fuel economy average for model year 2020 of at least 35 miles per gallon for the total fleet of passenger and non-passenger automobiles manufactured for sale in the United States for that model year.

(Emphasis added.) As discussed, this requirement is one of several that EISA mandated for CAFE standards between MY 2011 and MY 2020. Subsection 32902(a) contains a general requirement, not limited to any particular model year or period of model years, that the standards for a model year must be the "maximum feasible" standards for that model year. Subsections 32902(b)(2)(A) and (C) set forth three requirements specific to MYs 2011-2020. The standards for those years must be sufficiently high to result in a combined (passenger car and light truck) fleet fuel economy of at least 35 mpg by MY 2020, they must increase annually, and they must increase ratably. Each of these general and specific requirements must be interpreted in light of the other requirements.[358]

In the NPRM, NHTSA explained that the 35 mpg figure is not a standard and is not a requirement applicable to any individual manufacturer or group of manufacturers. Instead, it is a requirement applicable to the agency regarding the combined effect of the separate standards for passenger cars and light trucks that NHTSA is to establish for the

[358] We note that the requirement in subsection 32902(b)(2)(B) specific to the MY 2021-2030 standards is markedly different from the requirements in subsections 32902(b)(2)(A) and (C) specific to the MY 2011-2020 standards. The single model year specific requirement in subsection 32902(b)(2)(B) simply repeats the general requirement in subsection 32902(a), *i.e.*, that the standards must be set at the maximum feasible level. In contrast, the model year-specific requirements in subsections 32902(b)(2(A) and (C) do not repeat the general requirement. Instead, they constitute separate and additional requirements regarding the stringency of the MY 2011-2020 standards.

years leading up to MY 2020 and most particularly for MY 2020 itself. EISA does not specify precisely how compliance with this requirement is to be ensured or how or when the CAFE of the industry-wide combined fleet for MY 2020 is to be calculated for purposes of determining compliance. As a practical matter, to ensure that an industry-wide combined average fuel economy for passenger cars and light trucks of at least 35 mpg is achieved, the standard for MY 2020 passenger cars would have to produce an industry-wide average for passenger cars that is significantly above 35 mpg and the one for MY 2020 light trucks in an industry-wide average for light trucks that might or might not be below 35 mpg. Similarly, the CAFE of some manufacturers' combined fleet of MY 2020 passenger cars and light trucks would be above 35 mpg, while the combined fleet of others might or might not be below 35 mpg.

NHTSA received numerous comments regarding the 35 mpg-in-2020 requirement referring to the 35 mpg requirement as a floor and not a ceiling and urging the agency to set standards that raise the industry-wide combined average to 35 mpg sooner, as early as MY 2015.

On the other hand, many manufacturers commented that the proposed standards were too aggressive in the first couple years and even overall for the full 5-year period. They argued that there was insufficient lead time. Some manufacturers said NHTSA should revert to setting standards based on the capabilities of the least capable manufacturer.

NHTSA is well aware that the 35 mpg-in-2020 requirement is a floor and not a ceiling. EISA specifically states that the industry-wide combined average must be *at least* 35 mpg. However, the agency must also issue standards at the maximum feasible level in each model year, as discussed below. The agency has discretion as to how it makes that determination, with due regard to the 35 mpg-in-2020 requirement, and has done so based on the best available information and data and with full awareness of the three obligations under EISA (maximum feasible standards for each model year, annual ratable increases and a combined fleet average of at least 35 mpg in 2020) and environmental concerns under NEPA. The standards for MY 2010 are 27.5 mpg for passenger cars and 23.5 mpg for light trucks. The final combined standards in 2015 are 31.8 mpg, the largest 5-year rise in standards since the inception of the CAFE program. NHTSA is confident that these standards represent full compliance with these obligations and will continue to monitor manufacturers' achieved average fuel economy levels and capabilities to ensure that the 35 mpg fleet requirement will be met.

2. Annual ratable increase

Section 102(a)(2) of EISA also adds to 49 U.S.C. § 32902(b) a requirement that states as follows:

> (C) PROGRESS TOWARD STANDARD REQUIRED- In prescribing average fuel economy standards under subparagraph (A), the Secretary shall prescribe annual fuel economy standard increases that <u>increase the applicable average fuel economy standard ratably</u> beginning with model year 2011 and ending with model year 2020.

(Emphasis added.) Congress gave no indication in EISA itself as to what it meant by the term "ratably," but NHTSA notes that Representative Markey inserted an extension of remarks into the Congressional Record stating as follows:

> In asking for "ratable" progress, the intent of Congress is to seek relatively proportional increases in fuel economy standards each year, such that no single year through 2020 should experience a significantly higher increase than the previous year.[359]

[359] 153 CONG. REC. H14253 (editor's note) and H14444 (daily ed. Dec. 6, 2007) (statement of Rep. Markey).

In the NPRM, NHTSA stated that "EPCA requires that the MY 2011-2019 CAFE standards for passenger cars and for light trucks must both increase ratably to at least the levels necessary to meet [the] 35 mpg requirement for MY 2020."[360] NHTSA interpreted the "increase ratably" requirement "to mean that the standards must make steady progress toward the levels necessary for the average fuel economy of the combined industry wide fleet of all new passenger cars and light trucks sold in the United States during MY 2020 to reach at least 35 mpg."[361]

Several commenters argued that NHTSA had interpreted the "increase ratably" requirement incorrectly, frequently linking this argument to a criticism of the front-loading of the proposed standards as inconsistent with the "increase ratably" requirement.

The Alliance commented that NHTSA had provided insufficient explanation or analysis of its interpretation that "ratable" meant "steady progress" within the context of EISA. The Alliance speculated that NHTSA may have based its interpretation on the title of the EISA section adding the "increase ratably" requirement, "Progress Toward Standard Required," but argued that titles of sections should only be used for interpretive clues if the text of the section is ambiguous, and that NHTSA should undertake a full definitional analysis of "ratably" in order to determine its meaning in the context of EISA.

The Alliance commented that the two primary dictionary definitions of "ratable" are "capable of being rated, estimated, or appraised," and "proportional."[362] The Alliance argued that the meaning of "proportionally" made more sense in the context of EISA,

[360] 73 FR 24364 (May 2, 2008).
[361] *Id*.
[362] Alliance comment at 45, Docket No. NHTSA-2008-0089-0179.1, citing American Heritage Dictionary 1027 (2d college ed. 1991).

without providing any particular explanation of why it believed that that definition made more sense, but citing NHTSA's use of the term "diminishes ratably" later in the NPRM with reference to the proportional phase-out of the AMFA credit.[363]

The Alliance further argued that NHTSA appeared to be incorrect in equating "ratable increase" with "steady progress," since the term "steady progress" appeared in an earlier version of EPCA and there is a presumption against equating different statutory words chosen by Congress. However, the Alliance commented that if NHTSA is indeed correct that "ratable increase" meant "steady progress," then NHTSA should consider how it interpreted "steady progress" in prior rulemakings—that is, as requiring "annual increases in average fuel economy, but with none of the annual increments varying dramatically from the other annual increases."[364]

The Alliance concluded by arguing that whether "ratably" means "steady progress" or "proportionally," "it seems clear that 'ratably' is intended to impose some limitation on the variability in the rate of increase of CAFE standards over time."[365] The Alliance stated that NHTSA should undertake a more complete analysis of the "increase ratably" requirement for the final rule, and address how the "front-loaded" proposed standards "square with EISA's directive."[366]

GM supported the Alliance comments, and further urged NHTSA to consider a more gradual, less "front loaded" increase in the CAFE standards adopted in the final rule. GM argued that "standards [should be] more aligned with the ratable levels of increase noted in [EISA], i.e. a progression that is more even, less aggressive than the

[363] 73 FR 24456 (May 2, 2008).
[364] Alliance comments at 48, citing 42 FR 33537 (June 30, 1977).
[365] *Id*. at 49.
[366] *Id*.

proposed aggressive and front loaded 4.5%/yr rate, and more in line with the approximately 3%/yr rates needed to achieve the goal of EISA."[367]

Ford also supported the Alliance comments, and commented that the dictionary definition of "ratable" must be "proportional" in the context of EISA, because "capable of being rated" "does not make sense in the context of CAFE standard setting."[368] Thus, Ford argued, the "current, front-loaded proposal does not appear to reflect a series of 'ratable' increases," if "the rate of increase [should be] roughly constant from year to year."[369] Ford additionally commented that NHTSA had provided no justification for how the proposed standards reflected a "ratable increase." Ford suggested that to solve this problem of the proposed standards not being "ratable," NHTSA should determine fuel economy targets for passenger cars and light trucks for MY 2015, and then set footprint-based constrained logistic function standards for MY 2011-2014 at approximately a 3.8 percent per year increase to reach the calculated MY 2015 levels. Ford stated that the 3.8 percent per year increase would be "more equalized ('ratable')."[370]

Toyota also combined its comments on the "increase ratably" requirement with criticism of the rate of increase in the stringency of the proposed standards. Toyota argued that "While the term 'ratable' was not defined in EISA, Toyota believes this language was intended to recognize that large and/or inconsistent jumps in fuel economy targets are difficult for manufacturers to plan for because of product cycles and the lead time needed to incorporate technology throughout the fleet consistent with these product

[367] GM comments at 8 of 10, Docket No. NHTSA-2008-0089-0182.
[368] Ford comments at 11, fn 1, Docket No. NHTSA-2008-0089-0202.1.
[369] *Id*.
[370] *Id*. at 11-12.

cycles."[371] Toyota further argued that the 4.5 percent average rate of increase in the proposed standards was far greater than the "nominal 3.3% implied by the term 'ratable' in EISA."[372] Toyota added, however, with reference to the rate of increase in stringency of targets for smaller-footprint light trucks, that nothing in EISA suggested that "ratable" applied to individual footprint targets.[373] Toyota urged NHTSA to "reduce the disparity in year-to-year fuel economy increases to be more 'ratable.'"

Other commenters on the "increase ratably" requirement included the Washington Legal Foundation (WLF) and the American Council for an Energy Efficient Economy (ACEEE). WLF stated that it agreed with the Alliance comments that the "front-loading approach is inconsistent with EISA, which requires the yearly standards to be set 'ratably' over the ten-year period," although it did not explain further what it thought the "increase ratably" requirement meant.[374] ACEEE made no attempt to define or interpret "ratable," but commented that NHTSA should ensure "ratable" progress toward an average of at least 35 mpg in MY 2020 by including in the final rule "an express provision requiring NHTSA to periodically review progress toward the required fuel economy level and revise the standards accordingly."[375] This provision would mandate "mid-course corrections" in the standards if necessary.

NHTSA has further considered the "increase ratably" requirement in light of the comments received. Bearing in mind that the three basic requirements of EISA for MY 2011-2020 standards—35 mpg in 2020, increase annually and ratably, and maximum feasible—must be interpreted together so as to best achieve EPCA and EISA's

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[371] Toyota comments at 2 of 15, Docket No. NHTSA-2008-0089-0212.
[372] *Id*.
[373] *Id*. at 8 of 15.
[374] WLF comments at 4, Docket No. NHTSA-2008-0089-0228.1.
[375] ACEEE comments at 5, Docket No. NHTSA-2008-0089-0211.1.

overarching goal of energy conservation. NHTSA does not believe that Congress intended the sort of robotic 3 to 4 percent per year "ratable" increase that GM, Ford, and Toyota suggest, because a flat increase such as that would not be consistent with the requirement to set standards at the maximum feasible level for each model year.[376] Moreover, NHTSA disagrees that the 35 mpg-in-2020 requirement implies any intent by Congress to limit "ratable" increases to a particular percentage. As discussed above, 35 mpg in 2020 is a floor, not a ceiling.

NHTSA does agree with the commenters, however, that Congress' use of the term "ratably" appears to be intended to impose some limitation on the variability in the rate of increase of CAFE standards over time. Given the other statutory requirements of EPCA and EISA, NHTSA currently concludes that the best interpretation of the "increase ratably" requirement remains similar to the 1980s requirement that CAFE standards increase annually, but with none of the annual increments varying disproportionately from the other annual increases. This interpretation is consistent with Representative Markey's views expressed in his extension of remarks. From MY 1978 to MY 1985, for example, passenger car standards increased anywhere from 0.5 to 2.0 mpg per year, a range of 1.5 mpg. The ratio of the smallest to largest increase was 1 to 4.

NHTSA believes that manufacturer's objection to the 'front-loaded' fuel economy increases in the NPRM are rooted in concern about the ability to redesign vehicles and increase production of advanced technologies rapidly enough to comply with fuel economy standards. NHTSA believes that this concern has some merit, and accordingly has revised its assumptions with regard to technology phase-in caps as discussed in

[376] NHTSA notes that the insertion of extended remarks by Representative Markey does not, by itself, represent the views of Congress as a whole.

Section IV.C.10 of the preamble. This revision affected the magnitude of increases in the standards near the beginning and end of the MY 2011-2015 period. The final passenger car standards for MYs 2011-2015 increase between 0.9 and 2.3 mpg per year, a range of 1.4 mpg, and the final light truck standards for MYs 2011-2015 increase between 0.4 and 1.0 mpg, a range of only 0.6 mpg. The ratio of the smallest to largest increase is 1 to 2.55 for passenger cars and 1 to 2.5 for light trucks.

With regard to the comment by ACEEE that NHTSA should include an express provision in the final rule that NHTSA must undertake "mid-course corrections" to ensure "ratable" progress toward the 35 mpg requirement in 2020, NHTSA does not believe that such an addition is necessary. The agency is required to set standards at the maximum feasible level for each model year, and has the authority under 49 U.S.C. § 32902(g) to revise standards upward if necessary to reflect a new determination of maximum feasible, as long as it does so 18 months before the beginning of the model year whose standards are in question. NHTSA will carefully monitor manufacturers' achieved levels of average fuel economy, as well as changes in their capabilities, and set standards accordingly.

3. Maximum feasibility and the four underlying EPCA considerations

As explained above, EPCA requires the agency to set fuel economy standards for each model year and for each fleet separately at the "maximum feasible" level for that model year and fleet. 49 U.S.C. § 32902(a). In determining the maximum feasible level of average fuel economy, the agency considers the four statutory factors: technological feasibility, economic practicability, the effect of other motor vehicle standards of the

Government on fuel economy, and the need of the United States to conserve energy, which includes environmental considerations, along with additional relevant factors such as safety. In balancing these considerations, we are also mindful of EPCA's overarching purpose of energy conservation, as well as the requirements that standards must increase ratably to at least the level at which the combined U.S. fleet achieves 35 mpg in MY 2020. We are also mindful that environmental concerns are important to making the correct decision in this rulemaking. NHTSA's NEPA analysis for this rulemaking has informed the agency's final action.

Section VI discussed how the agency fits the target curves and analyzes different levels of CAFE stringency. This section sets forth the agency's interpretation of the four EPCA statutory factors (49 U.S.C. § 32902(f)), and sets forth how NHTSA has balanced the factors with NEPA considerations in deciding what final standards would be the maximum feasible ones.

(a) Technological feasibility

NHTSA defines "technological feasibility" as pertaining to whether a particular method of improving fuel economy can be available for commercial application in the model year for which a standard is being established. NHTSA explained in the NPRM that whether a technology may be feasibly applied in a given model year is not simply a function of whether the technology will exist in some form in that model year, but also whether the data sources reviewed by the agency support a conclusion that the technology will be mature enough to be commercially applied in that model year, whether it will conflict with other technologies being applied, etc. Many commenters stated that "the technology is available to make all cars go farther on a gallon of gas—

farther than NHTSA proposes."[377] According to NHTSA's final rule analysis, manufacturers overall will likely need to apply advanced fuel-saving technologies at significantly higher levels in order to meet the standards than NHTSA estimated in the NPRM,[378] although we note that manufacturers are free to meet the standards using whatever technologies they choose.

However, as NHTSA described in Chapter IV above, simply because a technology exists does not make it feasible to apply it to all vehicles within the timeframe of this rulemaking. While NHTSA recognizes, for example, that hybrid vehicles like the Toyota Prius are very popular currently with many American consumers, and that diesel vehicles on the road in Europe generally achieve higher fuel economy levels than otherwise-equivalent gasoline-engine vehicles here, it would still not be technologically feasible for NHTSA to set standards at the level that require all vehicles sold in the U.S. to be either hybrids or diesels by MY 2015. As discussed at much greater length in Chapter IV, component supply issues, engineering resource issues, federal emissions regulation issues (in the case of diesels), etc., together make such a level of technology application infeasible in the timeframe covered by the rulemaking.

NHTSA also recognizes, however, that there are potentially levels of technological feasibility between the level at which NHTSA has set the standards and the hypothetical example given above of a completely dieselized-hybridized MY 2015 fleet. Nevertheless, technological feasibility is but one of four EPCA factors that the agency must balance. While higher stringency levels might still be technologically feasible, they

[377] *See, e.g.,* Docket No. NHTSA-2008-0089-0192.1.
[378] *See* Tables IX-3 and IX-4 below.

might not be consistent with the other factors, and in fact might be outweighed by those factors.

(b) Economic practicability

As explained in the NPRM, NHTSA has historically assessed whether a potential CAFE standard is economically practicable in terms of whether the standard is one "within the financial capability of the industry, but not so stringent as to threaten substantial economic hardship for the industry." *See, e.g.*, Public Citizen v. NHTSA, 848 F.2d 256, 264 (DC Cir. 1988).

As has been widely reported in the public domain throughout this rulemaking, and as shown in public comments, the national and global economies are in crisis. Even before those recent developments, the automobile manufacturers were already facing substantial difficulties. Together, these problems have made NHTSA's economic practicability analysis particularly important and challenging in this rulemaking.

Automobile sales have dropped significantly. U.S. motor vehicle sales in 2007 were 6 percent below 2005 levels, and 2008 year-to-date sales declined a further 15 percent by comparison with the same period in 2007. October 2008 industry sales were 34 percent lower than October 2007.[379] The sales of every major manufacturer declined in the first ten months of 2008.[380] Vehicle manufacturers have not been able to raise prices to offset declining unit sales.[381]

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[379] Ward's Automotive, "Ward's U.S. Light Vehicle Sales Summary," November 2008. Available at: http://wardsauto.com/keydata/USSalesSummary0810/ (Last accessed 12 November 2008).

[380]ibid.. Only Daimler and Subaru have increased 2008 year-to-date sales.

[381] Commerce Department data indicates no apparent change in nominal prices of new vehicle sales over the past few years. *See supra* note 371.

The financial state of the major U.S. automotive manufacturers is particularly difficult, at best. General Motors' year-to-date U.S. vehicle sales are down 21 percent.[382] GM last earned an accounting profit in 2004, and has lost a cumulative $72 billion between 2005 and the third quarter of 2008.[383] GM has a negative net worth of $60 billion, and consumed more than $3.5 billion in cash in the third quarter. GM is largely unable to borrow additional funds in capital markets, and must rely on a dwindling pool of cash to fund any further operating losses and capital investments.

Ford Motor Company's 2008 year-to-date U.S. vehicle sales have declined 19 percent.[384] The firm has lost $24 billion since 2006. The firm has a negative net worth of $2 billion, and has consumed some $4.3 billion in cash in the third quarter of 2008.[385] Ford is also largely unable to borrow additional funds in capital markets, and must also rely on a dwindling pool of cash to fund any further operating losses and capital investments.

Chrysler is closely held, and consequently does not publish financial statements. However, Chrysler's 2008 year-to-date unit sales are 26 percent below last year's sales at this time. Chrysler's October sales were off 38 percent.[386] It would be reasonable to assume that a reduction in sales of this magnitude has negatively affected the firm's finances.

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[382] General Motors Corp, monthly sales report for October 2008. Available at: http://www.gm.com/corporate/investor_information/docs/sales_prod/08_10/deliveries_0810.pdf (last accessed November 12, 2008).
[383] General Motors Corp. annual report for 2007, quarterly earnings announcement for the third quarter of 2008. *Available at* http://www.gm.com/corporate/investor_information/earnings/index.jsp (last accessed November 12, 2008).
[384] Ford Motor Company, "F-Series Powers Ford to Highest Retail Share in Two Years: Flex, Lincoln MKS Gain More Retail Share," November 3, 2008. [October sales press release]. Available at: http://media.ford.com/article_display.cfm?article_id=29282 (last accessed 12 November 2008).
[385] Ford Motor Company, annual report 2007, p. 121 Form 10-Q for third quarter 2008.
[386] Ward's Automotive, op. cit.

As the figures set forth above demonstrate, the automobile industry is already experiencing substantial economic hardship, even in the absence of new fuel economy standards. All three firms have announced a steady stream of plant closings, layoffs, and employment of new employees at reduced wages.

NHTSA believes these hardships have much to do with the condition of the national economy and perhaps the price of gasoline, and little, if anything, to do with the stringency of CAFE standards for the current or recent model years. We believe that given the scale of the recent decline in industry sales, and the restrictiveness of private credit markets, that near-term developments will be compelled by the industry's immediate financial situation, rather than by the long-term financial consequences of this rulemaking.

Market forces are already requiring manufacturers to improve the fuel economy of their vehicles, as shown both by changes in product plans reported to NHTSA, and by automaker announcements in recent weeks. The improvements in fleet fuel economy required by this rule are consistent with the pressure induced by changing consumer preferences.

The various compliance flexibility mechanisms permitted by EISA, including flexible and alternative fuel vehicles, banking, averaging, and trading of fuel economy credits will also reduce compliance costs to some degree. By statute, NHTSA is not permitted to consider the benefits of flexibility mechanisms is assessing the costs and benefits of the rule.

On the other hand, the agency is mindful that CAFE standards do affect the relative competitiveness of different vehicle manufacturers, and recognizes that standards more stringent than those promulgated here could have a more detrimental effect.

The complexity of an economic practicability determination has been materially increased by Congress' decision to provide up to $25 billion in loan guarantees to facilitate the refurbishment of automobile manufacturing plants to build light-duty vehicles with fuel economy performance higher than that required by NHTSA standards, including the ones established by this rule.[387] Congress has taken specific steps to attempt to ameliorate the economic hardships associated with the marketplace and fuel economy regulation by undertaking to provide long-term, low-interest loans to underwrite the costs of meeting any new standard. However, the Department of Energy, which is responsible for developing the regulations to disburse these loans, recently issued an interim final rule to provide for direct loans to eligible automobile manufacturers and component suppliers for projects that reequip, expand, and establish manufacturing facilities in the United States to produce light-duty vehicles and components for such vehicles, which provide meaningful improvements in fuel economy performance beyond certain specified levels.[388] It is unclear what impact these federally-backed loans and government intervention in the markets may have on achieving compliance with the new standards. Further, at this time, NHTSA cannot know the full scope, depth or duration of the crisis unfolding in the national and world economies.

The agency also understands that some members of Congress are advocating additional action to provide an alternative funding vehicle for automobile manufacturers,

[387] The authorizing language for this provision is in Section 136 of EISA. This language is amended and funds are appropriated in the Emergency Economic Stabilization Act of 2008 (H.R. 1424, Pub.L. 110-343).
[388] 73 FR 66721 (Nov. 12, 2008).

and that there has been discussion of extending funds to auto manufacturers through the Treasury Department's Troubled Asset Relief Program (TARP). As of this writing, we do not know if funding will become available via either of these routes.

Given this uncertainty about the prospects for the auto manufacturers, NHTSA remains convinced that the approach taken to setting fuel economy standards in this rule is conceptually correct. We have attempted to set the CAFE standard so that it is both technologically and economically feasible while providing the maximum national public social benefit. In principle, vehicles meeting the standard will provide benefits to consumers greater than their cost, and the funds invested in building these vehicles, whether the ultimate origin of the funds is public or private, will be money wisely spent.

However, the worsening financial situation may have implications for the marketability of highly fuel-efficient vehicles. There has been substantial evidence that the increase in demand by the car-buying public for greater fuel efficiency caused by higher gas prices has in turn led manufacturers to revamp their product offerings (presumably at some considerable cost) to accommodate market demand, even in the absence of any new standards. However, to the extent that fuel prices decline in the future, or the national and global economic situation worsens, NHTSA cannot predict the marketability of highly fuel efficient vehicles.

One of the primary ways in which the agency seeks to ensure that its standards are within the financial capability of the industry is to attempt to ensure that manufacturers have sufficient lead time to modify their manufacturing plans to comply with the final standards in the model years covered by them. Employing appropriate assumptions about lead time in our analysis helps to avoid applying technologies before they are ready to be applied, or when their benefits are insufficient to justify their costs. It also helps avoid applying technologies too rapidly. NHTSA considers these matters in its analysis of issues including refresh and redesign schedules, phase-in caps, and learning rates.

A number of manufacturers commented that the proposed standards were too stringent in the early years and were therefore not economically practicable. In reevaluating the range of fuel-saving technologies expected to be available during MYs 2011-2015, the agency has developed more realistic estimates of the set of technologies available, the extent to which these technologies are most likely to be applied either at a vehicle freshening or redesign, and the limits (*i.e.*, caps) that should be applied to the rates at which these technologies can be phased in. NHTSA believes the resultant standards, which also reflect all other inputs to NHTSA analysis, are not inappropriately "front loaded." Compared to the proposed standards, the final ones result in combined averages that increase 0.5 mpg less in the first year and slightly more in the last two years.

NHTSA also considers the potential impact on employment. There are three potential areas of employment that fuel economy standards could impact. The first is the hiring of additional engineers by automobile companies and their suppliers to do research and development and testing on new technologies to determine their capabilities, durability, platform introduction, etc. The second area is the impact that new technologies would have on the production line. The third area is the potential impact that sales gains or losses could have on production employment.

Chapter VII of the FRIA contains estimates of employment impacts. The calculations assume that compliance costs are passed onto consumers in the form of higher prices. These higher vehicle prices (net of the benefits of added fuel savings and added resale value) lead to reduced demand for vehicles. Estimates of sales losses are made using the price changes and the elasticity of demand for new vehicles (-1.0). Losses in sales are translated into losses in jobs by dividing through by the average number of vehicles produced per full time jobs in the automotive industry (approximately 10.5 vehicles per job). In some rare cases, the fuel savings benefits exceed the compliance costs leading a reduction in price, and increase in sales, and an increase in employment.

The results for the six alternatives appear in Table VII-1 for the passenger car and light truck fleets. Job losses are cumulative – losses that are shown in 2013 (for example) include losses that occurred in 2012 and 2011. In general, job losses increase over time reflecting increases in stringency that take place. The first two alternatives (25% Below Optimized, Optimized) have roughly similar losses in employment ranging from a low of 714 jobs in 2011 to 11,127 jobs in 2015. The next most stringent alternative (25% Above Optimized) results in job losses that are double or sometimes triple the losses in the Optimized alternative. Job losses from the next alternative (50% Above Optimized) are slightly higher than the previous (25% Above Optimized) alternative. The last two alternatives (TC = TB and Technology Exhaustion) result in significant impacts on employment.

Table VII-1. Impact on Auto Industry Employment by Alternative for the Combined Light Truck and Passenger Car Fleet

	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
25% Below Optimized	-714	-1,287	-6,715	-5,580	-8,543
Optimized	-1,024	-2,572	-8,182	-7,662	-11,127
25% Above Optimized	-3,079	-8,651	-14,510	-18,207	-25,257
50% Above Optimized	-4,638	-14,913	-21,098	-24,682	-32,268
TC = TB	-8,232	-24,610	-30,545	-36,106	-48,847
Technology Exhaustion	-55,740	-145,724	-194,980	-223,053	-275,936

(c) Effect of other motor vehicle standards of the Government on fuel economy

This EPCA statutory factor constitutes an express recognition that fuel economy standards should not be set without giving due consideration to the effects of efforts to address other regulatory concerns, such as motor vehicle safety and criteria pollutant emissions. The primary influence of many of these regulations is the addition of weight to the vehicle, with the commensurate reduction in fuel economy. Manufacturers incorporate this added weight in their product plans, which are used as a starting point in the Volpe model analysis used to set the standards. Because the addition of weight to the vehicle is only relevant if it occurs within the timeframe of the regulations, *i.e.*, during MYs 2011-2015, we consider the Federal Motor Vehicle Safety Standards set by NHTSA and the Federal motor vehicle emissions standards set by EPA which become effective during the timeframe.

Federal Motor Vehicle Safety Standards

NHTSA has evaluated the impact of the Federal Motor Vehicle Safety Standards (FMVSS) using MY 2010 vehicles as a baseline. NHTSA has issued or proposed to issue a number of FMVSSs or amendments to FMVSSs scheduled to become effective between the baseline year and MY 2015. These have been analyzed for their potential impact on vehicle weight for vehicles manufactured in these years—as noted above, the fuel economy impact, if any, of these new requirements will take the form of increased vehicle weight resulting from the design changes needed to meet the new FMVSSs.

The average test weight (curb weight plus 300 pounds) of the passenger car fleet is currently 3,570 lbs. During the time period addressed by this rulemaking, the average test weight of the passenger car fleet is projected to be between 3,608 and 3,635 lbs. The average test weight of Chrysler's passenger car fleet is currently 3,928 lbs. The average test weight of Chrysler's passenger car fleet is projected to be between 3,844 and 3,993 lbs in the future. For Ford, the average test weight of the passenger car fleet is currently 3,660 lbs, and is projected to be between 3,649 and 3,677 lbs. For GM, the average test weight of the passenger car fleet is currently 3,649 lbs, and is projected to be between 3,768 and 3,855 lbs. For Toyota, the average test weight of the passenger car fleet is currently 3,330 lbs, and is projected to be between 3,416 and 3,451 lbs.

The average test weight (curb weight plus 300 pounds) of the light truck fleet is 4,727 pounds, and during the time period addressed by this rulemaking, the average test weight of the light truck fleet is projected to be between 4,824 and 4,924 lbs. The average test weight of Chrysler's light truck fleet is currently 4,673 lbs, while during the time period addressed by this rulemaking, the average test weight of Chrysler's light truck fleet is projected to be between 4,830 and 4,906 lbs. For Ford, the light truck fleet's average test weight is currently 4,887 lbs, while during the time period addressed by this rulemaking, the average test weight of light trucks is projected to be between 4,619 and 4,941 lbs. For GM, the light truck fleet's average test weight is currently 5,024 lbs, while during the time period addressed by this rulemaking, the average test weight is projected to be between 5,324 and 5,415 lbs. For Toyota, the light truck fleet's average test weight is currently 4,567 lbs, while during the time period addressed by this rulemaking, the average test weight is projected to be between 4,535 and 4,583 lbs.

Thus, overall, the four largest manufacturers of light-duty vehicles expect the average weight of their vehicles to remain mostly unchanged, with slight weight increases projected during the time period addressed by this rulemaking. The changes in weight include all factors, such as changes in the fleet mix of vehicles, required safety improvements, voluntary safety improvements, and other changes for marketing purposes. These changes in weight over the model years in question would have a negligible impact on fuel economy of passenger cars and light trucks.

Weight Impacts of Required Safety Standards (Final Rules)

NHTSA has issued two final rules on safety standards that become effective for passenger cars and light trucks between MY 2011 and MY 2015. These have been analyzed for their potential impact on passenger car and light truck weights, using MY 2010 as a baseline.

1. FMVSS No. 126, Electronic Stability Control
2. FMVSS No. 214, Side Impact Oblique Pole Test

FMVSS No. 126, Electronic Stability Control:

The phase-in schedule for vehicle manufacturers is:

Model Year	Production Beginning Date	Requirement
2009	September 1, 2008	55% with carryover credit
2010	September 1, 2009	75% with carryover credit
2011	September 1, 2010	95% with carryover credit
2012	September 1, 2011	All light vehicles

The final rule requires 75 percent of all light vehicles to meet the electronic stability control (ESC) requirement for MY 2010, 95 percent of all light vehicles to meet the ESC requirements by MY 2011, and all light vehicles to meet the requirements by MY 2012. Thus, in MY 2010, manufacturers must add ESC to 20 percent of vehicles; in MY 2011, to an additional 5 percent of vehicles; and in MY 2012, to another 5 percent of vehicles.

The agency's analysis of weight impacts found that an anti-lock braking system (ABS) (on which ESC depends) adds 10.7 lbs. and ESC adds 1.8 lbs. per vehicle for a total of 12.5 lbs. Based on manufacturers' plans for voluntary installation of ESC, 85 percent of passenger cars in MY 2010 would have ABS and 75 percent would have ESC. Thus, the total added weight in MY 2011 for passenger cars would be about 1.8 lbs. (0.10 x 10.7 + 0.43 x 1.8), and in MY 2012 an incremental 0.6 lbs. (0.05 x 10.7 + 0.05 x 1.8). For light trucks, manufacturers' plans indicate that 99 percent of all light trucks would have ABS by MY 2011 and that 75 percent would have ESC by that time. Thus for light trucks, the incremental weight impacts of adding ESC 0.4 lbs (0.21 x 1.8) in MY 2011 and an incremental 0.1 lbs (0.01 x 10.7 + 0.05 x 1.8) in MY 2012.

FMVSS No. 214, Side Impact Protection:

A little over one year ago, NHTSA issued a final rule to incorporate a dynamic pole test into FMVSS No. 214, "Side Impact Protection."[389] The rule will lead to the installation of new technologies, such as side curtain air bags and torso side air bags, that are capable of improving head and thorax protection to occupants of vehicles and that

[389] 72 FR 51907 (Sept. 11, 2007).

crash into poles and trees and vehicles that are laterally struck by a higher vehicle. The phase-in schedule for the side impact test is shown below:[390]

Phase-in Date	Percent of each manufacturer's light vehicles that must comply during the production period
September 1, 2010 to August 31, 2011	20 percent (excluding vehicles GVWR > 8,500 lbs.)
September 1, 2011 to August 31, 2012	40 percent vehicles (excluding vehicles GVWR > 8,500 lbs.)
September 1, 2012 to August 31, 2013	60 percent vehicles (excluding vehicles GVWR > 8,500 lbs.)
September 1, 2013 to August 31, 2014	80 percent vehicles (excluding vehicles GVWR > 8,500 lbs.)
On or after September 1, 2014	All vehicles, excluding vehicles GVWR > 8,500 lbs., altered and multistage vehicles
On or after September 1, 2015	All vehicles, including vehicles GVWR > 8,500 lbs., but not altered and multistage vehicles
On or after September 1, 2016	All altered and multistage vehicles

Based on manufacturers' plans to provide window curtains and torso bags voluntarily, we estimate that 90 percent of passenger cars and light trucks would have window curtains and 72 percent would have torso bags for MY 2011. A very similar percentage is estimated for MY 2011. A teardown study of 5 thorax air bags indicated in an average weight increase per vehicle of 4.77 pounds (2.17 kg).[391] In a second study, teardowns were performed on 5 window curtain systems.[392] One of the window curtain systems was very heavy (23.45 pounds). The other four window curtain systems had an average weight increase per vehicle of 6.78 pounds (3.08 kg), a figure which is assumed to be average for all vehicles in the future.

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[390] *Id.* 51971-72.
[391] Khadilkar, et al. "Teardown Cost Estimates of Automotive Equipment Manufactured to Comply with Motor Vehicle Standard – FMVSS 214(D) – Side Impact Protection, Side Air Bag Features," April 2003, DOT HS 809 809.
[392] Ludtke & Associates, "Perform Cost and Weight Analysis, Head Protection Air Bag Systems, FMVSS 201", page 4-3 to 4-5, DOT HS 809 842.

Based on the assumption that the typical system used to comply with the requirements of FMVSS No. 214 will be thorax bags with a window curtain, the average weight increase would be 2 pounds (0.10 x 6.78 + 0.28 x 4.77). However, there is the potential that some light trucks might need to add structure to meet the test. The agency has no estimate of this potential weight impact for structure.

Weight Impacts of Proposed/Planned Standards

Proposed FMVSS No. 216, Roof Crush:

On August 23, 2005, NHTSA proposed amending the roof crush standard to increase the roof crush force in the compliance test from 1.5 times the tested vehicle's weight to 2.5 times the tested vehicle's weight.[393] The NPRM proposed to extend the standard to vehicles with a GVWR of 10,000 pounds or less, thus including many light trucks that had not been required to meet the standard in the past. The proposed effective date was the first September 1 occurring three years after publication of the final rule. A Supplemental NPRM was published by the agency in January 2008, asking for public comment on a number of issues that may affect the content of the final rule, including possible variations in the proposed requirements. In the PRIA, the average light truck weight was estimated to increase by 6.1 pounds for a 2.5 strength to weight ratio. Based on comments on the NPRM, the agency believes that this weight estimate is likely to increase. However, the agency does not yet have an estimate for the final rule.

NHTSA initiative on Ejection Mitigation:

Pursuant to the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users, the agency will be issuing a NPRM on ejection mitigation. The

[393] 70 FR 49223 (Aug. 23, 2005). The PRIA for this NPRM is available at Docket No. NHTSA-2005-22143-2.

likely result of a final rule based on the anticipated proposal is for window curtain side air bags to be made larger and for a rollover sensor to be installed. The likely result will be an increase in weight of at least 2 pounds; however, this analysis is not completed. In addition, advanced glazing is one alternative that manufacturers might pursue for specific window applications (possibly for fixed windows for third row applications) or more broadly. Advanced glazing is likely to have weight implications. Again, the agency has not made an estimate of the likelihood that advanced glazing might be used or its weight implications.

Summary – Overview of Anticipated Weight Increases

The following table summarizes estimates made by NHTSA regarding the weight added by the above discussed standards or likely rulemakings. NHTSA estimates that weight additions required by final rules and likely NHTSA regulations effective in MY 2011 and beyond, compared to the MY 2010 fleet and manufacturers' plans, will increase passenger car weight by at least 10.4 lbs. and light truck weight by at least 10.6 lbs.

Table VII-1. Minimum Weight Additions Due to Final Rules or Likely NHTSA Regulations Compared to MY 2010 Baseline fleet

Standard	**Added Weight in pounds** Passenger Car	**Added Weight in kilograms** Passenger Car	**Added Weight in pounds** Light Trucks	**Added Weight in kilograms** Light Trucks
126 – ESC (Final)	2.4	1.1	0.5	0.2
214 – Side Impact (Final)	2.0	0.9	2.0 - ?	0.9 - ?
216 – Roof Crush (Proposed)	4.0 - ?	1.8 - ?	6.1 - ?	2.8 - ?
226 – Ejection Mitigation - (Proposed)	2.0	0.9	2.0	0.9
Total	10.4 - ?	4.7 - ?	10.6 - ?	4.8 - ?

Based on NHTSA's weight-versus-fuel-economy algorithms, a 3-4 pound increase in weight equates to a loss of 0.01 mpg in fuel economy. Thus, the agency's estimate of the safety/weight effects is 0.026 to 0.035 mpg or more for already issued or likely future safety standards.

Federal Motor Vehicle Emissions Standards

As discussed above, because the addition of weight to a vehicle is only relevant to its ability to achieve the MY 2011-2015 CAFE standards if it occurs in that timeframe, NHTSA only considers Federal motor vehicle emissions standards that become effective during the timeframe.

In the NPRM, NHTSA explained that on December 27, 2007, EPA published a final rule for fuel economy labeling that employs a new vehicle-specific, 5-cycle approach to calculating fuel economy labels which incorporates estimates of the fuel efficiency of each vehicle during high speed, aggressive driving, air conditioning operation and cold temperatures into each vehicle's fuel economy label.[394] The rule took effect starting with MY 2008, and will not impact CAFE standards or test procedures, or add weight to a vehicle or directly impact a manufacturer's ability to meet the CAFE standards. It will, however, allow for the collection of appropriate fuel economy data to ensure that existing test procedures better represent real-world conditions, and provide consumers with a more accurate estimate of fuel economy based on more comprehensive factors reflecting real-world driving use.

CARB commented that the NPRM had not addressed certain federal and California emissions regulations that NHTSA had analyzed in previous rulemakings, and stated that "NHTSA must analyze the potential effect of these emissions regulations on

[394] *See* 71 FR 77872 (Dec. 27, 2006).

its proposed standards." CARB further stated that "the NPRM must analyze the impact of California's ZEV regulations through at least MY 2011," which the commenter stated would "require NHTSA to consider the impact of rapidly shifting technologies that manufacturers will apply to meet a combination of government mandates and market conditions, most notably the electrification of vehicle drivetrains."[395]

In response, NHTSA reiterates that emissions standards that are completely phased in before MY 2011 are already accounted for in the agency's baseline for this rulemaking. EPA's "Tier 2" standards, which apply to all vehicles currently subject to CAFE and are designed to focus on reducing the emissions most responsible for the ozone and particulate matter (PM) impact from these vehicles, are scheduled to be completely phased in by 2009.[396] EPA's onboard vapor recovery (ORVR) system standards, which apply to all passenger cars and light trucks below 8,500 pounds GVWR, were completely phased in by MY 2008.[397] Thus, there is no additional effect of these emissions regulations on MY 2011-2015 vehicles for NHTSA to analyze, beyond what manufacturers have already included in their product plans in order to comply with these regulations, which NHTSA already accounts for.[398]

NHTSA agrees with CARB, however, that portions of the ZEV standards come into effect during MYs 2011-2015, although compliance with these standards is also already accounted for in manufacturers' product plans and thus forms part of NHTSA's baseline analysis. The State of California has established several emission requirements

[395] CARB comments at 10-11, Docket No. NHTSA-2008-0089-0173.
[396] *See* 65 FR 6698 (Feb. 10, 2000).
[397] *See* 59 FR 16262 (Apr. 6, 1994).
[398] Additionally, in calculating criteria pollutant emissions factors for analyzing air quality impacts, MOBILE6.2 accounted for EPA's emission control requirements for passenger cars and light trucks, including exhaust (tailpipe) emissions, evaporative emissions, and the Tier 2 program. *See* FEIS § 3.3.2.

under section 209(b) of the Clean Air Act as part of its Low Emission Vehicle (LEV) program. California initially promulgated these section 209(b) standards in its LEV I standards, and has subsequently adopted more stringent LEV II standards, also under section 209(b). The relevant LEV II regulations have been completely phased in for passenger cars and light trucks as of MY 2007.

The LEV II Program has requirements for "zero emission vehicles" (ZEVs) that apply to passenger cars and light trucks up to 3,750 pounds loaded vehicle weight (LVW) beginning in MY 2005, while trucks between 3,750 and 8,500 pounds are phased in to the ZEV regulation from 2007-2012. The ZEV requirements begin at 10 percent of vehicles sold by a manufacturer in California in 2005, and ramp up to 16 percent for 2018 under different paths. California will allow the 16 percent requirement to be met by greater numbers of "partial ZEVs" until 2018, which include ultra-clean gasoline-engine vehicles and hybrids.

Compliance with the ZEV standards is most often achieved through more sophisticated combustion management, frequently involving some of the technologies considered by NHTSA in its analysis. The associated improvements and refinement in engine controls generally improve fuel efficiency and have a positive impact on fuel economy.[399] However, such gains may be diminished because the advanced technologies required by the program can affect the impact of other fuel economy improvements, primarily due to increased weight. The agency has considered this potential impact in our evaluation of manufacturer product plans, many of which voluntarily identified particular models as ZEV or PZEV-compliant. This indicates to NHTSA that the

[399] NESCAUM, "White Paper: Comparing the Emissions Reductions of the LEV II Program to the Tier 2 Program," October, 2003.

manufacturers have already included compliance with these standards in their product plans, which in turn indicates that compliance with these standards is already accounted for in the agency's baseline.

NHTSA also explained in the NPRM that there are two groups of State emissions standards that do not qualify under 49 U.S.C. § 32902(f), and thus are not considered. One consists of State standards that cannot be adopted and enforced by any State because there has been no waiver granted by EPA under the preemption waiver provision in the Clean Air Act.[400] The other consists of State emissions standards that are expressly[401] or impliedly preempted under EPCA, and therefore cannot be enforced, regardless of whether or not they have received such a waiver under the Clean Air Act.[402] Preempted standards include, for example:

> (1) A state fuel economy standard that requires a manufacturer's fleet to achieve a specified number of miles per gallon. Compliance is determined by measuring each vehicle's CO_2 emissions per mile and converting that CO_2 figure into the mathematically equivalent number of miles per gallon of fuel, based on the carbon content of fuel;[403] and

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[400] 42 U.S.C. § 7543(a).

[401] 49 U.S.C. § 32919's express preemption provision states in relevant part as follows:

> **(a) General.—**When an average fuel economy standard prescribed under this chapter is in effect, a State or a political subdivision of a State may not adopt or enforce a law or regulation related to fuel economy standards or average fuel economy standards for automobiles covered by an average fuel economy standard under this chapter.

[402] NHTSA notes that in June 2002, the U.S. District Court for the Eastern District of California issued an order enjoining California's ZEV rule in *Central Valley Chrysler-Plymouth v. California Air Resources Board*, No. CV-f-02-5017 REC/SMS, 2002 U.S. Distr. LEXIS 20403 (E.D. Cal. June 11, 2002). The court found that the plaintiff automobile manufacturers and dealers had shown that the ZEV rule was "related to" fuel economy standards because it had the purpose and practical effect of regulating fuel economy. The court also found that "preemption cannot be avoided by intertwining preempted requirements with nonpreempted requirements." For further discussion, *see* 71 FR 17658 (Apr. 6, 2006).

[403] This is the method that EPA uses to determine compliance with NHTSA's CAFE standards.

(2) A state standard identical to (1), except for the following differences: (A) the required number of miles per gallon is converted into the mathematically equivalent number grams of CO_2 tailpipe emissions per mile, based on the carbon content of fuel; and (B) compliance is determined by measuring each vehicle's CO_2 emissions per mile, but no conversion to miles per gallon is made. Such a state standard has essentially the same structure, compliance measuring procedures, effects on motor vehicles and their manufacturers, and benefits for consumers and society as a fuel economy standard, and depends on the same types of technology for compliance, but is not labeled as fuel economy standard (i.e., a State tailpipe CO_2 standard). It is a fuel economy standard in all but name and stated purpose.

CARB commented that "NHTSA will need to consider the impact of California and other adopting states' motor vehicle GHG emission standard when those standards receive a waiver of preemption under the Clean Air Act; this may require re-opening this rulemaking or starting a new one." In response, NHTSA notes again that EPA denied California's request for a waiver, and that there is no indication from EPA that it intends to change its mind such that the inchoate California standards would impact NHTSA's final standards for MY 2011-2015. Regardless, even if EPA were to grant the waiver, that waiver would only affect preemption under the Clean Air Act. California's standards would remain preempted under 49 U.S.C. § 32919(a). The United States has consistently taken this position that EPCA preempts state standards regardless of any EPA waiver grant. For example, in the Ninth Circuit, the United States noted that "even if EPA were to grant a Clean Air Act waiver to a state standard, that standard would remain subject to the separate preemptive effect of EPCA." *See* United States Br. at 119, 131-35, Center for Biological Diversity v. NHTSA, No. 06-71891 (9th Cir. Filed Feb. 23, 2007). Moreover, in the Second Circuit, the United States has noted that "State GHG regulations, even if subject to an EPA waiver, would remain regulations 'adopt[ed] or enforc[ed]' by 'a State or political subdivision of a State' and therefore would be subject to preemption by EPCA." *See* United States Amicus Br. at 18-19, Green Mountain Chrysler-Plymouth-Dodge-Jeep v. Crombie, No. 07-4342(L) (2d Cir. Filed Apr. 16, 2008) (citing 49 U.S.C. § 32919(a)). Thus, NHTSA does not agree that it should re-open the rulemaking or begin a new one in the event that EPA reversed itself and granted the waiver.

(d) Need of the United States to conserve energy

Congress' requirement to set standards at the maximum feasible level and inclusion of the need of the nation to conserve energy as a factor to consider in setting CAFE standards ensures that standard setting decisions are made with this purpose and all of the associated benefits in mind. As discussed above, "the need of the United States to conserve energy" is a broad concept encompassing "the consumer cost, national balance of payments, environmental, and foreign policy implications of our need for large quantities of petroleum, especially imported petroleum."[404] Due to the breadth and scope of these issues, NHTSA does not believe that the need of the United States to conserve energy need be limited to consideration of purely domestic effects. While the overarching goal of EPCA is energy conservation, this energy savings factor (and related environmental concerns in connection with climate change) must nonetheless be balanced with the other EPCA factors. EPCA does not require or authorize the issuance of

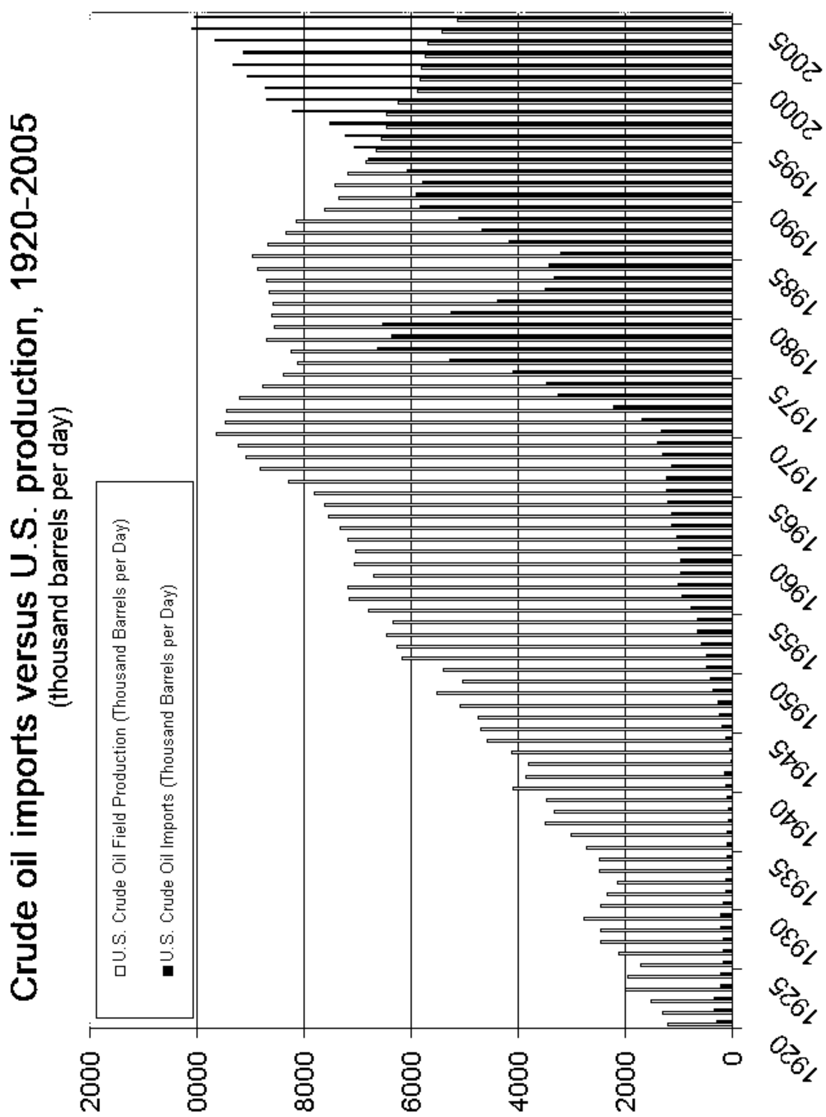
[404] 42 FR 63184, 63188 (Dec. 15, 1977).

standards that require the reducing of fuel consumption regardless of cost. The benefits of the energy savings from overly high standards would not outweigh countervailing severe economic costs. *See, e.g.*, Public Citizen v. NHTSA, 248 F.2d 256, 265 (DC Cir. 1988). Environmental implications principally include reductions in emissions of criteria pollutants and carbon dioxide and the associated public health and climate effects.

The need to reduce energy consumption is, from several different standpoints, more crucial today than it was at the time of EPCA's enactment in the late 1970s. U.S. energy consumption has been outstripping U.S. energy production at an increasing rate. At the time of this final rule, crude oil prices are currently around $70 per barrel, having peaked at $134 in mid-July 2008, despite having averaged about $13 per barrel as recently as 1998, and gasoline prices have doubled in this period.[405] Net petroleum imports now account for 60 percent of U.S. domestic petroleum consumption.406 World crude oil production continues to be highly concentrated, exacerbating the risks of supply disruptions and their negative effects on both the U.S. and global economies. Figure VII-1 below shows the increase of crude oil imports and the decline of U.S. oil production since 1920.

[405] Energy Information Administration, *Annual Energy Review 2006*, Table 5.21, p. 171. *Available at* http://www.eia.doe.gov/emeu/aer/pdf/pages/sec5_51.pdf (last accessed Nov. 29, 2007).
[406] Energy Information Administration, *Annual Energy Review 2006*, Table 5.1, p. 125. *Available at* http://www.eia.doe.gov/emeu/aer/pdf/pages/sec5_5.pdf (last accessed Nov. 29, 2007).

Figure VII-1



Source: DOE/EIA

The need of the nation to reduce energy consumption would be properly reflected in the buying decisions of vehicle purchasers, if:

- Vehicle buyers behaved as if they had unbiased expectations of their future driving patterns and fuel prices;

- The public social, economic, security, and environmental impacts of petroleum consumption were fully identified, quantified and reflected in current and future gasoline prices; and
- Vehicle buyers behaved as if they accounted for the impact of fuel economy on their future driving costs in their purchasing decisions.

Basic economic theory suggests that the price of vehicles should reflect the value that the consumer places on the fuel economy attribute of his or her vehicle. It is not clear that consumers have the information or inclination to value the impact of fuel economy in their vehicle purchasing decisions. Consumers generally have no direct incentive to value benefits that are not included in the price of fuel—for example, benefits such as energy security and limiting global climate change. These are the market failures that EPCA requires NHTSA to address.

NHTSA quantifies the need of the nation to conserve energy by calculating how much fuel economy a vehicle buyer ought to purchase, or rather, how much a vehicle buyer ought to value fuel economy, based both on fuel prices and potentially estimable externalities (including energy security, the benefits of mitigating a ton of CO_2 emissions, criteria pollutant emissions, noise, safety, and others). NHTSA discusses the specific issues related to the need of the United States to conserve energy in more detail below.

(i) Consumer cost

The Bureau of Labor Statistics estimates that about 4.9 percent of personal consumption expenditures in 2006 were accounted for by vehicle fuel and oil.[407] Given much higher gasoline prices since, the figure will certainly be higher in 2007-2008.

[407] Bureau of Labor Statistics, 2006 Consumer Expenditure Survey, http://www.bls.gov/cex/#tables. (last accessed Oct. 23, 2008).

Historically, gasoline consumption has been relatively insensitive to fluctuations in both price and consumer income, in large part because consumers are largely "locked in" in the short run to particular travel patterns by their choice of job, housing, schools, and lifestyle. People tend to view gasoline consumption as a non-discretionary expense.

Other non-discretionary expenses such as housing (34 percent of expenditures) and insurance/social security (11 percent), and health expenditures (6 percent) are larger, but more predictable. The mirror image of the relative stability in gasoline consumption is instability in the amount of money available in household budgets for everything else, and particularly for savings and discretionary expenses. When gasoline's share in consumer expenditures rises, the public experiences fiscal distress. This fiscal distress can, in some cases, have macroeconomic consequences for the economy at large.

NHTSA incorporates the impacts of consumer cost into its analysis through the use of fuel price projections in setting fuel economy standards. It should be noted that fuel economy is not free: consumers must "pay" for fuel economy through some combination of higher vehicle prices or loss of valued vehicle attributes. Vehicle purchases accounted for 7 percent of consumer expenditures in 2006. NHTSA uses cost-benefit analysis to ensure that consumers do not lose more through higher vehicle costs than they gain through lower fuel consumption.

(ii) National balance of payments

According to EIA, imports of crude oil and petroleum products accounted for about 65 percent of U.S. petroleum consumption in 2007.[408] Since U.S. crude oil and liquids production is only affected by fluctuations in crude oil prices over a period of

[408] Energy Information Administration, Petroleum Supply Annual 2007, http://tonto.eia.doe.gov/dnav/pet/pet_sum_snd_d_nus_mbbl_a_cur.htm (last accessed Oct. 23, 2008)

years, any changes in petroleum consumption largely flow into changes into the quantity of imports; and any changes in crude oil or wholesale products prices directly flow into changes in the value of imports. Thus, any improvement in light duty vehicle fuel economy will flow into a corresponding reduction in merchandise imports, just as higher prices flow into an increase in the value of imports.

According to the Census, in 2007, the United States imported $293 billion in crude oil and petroleum products, accounting for 36 percent of U.S. imports of goods.[409] In the first eight months of 2008, petroleum accounted for 49 percent of U.S. merchandise imports. The United States gross domestic product is about $14 trillion per year, so petroleum imports only account for about 2 percent of GDP. Nonetheless, petroleum imports are large enough to create a discernable fiscal drag, particularly since the usual macroeconomic adjustment mechanisms, such as price or income elasticity, or offsetting changes in currency valuation, are not very effective in reducing petroleum imports. Hence, most of the burden for any necessary macroeconomic adjustment will be borne by other sectors of the economy, and unrelated imports. Conversely, however, measures that reduce petroleum consumption, such as fuel economy standards, will flow directly into the balance-of-payments account, and strengthen the domestic economy to some degree.

(iii) Environmental implications

The need to conserve energy is also more crucial today because of growing greenhouse gas emissions from growing petroleum consumption by the on-the-road fleet of motor vehicles and growing concerns about the climate effects of those emissions.

[409] U.S. Department of Commerce, Bureau of the Census, FT900, U.S. International Trade in Goods and Services, August 2008. http://www.census.gov/foreign-trade/Press-Release/current_press_release/press.html (last accessed October 21, 2008)

Since 1999, the transportation sector has led all U.S. end-use sectors in emissions of CO_2. Transportation sector CO_2 emissions in 2006 were 407.5 million metric tons higher than in 1990, an increase that represents 46.4 percent of the growth in unadjusted energy related CO_2 emissions from all sectors over the period. Petroleum consumption, which is directly and substantially related to fuel economy, is the largest source of CO_2 emissions in the transportation sector.[410] Moreover, transportation sector emissions from gasoline and diesel fuel combustion generally parallel total vehicle miles traveled. The need of the nation to conserve energy encompasses all of these issues, since CO_2 emissions from passenger cars and light trucks decrease as fuel economy improves and more energy is conserved.[411] Indeed, the only way to make the substantial necessary reductions in CO_2 tailpipe emissions is to improve fuel economy.

These CAFE standards will reduce passenger car and light truck fuel consumption and CO_2 tailpipe emissions over the next several decades, responding to the need of the nation to conserve energy, as EPCA intended. More specifically, the proposed standards will save 23.6 billion gallons of fuel and avoid 218 million metric tons of CO_2 tailpipe emissions over the lifetime of the regulated vehicles.

NHTSA evaluated in great detail the potential environmental impacts associated with such CO_2 emissions reductions and other environmental impacts of the proposed standards through the Final Environmental Impact Statement prepared in conjunction

[410] However, increases in ethanol fuel consumption have mitigated the growth in transportation-related emissions somewhat (emissions from energy inputs to ethanol production plants are counted in the industrial sector).
[411] The above statistics are derived from Energy Information Administration, "Emissions of Greenhouse Gases Report," Report # DOE/EIA-0573 (2006), released November 28, 2007. *Available at* http://www.eia.doe.gov/oiaf/1605/ggrpt/carbon.html (last accessed Oct. 23, 2008).

with this rulemaking.[412] They take the form of unambiguous reductions in emissions of CO_2, and very small and uncertain changes in emissions of urban air pollutants and toxic pollutants, with reductions in emissions of most pollutants.

(iv) Foreign policy considerations

Fuel economy standards have only an indirect and general impact on U.S. foreign policy. U.S. foreign policy has been affected for decades by rising U.S. and world dependency of crude oil as the basis for modern transportation systems. In general, the United States and oil exporting states have a powerful long-term mutual interest a smoothly functioning international oil market. However, other governments sometimes behave erratically, and, on occasion will pursue short-term benefits at the expense of long-term advantage.

- The political stability of major oil exporting states and states controlling petroleum transportation routes is important to the United States, because chaos could lead to an interruption of oil production or shipments and worldwide increases in oil prices affecting the U.S. and world economy. Physical shortages of petroleum would be even more disruptive than high prices.
- The United States may give additional consideration to the political views of the governments of current or potential future oil exporting states, because the United States would like to influence these governments to invest in increased oil production capacity, to produce more oil, to sell their oil at reasonable prices, and to encourage other oil exporters to do the same.

[412] The Final Environmental Impact Statement (FEIS) is available on NHTSA's website at http://www.nhtsa.gov, under "Fuel Economy." On October 17, 2008, EPA published a notice announcing the availability of NHTSA's EIS for this rulemaking. 73 FR 61859.

- The United States may, under some circumstances, be prepared to overlook otherwise objectionable behavior by actual or potential oil exporters.
- The United States must take an interest in the military security of major foreign oil production, refining, export, and transportation facilities because damage to these facilities could affect the U.S. and world economy, even if the affected facilities do not produce or ship petroleum for the U.S. market.
- To the extent that oil exporting states accumulate large foreign currency reserves as a result of cumulative balance-of-payments surpluses, the United States may have additional reasons for giving such states additional consideration.

NHTSA considers oil price externalities that cover the benefits associated with reduced risk of an oil price spike, possibly induced by foreign political developments. However, other externalities in connection with foreign policy considerations such as those set forth above are exceedingly difficult to quantify, much less monetize as a discrete economic value. No commenter set forth a methodology by which NHTSA could reasonably quantify this particular set of externalities, and NHTSA is unaware of literature which addresses quantifying these considerations. Nevertheless, in considering the need of the nation to conserve energy, NHTSA has taken foreign policy considerations into account as a part of its qualitative analysis. For further discussion of how NHTSA accounts for petroleum consumption and import externalities in its analysis, see section V.B.11 above.

Accordingly, upon consideration of the entire record, and on the basis of all public comments and applicable law, NHTSA has considered the need of the nation to conserve energy.

4. Comparison of alternatives

NHTSA's analyses of the levels of CAFE that would be required under the alternatives considered by the agency and the associated costs are described below and then summarized in Tables VII-2 through VII-6:

VII-2. Average Required CAFE Levels: Under an attribute-based CAFE standard, the CAFE level required of each manufacturer depends on the distribution of footprint values and projected sales of individual models comprising the fleet of vehicles it produces. Table VII-2 contains a sales-weighted harmonic average of these requirements.

VII-3. Average CAFE Shortfall: If a manufacturer is not expected to achieve the required CAFE level, either because of an expected economic decision or because all opportunities to add technology are expected to be exhausted, the manufacturer is expected to have a shortfall that will result in civil penalties (unless sufficient CAFE credits are available to offset the shortfall). Table VII-3 summarizes these shortfalls (where they exist) at the industry-wide level.

VII-4. Total Benefits (versus Baseline): The societal benefits resulting from each alternative are calculated relative to the baseline CAFE standards. Section V discusses the components of these benefits. Table VII-4 shows the discounted present value of benefits accrued over the useful life of vehicles sold in each model year.

VII-5. Total Costs (versus Baseline): The total costs of each alternative are measured by the estimated industry-wide increase in technology outlays from those under baseline CAFE standards.

VII-6. Net Benefits (versus Baseline): Net benefits reflect the amount by which total benefits exceed total costs. In Table VII-6, negative values indicate instances in which total costs exceed total benefits.

Table VII-2. Average Required CAFE Levels (mpg)

	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
Passenger Cars					
Baseline	27.5	27.5	27.5	27.5	27.5
25% Below	29.9	31.6	34.1	35.0	36.7
Optimized	30.2	32.1	34.4	35.4	37.1
25% Above	30.5	32.7	34.8	35.8	37.5
50% Above	30.9	33.3	35.3	36.2	37.9
TC = TB	31.5	34.4	36.2	37.0	38.7
Technology Exhaust	35.5	45.9	47.1	47.2	47.1
Light Trucks					
Baseline	23.3	23.4	23.3	23.4	23.4
25% Below	24.1	24.9	25.9	26.3	26.2
Optimized	24.1	25.1	26.1	26.7	27.1
25% Above	24.2	25.2	26.3	27.1	27.9
50% Above	24.2	25.4	26.5	27.5	28.8
TC = TB	24.3	25.7	26.9	28.3	30.6
Technology Exhaust	29.0	30.7	34.0	34.2	37.2
Combined Passenger Car and Light Truck					
Baseline	25.5	25.6	25.5	25.5	25.5
25% Below	27.2	28.4	30.0	30.6	31.1
Optimized	27.3	28.7	30.3	31.0	31.8
25% Above	27.5	29.1	30.6	31.4	32.5
50% Above	27.7	29.5	30.9	31.8	33.2
TC = TB	28.0	30.1	31.5	32.6	34.6
Technology Exhaust	32.4	38.0	40.5	40.5	42.0

Table VII-3. Average CAFE Shortfall (mpg)

	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
Passenger Cars					
Baseline					
25% Below			0.8	0.8	1.3
Optimized		0.2	0.9	0.9	1.5
25% Above		0.4	1.0	0.9	1.6
50% Above		0.6	1.1	1.0	1.7
TC = TB	0.4	1.1	1.4	1.2	2.0
Technology Exhaust	3.1	9.9	8.9	7.3	6.2
Light Trucks					
Baseline	0.3				
25% Below	1.0	0.1	0.3		
Optimized	1.0	0.2	0.4	0.2	
25% Above	1.1	0.2	0.4	0.4	0.2
50% Above	1.1	0.3	0.4	0.5	0.7
TC = TB	1.1	0.4	0.5	0.8	1.6
Technology Exhaust	5.4	3.9	5.7	4.0	4.6
Combined Passenger Car and Light Truck					
Baseline					
25% Below	0.2		0.5	0.3	0.2
Optimized	0.3	0.2	0.6	0.5	0.6
25% Above	0.4	0.3	0.7	0.6	0.8
50% Above	0.6	0.5	0.7	0.7	1.1
TC = TB	0.8	0.7	0.9	1.0	1.8
Technology Exhaust	4.4	6.5	7.2	5.5	5.3

Table VII-4. Total Benefits (versus Baseline) Over Model Year Lifetime – Present Value (Millions of 2007 Dollars)

	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
Passenger Cars					
25% Below	786	2,047	5,061	7,149	9,661
Optimized	1,027	2,742	5,885	8,026	10,371
25% Above	1,332	3,768	6,756	8,956	11,081
50% Above	1,773	4,944	7,934	9,892	11,763
TC = TB	2,487	6,966	9,597	11,326	13,085
Technology Exhaust	6,406	14,816	18,249	20,949	22,067
Light Trucks					
25% Below	921	3,385	5,515	5,922	6,382
Optimized	921	3,771	6,180	6,807	8,454
25% Above	989	4,183	6,724	7,811	10,877
50% Above	989	5,022	7,712	9,022	12,529
TC = TB	1,189	5,819	8,821	11,038	16,030
Technology Exhaust	2,950	11,972	16,065	19,751	26,944
Combined Passenger Car and Light Truck					
25% Below	1,707	5,432	10,576	13,071	16,042
Optimized	1,948	6,513	12,066	14,833	18,825
25% Above	2,321	7,951	13,480	16,767	21,958
50% Above	2,763	9,966	15,646	18,913	24,293
TC = TB	3,676	12,785	18,418	22,364	29,115
Technology Exhaust	9,356	26,788	34,314	40,701	49,011

Table VII-5. Total Costs (versus Baseline) (Millions of 2007 Dollars)

	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
Passenger Cars					
25% Below	291	996	3,713	5,055	7,192
Optimized	496	1,549	4,423	6,003	8,040
25% Above	1,003	3,272	5,887	7,979	9,411
50% Above	1,630	4,978	7,801	9,504	11,023
TC = TB	2,619	7,687	9,728	11,370	13,115
Technology Exhaust	11,907	27,758	35,713	39,968	42,114
Light Trucks					
25% Below	649	2,237	3,651	3,398	3,539
Optimized	649	2,548	4,040	3,870	4,791
25% Above	915	3,345	5,151	6,087	9,497
50% Above	915	4,527	6,340	7,629	11,006
TC = TB	1,391	6,035	8,759	11,119	16,163
Technology Exhaust	6,214	22,688	34,171	44,155	64,394
Combined Passenger Car and Light Truck					
25% Below	940	3,234	7,364	8,454	10,732
Optimized	1,145	4,097	8,462	9,874	12,831
25% Above	1,918	6,617	11,038	14,067	18,908
50% Above	2,545	9,505	14,141	17,133	22,030
TC = TB	4,009	13,722	18,487	22,488	29,279
Technology Exhaust	18,120	50,446	69,884	84,123	106,508

Table VII-6. Net[413] Benefits (versus Baseline) Over the Vehicle's Lifetime – Present Value (Millions of 2007 Dollars)

	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
Passenger Cars					
25% Below	496	1,051	1,348	2,093	2,468
Optimized	531	1,193	1,463	2,023	2,331
25% Above	329	496	869	977	1,670
50% Above	143	(34)	133	388	740
TC = TB	(132)	(721)	(131)	(44)	(31)
Technology Exhaust	(5,501)	(12,942)	(17,464)	(19,018)	(20,047)
Light Trucks					
25% Below	272	1,147	1,864	2,524	2,842
Optimized	272	1,223	2,140	2,936	3,663
25% Above	75	838	1,573	1,724	1,380
50% Above	75	495	1,372	1,392	1,523
TC = TB	(202)	(216)	62	(81)	(133)
Technology Exhaust	(3,264)	(10,716)	(18,106)	(24,404)	(37,450)
Combined Passenger Car and Light Truck					
25% Below	767	2,198	3,213	4,617	5,311
Optimized	802	2,416	3,603	4,959	5,994
25% Above	403	1,334	2,442	2,701	3,050
50% Above	218	461	1,505	1,781	2,263
TC = TB	(334)	(937)	(69)	(124)	(164)
Technology Exhaust	(8,765)	(23,658)	(35,570)	(43,422)	(57,497)

NHTSA believes that some differences among specific alternatives analyzed are worth noting here. As Tables VII-4 and VII-5 reveal, costs increase more rapidly than do benefits as required CAFE levels increase, particularly beyond the level at which total costs equal total benefits. Increasing compliance costs reduce both new vehicle sales and employment. Each of the alternatives that is more stringent than the Optimized

[413] Negative values mean that costs exceed benefits.

Alternative will reduce sales and employment from the levels observed under the Optimized alternative, as documented in the FRIA in Chapter VII. Additionally, under the more stringent alternatives, the Volpe model predicts that increasing numbers of manufacturers will run out of technology to apply, and potentially resort to paying statutory penalties. The CAFE shortfalls shown in Table VII-3 measure how widespread this outcome could become. Even the "25 percent below optimized" alternative results in standards that increase more rapidly between successive model years than the standards that the agency has proposed since the first years of the program, although it is possible that choosing that alternative could jeopardize the ability of the combined fleet to reach the 35 mpg target in 2020 required by EISA.

Underlying the differences in costs, benefits, and net benefits among the alternatives are differences in the extent to which NHTSA has estimated that fuel economy technologies would be applied in response to the standards corresponding to each of these alternatives. While Section IX.E below comprehensively documents the estimated penetration rates for each technology under the final standards, the following tables show estimates of the average penetration rates of selected technologies in the MY 2015 passenger car and light truck fleets under each of the alternatives discussed here for comparison:

Table VII-7. Estimated Average Technology Penetration (Largest Seven Manufacturers) MY 2015 Passenger Cars

	Base	25% Below Final	Optimized	25% Above Final	50% Above Final	TC=TB	Tech. Exh.
Dual Clutch or Auto. Manual Trans.	8%	40%	43%	43%	51%	60%	27%
Stoich. Gasoline Direct Injection	30%	30%	37%	36%	34%	39%	24%
Turbocharging & Engine Downsizing	11%	16%	16%	18%	20%	24%	25%
Diesel Engine	0%	4%	4%	5%	10%	12%	62%
Hybrid Electric Vehicles	9%	16%	17%	24%	25%	34%	69%

Table VII-8. Estimated Average Technology Penetration (Largest Seven Manufacturers) MY 2015 Light Trucks

	Base	25% Below Final	Optimized	25% Above Final	50% Above Final	TC=TB	Tech. Exh.
Dual Clutch or Auto. Manual Trans.	13%	52%	66%	65%	71%	74%	21%
Stoich. Gasoline Direct Injection	30%	36%	40%	53%	53%	63%	19%
Turbocharging & Engine Downsizing	13%	17%	17%	30%	33%	42%	25%
Diesel Engine	8%	10%	10%	12%	12%	16%	71%
Hybrid Electric Vehicles	5%	10%	14%	21%	21%	26%	83%

As the first of the above two tables indicates, under the optimized alternative, manufacturers might nearly double the estimated baseline utilization of hybrid electric technologies in the passenger car fleet. This table also indicates that the use of these technologies in passenger cars might increase by an additional 50 percent (from 17 to 24 percent) under the "25% above final" alternative.

Similarly, the second table indicates that, under the optimized standards, manufacturers might nearly triple the estimated baseline utilization of hybrid electric technologies in the light truck fleet from the levels anticipated in their product plans. This table also shows that the use of these technologies in light trucks might increase by an additional 50 percent (from 14 to 21 percent) under the "25% above final" alternative.

Along the continuum, each alternative represents a different way in which NHTSA could conceivably balance the four EPCA factors and the attendant environmental concerns. The alternatives that fall above the Optimized Alternative (the +25, +50, TC = TB, and Technology Exhaustion alternatives), if chosen, would represent an agency decision to put progressively more emphasis on reducing energy consumption and CO_2 emissions, due to the need of the nation to conserve energy, and less on the other factors, such as economic practicability and the impacts of higher stringencies on the industry. The -25% alternative, in contrast, would represent an agency decision to put more emphasis on the economic situation of the industry and its ability to apply advanced technologies in the relevant timeframe, while placing less on the other factors, such as the need of the nation to conserve energy.

5. Other considerations under EPCA

(a) Safety

NHTSA explains in Section VIII below that it has historically considered safety in setting the CAFE standards. NHTSA refers the reader to that discussion.

(b) AMFA credits

49 U.S.C. § 32902(h) expressly prohibits NHTSA from considering the fuel economy of "dedicated" automobiles in setting CAFE standards. Dedicated automobiles are those that operate only on an alternative fuel, like all-electric or natural gas vehicles.[414] Dedicated vehicles often achieve higher mile per gallon (or equivalent) ratings than regular gasoline vehicles, so this prohibition prevents NHTSA from raising

[414] 49 U.S.C. § 32901(a)(7). "All-electric" would thus not include a plug-in hybrid (PHEV), since that vehicle is also capable of operating on gasoline.

CAFE standards by averaging these vehicles into our determination of a manufacturer's maximum feasible fuel economy level.

Section 32902(h) also directs NHTSA to ignore the fuel economy incentives for dual-fueled (*e.g.*, E85-capable) automobiles in setting CAFE standards. § 32905(b) and (d) use special calculations for determining the fuel economy of dual-fueled automobiles that give those vehicles higher fuel economy ratings than otherwise-identical regular automobiles. Through MY 2014, manufacturers may use this "dual-fuel" incentive to raise their average fuel economy up to 1.2 miles per gallon higher than it would otherwise be. After MY 2014, Congress has set a schedule by which the dual-fuel incentive diminishes partially each year until it is extinguished after MY 2019.[415] This issue is discussed further in Section XII.C below.

Although manufacturers may use this additional credit for their CAFE compliance, NHTSA may not consider it in setting standards. As above, this prohibition prevents NHTSA from raising CAFE standards by averaging these vehicles into our determination of a manufacturer's maximum feasible fuel economy level.

No comments were received regarding the statutory prohibition on NHTSA's consideration of these alternative-fuel vehicle incentives, but the agency notes that given that the final rule standards increase more rapidly than any CAFE standards since the inception of the CAFE program, we believe it likely that manufacturers will use the incentive to a considerable degree.

(c) Flexibility mechanisms: credits, fines

[415] 49 U.S.C. § 32906(a). NHTSA notes that if there is any possible misinterpretation of this table, the schedule laid out by Congress in EISA controls.

As discussed at length below in Chapter XII, EPCA and EISA also allow manufacturers to use credits (either earned or purchased) and to pay fines in order to meet CAFE standards. However, 49 U.S.C. § 32902(h)(3) expressly states that NHTSA "may not consider, when prescribing a fuel economy standard, the trading, transferring, or availability of credits under section 32903." Thus, NHTSA may not raise CAFE standards because manufacturers have enough credits to meet higher standards, nor may NHTSA lower standards because manufacturers do not have enough credits to meet existing standards.

A number of commenters, including AIAM, Mercedes, Ferrari, NADA, and ACEEE, suggested that the use of the credit trading system which NHTSA proposed to develop under the new authority given by EISA would not likely be very extensive, at least initially, due to competitive concerns among manufacturers. Whether this prediction will be borne out remains to be seen, but the agency notes that credit trading gives more flexibility and could potentially lower compliance costs for manufacturers, which should provide an incentive for manufacturers to engage in trading.

As for fines, CFA commented that "NHTSA allows the historical desire of automakers to avoid paying fines to pull down the level of the standard, by assuming that setting standards at a level that might cause automakers to pay fines does no good." CFA suggested that fines are "not only punitive; they are motivational."

NHTSA considers the levels of stringency at which different manufacturers are estimated to run out of technology and begin paying fines. NHTSA agrees that fines may be motivational, but believes that CFA misunderstands how fines function in standard setting. All manufacturers (except the few that have paid fines historically) are assumed to be willing to pay any price, no matter how high, in order to avoid paying fines. In the Volpe model analysis, manufacturers cease adding technology to achieve compliance only when there are no more technologies available to add.

This is not because NHTSA wishes to protect the manufacturers from having to pay fines, but for the following two reasons: first, because the point at which manufacturers run out of technology gives NHTSA a strong indication of what would be economically practicable and technologically feasible, and second, because if manufacturers are paying fines instead of meeting the CAFE standards, the projected level of fuel savings is not being achieved. NHTSA recognizes that fines are motivational for manufacturers, particularly for the U.S. domestic manufacturers, but continues to believe that setting standards above the levels achievable through fuel saving technologies at reasonable cost because we think that manufacturers might be motivated to avoid paying fines would only result in higher standards, without resulting in additional fuel savings.

D. Environmental consequences relevant to the selection of the final standards

The FEIS analyzes in detail the potential direct, indirect, and cumulative impacts of the alternatives. NHTSA's Preferred Alternative, the Optimized CAFE Standards, was one of the alternatives that was explicitly and fully evaluated in the FEIS.[416]

The Technology Exhaustion Alternative is the overall environmentally preferable alternative. Specifically, the Technology Exhaustion alternative is the Environmentally Preferable Alternative in terms of the following reductions: fuel use, CO_2 emissions,

[416] *See generally* FEIS, *available at* Docket No. NHTSA-2008-0060-0605.

criteria air pollutant emissions, and their resulting health impacts, and emissions of majority of mobile source air toxics (MSATs).

According to NHTSA's analysis set forth in the FEIS (and summarized here), the MSATs acrolein and formaldehyde demonstrate larger increases under Technology Exhaustion Alternative than under the other alternatives). However, the analysis of acrolein emissions presented in the FEIS is incomplete, because upstream emissions factors for that MSAT are not available and the agency is thus unable to estimate the net change in acrolein emissions likely to result under each alternative. The agency, therefore, is unable to conclude which alternative is environmentally preferable.

As explained in Chapter 5 of the FEIS, however, the reductions in fuel consumption from higher fuel economy cause emissions that occur during fuel refining and distribution to decline. For most pollutants, this decline is more than sufficient to offset the increase in tailpipe emissions that results from increased rebound-effect driving, thus leading to a net reduction in emissions. If the agency had been able to estimate reductions in these "upstream" emissions of acrolein as part of its analysis, acrolein emissions would show smaller increases or even net declines.

With regard to formaldehyde, the Optimized Alternative is the agency's Environmentally Preferable Alternative, as it results in the smallest level of emissions.

Overall, however, the Technology Exhaustion alternative is the agency's Environmentally Preferable Alternative. For additional discussion regarding the alternatives considered by the agency in reaching its decision, including the alternatives considered to be environmentally preferable, see Section XI of this final rule. For a discussion of the environmental impacts associated with the alternatives, see Chapter 3, Chapter 4 and Appendix B of the FEIS. *See also* Section VII.H of this final rule.

The effects of the alternatives on climate – CO_2 concentrations, temperature, precipitation, and sea-level rise – have been the subject of particular public interest and comment. Accordingly, we have set forth below some of the charts from the FEIS comparing the alternatives in these areas. The effects on climate can translate into impacts on key resources, including freshwater resources, terrestrial ecosystems, coastal ecosystems, land use, human health, and environmental justice. Although the alternatives have the potential to substantially decrease GHG emissions, none of them would completely prevent climate change from occurring.

However, the magnitudes of the changes in these climate effects under the alternatives – a few parts per million of CO_2, one or two one-hundredths of a degree Celsius difference in temperature, a small percentage change (0.02 percent to 0.03 percent) in the rate of precipitation increase, and 1 or 2 millimeters of sea-level change – are too small to meaningfully address quantitatively in terms of their impacts on resources. Given the enormous global values of these resources, these distinctions could be important – very small percentages of huge numbers can still yield substantial results – but they are too small for current quantitative techniques to resolve. Consequently, the discussion of resource impacts does not distinguish among the CAFE alternatives, but rather provides a qualitative review of the benefits of reducing GHG emissions and the magnitude of the risks involved in climate change.

Table VII-9

Mid-2 Scenario Passenger Car Annual Fuel Consumption and Fuel Savings (billion gallons)

	Alternative CAFE Standards for Model Years 2011-2015						
	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7
Calendar Year	No Action	25% Below Optimized	Optimized	25% Above Optimized	50% Above Optimized	Total Cost Equal Total Benefit	Technology Exhaustion
			Fuel Consumption				
2020	62.1	59.4	59.2	58.9	58.6	58.1	54.5
2030	71.1	65.9	65.5	65.1	64.7	63.9	58.0
2040	81.4	75.2	74.8	74.3	73.9	73.0	66.0
2050	93.2	86.2	85.7	85.1	84.6	83.6	75.6
2060	106.2	98.1	97.5	96.9	96.3	95.2	86.1
			Fuel Savings from No Action				
2020	--	2.7	2.9	3.2	3.5	4.0	7.7
2030	--	5.2	5.6	6.0	6.4	7.1	13.1
2040	--	6.2	6.6	7.1	7.6	8.4	15.4
2050	--	7.1	7.6	8.1	8.7	9.7	17.6
2060 a/	--	8.1	8.6	9.3	9.9	11.0	20.1

a/ Uncertainties in the growth of VMT and number of vehicles in operation make forecasts past 2060 uncertain.

Table VII-10

Mid-2 Scenario Light Truck Annual Fuel Consumption and Fuel Savings (billion gallons)

	Alternative CAFE Standards for Model Years 2011-2015						
	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7
Calendar Year	No Action	25% Below Optimized	Optimized	25% Above Optimized	50% Above Optimized	Total Cost Equal Total Benefit	Technology Exhaustion
				Fuel Consumption			
2020	77.0	75.1	74.6	74.0	73.6	72.7	69.2
2030	84.3	80.9	79.9	78.7	77.9	76.1	69.8
2040	95.8	91.6	90.4	88.8	87.8	85.6	77.8
2050	109.4	104.6	103.1	101.3	100.1	97.5	88.4
2060	124.6	119.1	117.4	115.4	114.0	111.0	100.6
				Fuel Savings from No Action			
2020	--	1.9	2.4	3.0	3.4	4.3	7.8
2030	--	3.3	4.3	5.5	6.3	8.1	14.4
2040	--	4.1	5.4	6.9	7.9	10.2	18.0
2050	--	4.8	6.3	8.1	9.2	11.9	21.0
2060 a/	--	5.5	7.2	9.2	10.6	13.6	24.0

a/ Uncertainties in the growth of VMT and number of vehicles in operation make forecasts past 2060 uncertain.

Table VII-11

Mid 2 Scenario Emissions and Emission Reductions (compared to the No Action Alternative) Due to the MY 2011-2015 CAFE Standard Alternatives from 2010-2100 (MMTCO2)

Alternative	Emissions	Emission Reductions Compared to No Action Alternative
No Action	195,501	0
25 Percent Below Optimized	185,761	9,740
Optimized	184,038	11,463
25 Percent Above Optimized	182,281	13,221
50 Percent Above Optimized	180,886	14,615
Total Costs Equal Total Benefits	178,093	17,408
Technology Exhaustion	170,829	24,672

Table VII-12

Mid 2 Scenario 2011-2015 CAFE Standard Alternatives Impact on CO_2 Concentration, Global Mean Surface Temperature Increase, and Sea-level Rise in 2100 Using MAGICC

	CO_2 Concentration (ppm)			Global Mean Surface Temperature Increase (°C)			Sea-level Rise (cm)		
Totals by Alternative	**2030**	**2060**	**2100**	**2030**	**2060**	**2100**	**2030**	**2060**	**2100**
No Action (A1B-AIM)a/	455.5	573.7	717.2	0.874	1.944	2.959	7.99	19.30	37.10
25 Percent Below Optimized	455.4	573.3	716.3	0.873	1.943	2.955	7.99	19.28	37.07
Optimized	455.4	573.2	716.2	0.873	1.942	2.955	7.99	19.28	37.06
25 Percent Above Optimized	455.4	573.1	716.0	0.873	1.942	2.954	7.99	19.28	37.06
50 Percent Above Optimized	455.4	573.1	715.9	0.873	1.942	2.953	7.99	19.28	37.05
Total Costs Equal Total Benefits	455.4	573	715.6	0.873	1.941	2.952	7.99	19.27	37.04
Technology Exhaustion	455.3	572.6	714.9	0.872	1.938	2.948	7.99	19.26	37.00
Reduction from CAFE Alternatives									
25 Percent Below Optimized	0.1	0.4	0.9	0.000	0.002	0.004	0.00	0.02	0.03
Optimized	0.1	0.5	1.0	0.001	0.002	0.004	0.00	0.02	0.04
25 Percent Above Optimized	0.1	0.6	1.2	0.001	0.002	0.005	0.00	0.02	0.04
50 Percent Above Optimized	0.1	0.6	1.3	0.001	0.003	0.006	0.00	0.02	0.05
Total Costs Equal Total Benefits	0.1	0.7	1.6	0.001	0.003	0.007	0.00	0.03	0.06
Technology Exhaustion	0.2	1.1	2.3	0.002	0.006	0.011	0.00	0.04	0.10

a/ The A1B-AIM scenario is the SRES marker scenario used by the IPCC WG1 to represent the SRES A1B (medium) storyline.

E. Picking the final standards

1. Eliminating the alternatives facially inconsistent with EPCA

(a) No-action alternative

Two of these alternatives are facially inconsistent with EPCA. Regardless of how this alternative is defined, *i.e.*, either in terms of setting no standard or setting the MY 2011-2015 standards at the MY 2010 level, this alternative violates EPCA. Under the former definition, the no action alternative violates, among other EPCA provisions, subsections 32902(a) and (b)(1) and (2), each of which requires the Secretary to establish

CAFE standards for each of MYs 2011-2015. Under the latter definition, the no action alternative violates subsection 32902(b)(2)(A) which requires the MY 2011-2020 standards to be set high enough to ensure that the industry-wide fleet achieves a combined passenger car/light truck average fuel economy of at least 35 mpg. It also violates the requirement in subsection 32902(b)(2)(B) that the standards for MYs 2011-2020 increase annually and ratably.

(b) Technology exhaustion alternative

Although the maximum technology alternative is the environmentally preferable alternative for NEPA purposes, it does not reflect any consideration of economic practicability. This omission violates subsections 32902(a) and (b), which require setting standards at the maximum feasible level, and subsection 32902(f), which requires that "(w)hen deciding maximum feasible average fuel economy under this section, the Secretary of Transportation shall consider technological feasibility, *economic practicability*, the effect of other motor vehicle standards of the Government on fuel economy, and the need of the United States to conserve energy." (Emphasis added.)

2. Choosing among the remaining alternatives

(a) Difficulty and importance of achieving a reasonable balancing of the factors

Section 1(a) of E.O. 12866 provides that "(i)n choosing among alternative regulatory approaches, agencies should select those approaches that maximize net benefits (including potential economic, environmental, public health and safety, and other advantages; distributive impacts; and equity), unless a statute requires another regulatory approach." The Ninth Circuit ruled in *CBD v. NHTSA* 538 F.3d 1172, 1197 that EPCA does not require another regulatory approach.

We recognize that the Ninth Circuit coupled that ruling with the following cautionary statement about basing decisions about the stringency of CAFE standards on the principle of maximizing net benefits:

> (W)e reject only Petitioners' contention that EPCA prohibits NHTSA's use of marginal cost-benefit analysis to set CAFE standards. Whatever method it uses, NHTSA cannot set fuel economy standards that are contrary to Congress's purpose in enacting the EPCA-energy conservation. We must still review whether NHTSA's balancing of the statutory factors is arbitrary and capricious. Additionally, the persuasiveness of the analysis in Public Citizen and Center for Auto Safety is limited by the fact that they were decided two decades ago, when scientific knowledge of climate change and its causes were not as advanced as they are today. … The need of the nation to conserve energy is even more pressing today than it was at the time of EPCA's enactment.
> …
>
> What was a reasonable balancing of competing statutory priorities twenty years ago may not be a reasonable balancing of those priorities today. (footnotes omitted)

538 F.3d 1172, 1197-98

As discussed below, achieving a reasonable balancing of the factors is critical. While, as the Court suggested, there are risks associated with setting standards that are too low, there are also considerable risks associated with setting standards that are too high. Both types of risks must be part of the balancing process.

We recognize that the on-road fleet of passenger cars and light trucks is one of largest consumers of petroleum and emitters of CO_2 in the U.S. economy. We recognize too that global CO_2 emissions have been exceeding the highest of the IPCC 2007 scenarios. We appreciate that, among the remaining alternatives, the total cost/total benefit alternative is the one that reduces those emissions the most.

At the same time, we cannot fail to recognize and fully take into account the very serious conditions of the automobile industry, the national economy, and even the global economy. We understand that some aid has been authorized and appropriated for the automobile industry and that the possibility of other aid has been broached, but the timing and amount of even the former aid is uncertain. What is certain is that the mere fact substantial aid is even being discussed is a reflection of the unusual and extremely serious conditions we face. What is certain too is that there would be a sharp increase in implementation costs to the extent that CAFE standards are set above the level that maximize net benefits.

(b) The correct balancing of the factors for MYs 2011-15 is to maximize societal net benefits

We have discussed above how NHTSA considered and balanced the four statutory factors. This section discusses NHTSA's decision that the final standards are the maximum feasible for MYs 2011-2015.

Congress left the determination of what levels of CAFE standards are "maximum feasible" to NHTSA's discretion, requiring only that NHTSA consider the four statutory factors. 49 U.S.C. § 32902. NEPA applies independently to require consideration of environmental factors in the decision-making process. The EPCA factors are in tension and tend to pull in opposite directions in terms of stringency, with technological feasibility and especially the need of the nation to conserve energy pointing toward higher standards and economic practicability pointing toward lower ones. Accordingly, NHTSA has historically considered the factors from the perspective of balancing them, given EPCA's overarching purpose of energy conservation.[417] Thus, NHTSA determines that standards are the maximum feasible if they represent the proper balancing of the four statutory factors, based on all the information before the agency and the entire record.

The "need of the United States to conserve energy" primarily functions to encourage NHTSA to set standards ever higher. Many commenters cast the need of the nation to conserve energy in terms of the impact of CAFE standards on global warming, and urged NHTSA to give this factor more weight than the others in its determination of the maximum feasible standards, in order to have the maximum possible beneficial impact. Many of these commenters suggested that if NHTSA gave more weight to the need of the nation to conserve energy, it would set standards at levels substantially higher, for example, than those necessary to raise the industry-wide combined average to 35 mpg by MY 2015, or at the level at which total costs equal total benefits, and so forth.

NHTSA recognizes that seriousness of the global warming problem facing the nation and the world today, and that CAFE is one of many actions needed around the world to address that problem. NHTSA also recognizes that the higher CAFE standards are, the less they add to global warming and other environmental impacts (as demonstrated in our FEIS), just as the higher CAFE standards are, the less oil the United States must purchase from abroad, with the corresponding impacts on consumer costs, national balance of payments, and foreign policy objectives. The final standards push CAFE higher and faster than any set of standards since the earliest years of the program, and put the agency on track to meet EISA's MY 2020 requirement of an industry-wide combined average of at least 35 mpg several years ahead of time.

[417] The Ninth Circuit in *CBD* agreed that NHTSA has discretion to balance the factors in determining what level of stringency is maximum feasible. *CBD*, 538 F.3d 1172, 1197 (9th Cir. 2008).

However, NHTSA reiterates that it is required to consider the other three factors in addition to the need of the nation to conserve energy in determining the maximum feasible level of the standards. While considering the need of the nation to conserve energy alone might counsel for setting the standards at the levels suggested by proponents of higher standards, NHTSA does not believe that those standards would be consistent with economic practicability or technological feasibility.

Manufacturers commented that even standards set at the proposed levels would be above the maximum feasible level because, in their view, NHTSA had overestimated benefits and underestimated costs of the fuel-saving technologies. Conversely, many other commenters argued that the proposed standards were below the maximum feasible level because, in their view, NHTSA had underestimated benefits and overestimated costs of the technologies.

To respond to these commenters, and aid in resolving their conflicting views and arguments, NHTSA re-examined all of its technology assumptions, with the assistance of Ricardo, as described in Chapter IV. This effort resulted in the agency's revising the methodology underlying the making of many of its technology assumptions in ways that the agency believes makes its final rule analysis substantially more robust than its NPRM analysis. NHTSA is confident that its revised analysis ensures that the standards adopted in this final rule are technologically feasible. The effect of other motor vehicle standards of the Government on fuel economy is incorporated into the agency's analysis through the baseline and the manufacturers' product plans.

Yet the question of economic practicability and what level of stringency would cause manufacturers substantial economic hardship must be considered not only in terms of technological feasibility, but also in terms of the economic situation today and as it is anticipated to be in the period leading up to MYs 2011-2015 and in those years themselves. The current economic realities are markedly different from those at the time of the NPRM; just several months later, the national and global economies are in crisis and by all accounts heading into recession. As the economy contracts and consumers reassess their personal spending priorities manufacturers are less able to pass the costs of fuel economy-improving technologies on to consumers. As discussed above in the section on economic practicability, manufacturers have only so much ability to absorb those costs, especially given the financial difficulties of some of the larger manufacturers.

NHTSA additionally notes that the agency has the authority under 49 U.S.C. § 32902(c) to amend the standards for a model year to a level that the Secretary decides is the maximum feasible average fuel economy level for that model year. NHTSA has previously used this authority to lower the MY 1986 passenger car standards because they were deemed to be beyond maximum feasible. However, NHTSA believes that the authority to lower CAFE standards in MYs 2011-2020 has been constricted by the EISA requirements that standards increase annually and ratably and result in a combined fleetwide average fuel economy of at least 35 mpg in MY 2020. Thus, being unable to predict the economic situation in MYs 2011-2015, NHTSA is particularly mindful of economic practicability in establishing the current standards.

In balancing the EPCA factors against one another and carefully considering the environmental impacts associated with the various alternatives evaluated, NHTSA continues to believe that the proper overall balance of all relevant consideration is the point at which social net benefits are maximized, and results in CAFE standards that are the maximum feasible for MYs 2011-2015. As mentioned above, in identifying this point for each model year, NHTSA evaluated more than 100 alternative stringency levels, and for each one, calculated net benefits in a manner that explicitly accounted for the need of the nation to conserve energy, and for the benefits of reducing greenhouse gas emissions. EPCA's overarching purpose of energy conservation is met by setting standards at the maximum feasible level—EPCA does not require or even permit that standards be set *beyond* the maximum feasible level in order to achieve more energy conservation. NEPA's purpose is to integrate environmental considerations into that decision-making process. Setting standards at the point at which social net benefits are maximized in NHTSA's analysis results in standards that still increase higher and faster than any standards since the inception of the program, do not require the addition of technologies that the agency does not believe will pay for themselves, and result in measurable environmental benefits. The standards thus fulfill NEPA's objectives and, under EPCA, the need of the nation to conserve energy, while not imposing substantial economic hardship on the industry, while taking into account the feasibility of applying technologies appropriately and consistent with manufacturers' natural cycles, and the other motor vehicle standards of the government which manufacturers have to comply with. NHTSA is exercising its discretion and informed judgment, based upon the entire record and including the FEIS, as to the precise levels of CAFE that are the maximum feasible for MY 2011-2015 passenger cars and light trucks, as mandated by 49 U.S.C. § 32902.

VIII. Safety

A. Background

Given its statutory mission, NHTSA considers safety in everything it does, and safety and fuel economy are our two primary program responsibilities, which must be carried out in an integrated way. To ignore likely safety consequences when exercising our fuel economy authority would be an abdication of NHTSA's vehicle safety mission. Thus, NHTSA has historically examined the safety consequences whenever we determine the "maximum feasible" level for CAFE standards. Reviewing courts have upheld NHTSA's actions in considering safety.[418] The relationship of safety to CAFE standards is so fundamental to understanding the attribute-based fuel economy standards, and an area that is raised by so many commenters, that it is worth reviewing the actions by NHTSA and others in this area.

The relationship of vehicle weight to safety has been a contentious issue for many years. However, the debate had consisted primarily of competing sound bites until around 1990. For instance, "The laws of physics cannot be repealed – in a crash, heavier vehicles experience lesser crash forces than lighter vehicles," would be the response to "Vehicles now are safer than they have ever been, fewer people are killed and injured on the roads, so any safety issues associated with lighter vehicles can be more than offset by more advanced safety technology." While both of these statements begin from premises that are supported by data, neither purports to be a serious or complete analysis of the available empirical data.

The absence of serious analysis did not arise from bad faith on the part of the competing views, but rather from the difficulty of isolating vehicle weight from other confounding factors (*e.g.*, driver factors, such as age and gender, other vehicle factors,

[418] *See, e.g.*, *Competitive Enterprise Institute v. NHTSA*, 901 F.2d 107, 120, n. 11 (DC Cir. 1990) ("NHTSA has always examined the safety consequences of the CAFE standards in its overall consideration of relevant factors since its earliest rulemaking under the CAFE program.").

such as engine size and wheelbase, and environmental factors, such as rural/urban). In addition, several vehicle factors were closely related, such as vehicle mass, wheelbase, track width, and structural integrity. (Historically, as vehicles got longer and wider, they also got heavier). The papers that were initially published addressing vehicle size and safety did not attempt to fully address all of these factors.

1. NHTSA's Early Studies

It was important for NHTSA to help move the debate forward with more serious analyses. After all, NHTSA must understand the relationship between vehicle factors and safety, both for establishing our safety standards and for establishing our CAFE standards. In July 1991, NHTSA published a study of the effects of passenger car downsizing during 1970-1982 titled *Effect of Car Size on Fatality and Injury Risk*. In this report, NHTSA concluded that changes in the size and weight composition of the new car fleet from 1970 to 1982 resulted in increases of nearly 2,000 deaths and 20,000 serious injuries per year over the number of deaths and serious injuries that would have occurred absent this downsizing.

Parties reviewing NHTSA's 1991 report identified a number of areas that could be improved. Suggestions included extending the analyses to include light trucks and vans, examining finer gradations to distinguish the relative impacts of weight reduction for the heavier cars from the lighter cars, analyzing all crash modes, and doing more to isolate the effects of vehicle mass from behavioral and environmental variables.

NHTSA agreed that these suggestions would make the study more useful as a tool for NHTSA decisions on safety and fuel economy standards. Accordingly, Dr. Charles Kahane of NHTSA developed a more comprehensive analytic model to encompass all light vehicles, and to allow a finer look at safety impacts in different segments of the light vehicle population. This study was NHTSA's first effort to estimate the effect of a 100-pound weight reduction in each of the important crash modes, and to do this separately for cars and light trucks. NHTSA recognized that the findings would be controversial, so the agency chose to have the draft report peer-reviewed by the National Academy of Sciences before publishing the document. The Academy published its review on June 12, 1996.[419] The report expressed concerns about the methods used in the analyses and concluded, in part, "the Committee finds itself unable to endorse the qualitative conclusions in the reports about projected highway fatalities and injuries because of large uncertainties associated with the results. . ." These reservations were principally concerned with the question of whether the NHTSA analyses had adequately controlled for confounding factors, such as driver age, gender, and aggressiveness.

Dr. Kahane responded at length to the committee report, and revised his report to address the committee recommendations. The revised report was published as a finished document in 1997,[420] with a new Appendix F titled "Summary and Response to TRB's Recommendations on the Draft Report."

In this 1997 report, NHTSA concluded that, calibrated from 1985-93 cars and light trucks involved in crashes in calendar years 1989-1993, there was little overall effect for a 100-pound weight reduction in light trucks and vans, because increased fatalities of truck occupants were offset by a reduction of fatalities in the vehicles that

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[419] Transportation Research Board, Letter Report – Committee to Review Federal Estimates of the Relationship of Vehicle Weight to Fatality and Injury Risk, Accession Number 00723787. *See* http://onlinepubs.trb.org/onlinepubs/reports/letrept.html (last accessed Nov. 11, 2008).

[420] Kahane, C. J., 1997. Relationships Between Vehicle Size and Fatality Risk in Model Year 1985-93 Passenger Cars and Light Trucks, NHTSA Technical Report, DOT HS 808 570. Springfield, VA: National Technical Information Services.

collided with the lighter trucks, whereas a 100-pound reduction in cars was associated with an increase of about 300 fatalities per year. Based on this analysis and subsequent activities, the safety consequences of weight reduction have been considered by NHTSA in deciding upon the appropriate stringency of each of the new safety and fuel economy requirements since that time.

Of course, Dr. Kahane's report did not end the public discussion of this issue. NHTSA followed its standard practice of publishing a notice announcing the report and inviting public comment on Dr. Kahane's report.[421] In addition to comments to NHTSA's docket, other papers analyzing the relationship of vehicle weight and safety were published. For instance, Dr. David L. Greene of the U.S. Department of Energy's Oak Ridge National Laboratory published a report titled *Why CAFE Worked* soon after Dr. Kahane's report was released.[422] In section 5.2 of this report, Dr. Greene's introductory paragraph reads as follows:

> *Vehicle weight significantly affects the safety of the vehicle's occupants. Enough credible work has been done on this subject that this assertion cannot be seriously questioned (citations omitted)*. On the other hand, the nature of the trade-off between vehicle mass and safety is often misunderstood, and the implications for fuel economy regulations are generally misinterpreted. *The relationship between fuel economy, mass, and public safety is complex, yet it is probably reasonable to conclude that reducing vehicle mass to improve fuel economy will require some trade-off with safety.* The rational person will realize that individuals, manufacturers, and governments are constantly making trade-offs between safety and cost, safety and other vehicle attributes, safety and convenience, etc. (citation omitted). *An essential feature of a rational economic consumer is the willingness to trade-off risk for money and, since fuel economy saves money, to trade-off safety for fuel economy.*

David L. Greene, 1997, *Why CAFE Worked*, ORNL/CP-94482, Oak Ridge National Laboratory, Oak Ridge, Tennessee, at 22 (Emphases added).

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[421] *See* 62 FR 34491 (June 26, 1997).
[422] Dr. Greene's report is available online at http://www.osti.gov/bridge/servlets/purl/625225-KPQDOu/webviewable/625225.pdf (last accessed October 28, 2008).

It is noteworthy that Dr. Greene's published work explicitly acknowledges the vehicle weight-safety trade-off documented by NHTSA's studies of the real world crash data. As to Dr. Greene's concerns that the trade-off will be misunderstood, NHTSA has been clear on this. NHTSA wants to ensure that the public, manufacturers, and governments are aware of the empirical data that demonstrate that there is a trade-off between vehicle mass and safety. For any of these parties to make informed decisions, they must understand this trade-off exists and the size of the trade-off should be quantified as accurately as possible, so it can be considered as part of the decision. Denying that a safety trade-off exists does not make the safety trade-off go away – it just ensures that whatever decision is made is not fully informed.

It is possible that some other government agencies might share Dr. Greene's views that a rational person must be willing to trade off safety for fuel economy. The responsible course of action in that case would be for the government agency to disclose to the public the safety trade-off it had made, and explain its reasons for making that choice. NHTSA, however, was never comfortable making such a trade-off. As a consequence, the CAFE standards set by NHTSA were not as high as they might have been had NHTSA been willing to trade safety for even greater fuel economy.[423]

2. The 2002 National Academy of Sciences Study

The next significant event in the vehicle weight and safety discussion began in October 2000, when the Department of Transportation's Appropriations Act for fiscal year 2001 was signed into law. That appropriations law included a provision directing DOT to fund a National Academy of Sciences (NAS) study on the effectiveness and

[423] This dilemma was addressed and resolved by the enactment of the Energy Independence and Security Act, which mandates attribute-based standards, as recommended in the 2002 report by the National Academy of Sciences.

impacts of CAFE standards. NAS released its final study in January 2002 (hereafter, the 2002 NAS Report).[424]

As part of a comprehensive look at the impacts of CAFE standards, it was necessary for the 2002 NAS Report to address the safety impacts of CAFE standards. In Chapter 2 of the study, NAS looked back at the safety impacts of past CAFE standards. To do this, the committee focused on the NHTSA analysis by Dr. Kahane. Since there are many published papers on this subject in the literature, the question must be asked, "Why did the National Academy of Sciences choose the NHTSA analyses out of all the published papers?" The NAS committee clearly and unequivocally answered this in its report, where it found that "NHTSA's fatality analyses are still the most complete available in that they accounted for all crash types in which vehicles might be involved, for all involved road users, and for changes in crash likelihood as well as crashworthiness."[425] The NAS committee went on to find that "The April 1997 NHTSA analyses allow the committee to reestimate the approximate effect of downsizing the fleet between the mid-1970s and 1993." In other words, a committee of the National Academy of Sciences found that NHTSA's analyses were the most thorough of all the published papers, and that NHTSA's analyses were sufficiently persuasive and rigorous to permit a reasonable estimate of the safety penalty associated with downsizing the fleet. In the committee's words:

> Thus, the majority of this committee believes that the evidence is clear that past downweighting and downsizing of the light-duty vehicle fleet, while resulting in significant fuel savings, has also resulted in a safety penalty. In 1993, it would appear that the safety penalty included between 1,300 and 2,600 motor vehicle

[424] *Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards* (NRC, 2002)
[425] *Id.*, at 27.

> crash deaths that would not have occurred had vehicles been as large and heavy as in 1976.[426].

While this look back is informative, the greater challenge is to use this understanding of the past to guide future actions. Again the NAS committee offered clear guidance in this regard. The NAS Report said:

> In summary, the majority of the committee finds that the downsizing and weight reduction that occurred in the late 1970s and early 1980s most likely produced between 1,300 and 2,600 crash fatalities and between 13,000 and 26,000 serious injuries in 1993. The proportion of these casualties attributable to CAFE standards is uncertain. It is not clear that significant weight reduction can be achieved in the future without some downsizing, and similar downsizing would be expected to produce similar results. Even if weight reduction occurred without any downsizing, casualties would be expected to increase. Thus, any increase in CAFE as currently structured could produce additional road casualties, unless it is specifically targeted at the largest, heaviest light trucks.
>
> For fuel economy regulations not to have an adverse impact on safety, they must be implemented using more fuel-efficient technology. Current CAFE requirements are neutral with regard to whether fuel economy is improved by increasing efficiency or by decreasing vehicle weight. One way to reduce the adverse impact on safety would be to establish fuel economy requirements as a function of vehicle attributes, particularly vehicle weight (see Chapter 5). …
>
> If an increase in fuel economy is effected by a system that encourages either downweighting or the production and sale of more small cars, some additional traffic fatalities would be expected. Without a thoughtful restructuring of the program, that would be the trade-off that must be made if CAFE standards are increased by any significant amount.[427]

This discussion by the NAS committee was the impetus for NHTSA to use its existing statutory authority to reform its light truck CAFE program. This involved moving away from the single flat standard for light trucks, because those standards' neutrality with regard to decreasing vehicle weight, in lieu of increasing efficiency to improve fuel economy, means they necessarily have a potential safety trade-off. In place of the single flat standard, NHTSA established an attribute-based standard that is a function of the vehicle's footprint. Under this attribute-based standard, the fuel economy target for a vehicle increases as the vehicle is downsized. As long as vehicle manufacturers have to

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[426] *Id.*, at 28.
[427] *Id.*, at 77.

expend the same levels of advanced technology for each footprint size, there is no incentive to change the vehicle to get a less-demanding fuel economy target. Thus, the necessary safety trade-off under the single flat standard system does not arise under an attribute-based system. That is not to suggest there are no safety consequences if vehicle mass is reduced – there are, as documented by NHTSA and explained by the National Academy of Sciences. However, a government program is not conferring an advantage to a manufacturer that makes those trade-offs. This is a key feature of the attribute-based fuel economy program NHTSA implemented for light trucks.

As Congress was developing the bill that ultimately became EISA, Congress considered NHTSA's reformed light truck CAFE program established under existing NHTSA authority in deciding what additional CAFE authority NHTSA should be given and what constraints should be put on that authority. Ultimately, Congress passed and the President signed EISA, which mandates that NHTSA establish an attribute-based CAFE system for cars and light trucks.

It must be noted that two of the 13 NAS committee members dissented on the safety issues.[428] The dissent acknowledges that, "Despite these limitations, Kahane's analysis is far and away the most comprehensive and thorough analysis" of the safety issue. The dissent's primary disagreement with the other 11 committee members centers on the large uncertainties associated with Dr. Kahane's analyses. The dissent acknowledges Dr. Kahane's efforts to quantify the safety penalty, but concludes that the number of factors in real world crashes is so large and the controls used by the analytical

[428] One of the two dissenters was Dr. David Greene, the author of the 1997 report *Why CAFE Worked*, discussed *supra*.

models introduce so much uncertainty that it is not possible to definitively make any statements about a safety penalty.[429]

It should also be noted that the majority of the committee responded to the dissent by saying:

> However, the committee does not agree that these concerns should prevent the use of NHTSA's careful analyses to provide some understanding of the likely effects of future improvements in fuel economy, if those improvements involve vehicle downsizing. The committee notes that many of the points raised in the dissent (for example, the dependence of the NHTSA results on specific estimates of age, sex, aggressive driving and urban vs. rural location) have been explicitly addressed in Kahane's response to the [NAS] review and were reflected in the final 1997 report. The estimated relationship between mass and safety were (sic) remarkably robust in response to changes in the estimated effects of these parameters. The committee also notes that the most recent NHTSA analyses yield results that are consistent with the agency's own prior estimates of the effect of vehicle downsizing (citations omitted) and with other studies of the likely effects of weight and size changes in the vehicle fleet (citation omitted). The consistency over time and methodology provides further evidence of the robustness of the adverse safety effects of vehicle size and weight reduction.[430]

In addition, the NAS Committee unanimously agreed that NHTSA should undertake additional research on the subject of fuel economy and safety, "including (but not limited to) a replication, using current field data, of its 1997 analysis of the relationship between vehicle size and fatality risk."[431] NHTSA concurred with this recommendation, and Dr. Kahane immediately undertook a replication of his 1997 study, using the additional field data that were now available.

3. NHTSA's Updated 2003 Study

In October 2003, Dr. Kahane published an updated study.[432] Dr. Kahane's update again used regression models to calibrate crash fatality rates per billion miles for model

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[429] 2002 NAS Report, at Appendix A.
[430] *Id.*, at 27-28.
[431] *Id.*, at 6.
[432] Charles J. Kahane, "Vehicle Weight, Fatality Risk, and Crash Compatibility of Model Year 1991-99 Passenger Cars and Light Trucks," DOT HS 809 662, October 2003. This report is available online at http://www.nhtsa.dot.gov/cars/rules/regrev/evaluate/pdf/809662.pdf (last accessed Oct. 28, 2008).

year 1991-1999 passenger cars, pickup trucks, SUVs, and vans during calendar years 1995-2000. These rates were calibrated separately by vehicle weight, vehicle type, driver age and gender, urban/rural and other vehicle, driver, and environmental factors. One major point of note is that, as the analyses get more sophisticated and able to differentiate the safety trade-off among different types of vehicles, each analysis NHTSA has ever conducted continues to show that there is a safety trade-off for the existing light vehicle fleet as vehicle mass is reduced.

After controlling for vehicle, driver and environmental factors, the new study found that:

- The association between vehicle weight and overall crash fatality rates in the heavier 1991-1999 light trucks and vans was not significant. Thus, there was no safety penalty for reducing weight in these vehicles.
- In the other three groups of 1991-1999 vehicles – the lighter light trucks and vans, the heavier cars, and especially the lighter cars – fatality rates increased as weights decreased.
    - Lighter light trucks and vans would have an increase of 234 fatalities per year per 100-pound weight reduction.
    - Heavier cars would have an increase of 216 fatalities per year per 100-pound weight reduction.
    - Lighter cars would have an increase of 597 fatalities per year per 100-pound weight reduction.
- There is a crossover weight, above which crash fatality rates increase for heavier light trucks and vans, because the added harm for other road users from the additional weight exceeds any benefits for the occupants of the vehicles.

> This occurs in the interval of 4,224 pounds to 6,121 pounds, with the most likely single point being 5,085 pounds. The fatality rate changes by less than ±1 percent per 100-pound weight increase over this range.

NHTSA had the draft report reviewed by Drs. James H. Hedlund, Adrian K. Lund, and Donald W. Reinfurt before publication. The review process is on record – the comments on the draft are available in Docket NHTSA-2003-16318-0004. Consistent with NHTSA's standard practice, we published Dr. Kahane's analysis and sought public comment on it.[433] Dr. Kahane then docketed a response to the public comments on November 9, 2004.[434] There were three principal criticisms of Dr. Kahane's updated study.

1) The analyses only considered the relationship of vehicle mass to fatality risk. It did not consider other attributes of vehicle size, such as track width and wheelbase. Dynamic Research Inc. (DRI) presented analyses that included all three of these variables, and its analysis indicated that mass was harmful (*i.e.*, reducing it would be positive for safety) while track width and wheelbase were beneficial. If true, this meant that weight reduction would benefit safety if track width and wheelbase were maintained.

Agency response: The DRI results were strongly biased as a consequence of including 2-door cars in the analysis. Two-door muscle and sports cars stand apart from all other groups of cars by having a short wheelbase relative to their weight. They also have by far the highest fatality rates of all cars, for reasons mostly related to the drivers.

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[433] *See* 68 FR 66153 (Nov. 5, 2003).
[434] Docket No. NHTSA-2003-16318-0016.

The regression analysis immediately identifies short wheelbase with high weight as a disastrous combination. Being a regression, it tells you that you can make any car safer, including 4-door cars, by increasing wheelbase and/or reducing weight. This bias is amplified by treating highly correlated size attributes as independent factors in the model.

To clarify this latter concern, NHTSA's analyses are calibrating the historical relationship of vehicle mass and fatality risk. In this type of analysis, "vehicle mass" incorporates not only the effects of vehicle mass *per se*, but also the effects of many other size attributes that are historically and/or causally related to mass, such as wheelbase, track width, and structural integrity. If historical relationships between mass and these other size attributes continue, future changes in mass will continue to be associated with similar changes in fatality risk. If the historical relationships change, one will be able to analyze the mass and size attributes independently, but it will take some years to get such data.

However, as a check of DRI's suggestion that mass was not as significant as track width and wheelbase, NHTSA ran both its 1997 and 2003 analyses of 4-door cars only with mass, track width, and wheelbase as separate variables. When we did this, we saw that mass continued to have a substantial effect, even independent of track width and wheelbase in all crash modes except rollovers. In fact, only curb weight had a consistent, significant effect in both the data sets used in Dr. Kahane's 1997 analyses and his 2003 analyses. This was publicly reported four years ago, in Dr. Kahane's November 2004 response to the comments on his 2003 analyses.

After considering the DRI submission, NHTSA made no change to the findings in its 2003 report.

2) Marc Ross, of the University of Michigan, and Tom Wenzel, of Lawrence Berkeley National Laboratory, commented that vehicle "quality" has a much stronger relationship with fatality risk than vehicle mass. They suggest that lighter cars have a higher fatality risk on average because they are usually the least expensive cars and, in many cases, the "poorest quality" cars. If true, weight reduction is fairly harmless, as long as the lighter cars are of the same "quality" as the heavier cars they replace.

Agency response: In their analyses, Ross and Wenzel did not adjust their rates for driver age and gender. Absent those adjustments, the analysis mingles the effects of what sort of people buy and drive the car with the intrinsic safety of the car, making its conclusions about the intrinsic safety of the car suspect, at best. On average, and considering all crash modes as well as both weight groups of cars, controlling for price has little effect on the weight-safety coefficients in NHTSA's analyses. As a final check, NHTSA ran an analysis of head-on collisions of two 1991-99 cars, since this is a pure measure of the vehicle's performance. The results were that the more expensive vehicle's driver had a slightly *higher* fatality risk than the less expensive vehicle's driver, although the difference was not statistically significant. This indicates that the lower fatality rates for more expensive cars in Ross and Wenzel's study are not due to superior vehicle performance.

Accordingly, NHTSA made no changes to the findings in response to its 2003 report in response to the Ross and Wenzel comment.

3) The Alliance of Automobile Manufacturers, DaimlerChrysler, William E. Wecker Associates, and Environmental Defense all question the accuracy and

robustness of the report's calculation of a "crossover weight," above which weight reductions have a net benefit, instead of harm. NHTSA's report said that this crossover point occurs somewhere in the range of 4,224 pounds to 6,121 pounds (this is the "interval estimate"); with the most likely location of the crossover point at 5,085 pounds (this is the "point estimate"). Wecker suggested that NHTSA's interval estimate of from 4,224 to 6,121 pounds only takes sampling error into account. Wecker identified additional factors that make this estimate not robust, and suggests that the interval estimate should be wider. The Alliance and DaimlerChrysler suggested that the crossover weight could be substantially greater than 5,085 pounds, in which case weight reductions for light trucks and vans in the 5-6,000 pound range would have detrimental net effects on safety. Conversely, Environmental Defense believes the crossover weight is well below 5,085 pounds, in which case there would be opportunities to reduce vehicle mass in many light trucks and vans without any safety penalty.

Agency response: While NHTSA's report makes a point estimate for the crossover weight, the report expressly acknowledged the uncertainty about the exact location of the crossover weight. That is why the report highlighted the interval estimate, instead of the point estimate. It is important to note that the net weight-safety relationship remains close to zero for many hundreds of pounds above and below the point estimate for the crossover weight. As shown on pages 163-166 of Dr. Kahane's 2003 report, the crash fatality rate changes by less than ±1 percent per 100-pound weight increase over a 1,200 pound range on either side of the point estimate for the crossover weight. The data and analysis in the report will not show a statistically significant relationship, in either direction, between weight and safety for the heavier light trucks and vans. That is the important information the report puts in front of the decision maker – that the robust relationship between weight and safety that exists for most vehicles does not exist for the heavier light trucks and vans. With the available data, one cannot develop a precise point estimate for this crossover weight.

Thus, NHTSA did not change its report in response to these comments.

4. Summary of Studies Prior to this Rulemaking

Several important observations can be made based on the various studies performed in the years preceding this rulemaking on the relationship between safety and vehicle weight in the context of fuel economy:

1. The question of the effect of weight on vehicle safety is a complex question that poses serious analytic challenges. The issue has been addressed in the literature for more than two decades.
2. NHTSA has been actively engaged in this discussion.
3. All of NHTSA's analyses have found that there is a strong correlation between vehicle mass and vehicle safety for cars and light trucks, up to a certain weight range.
    a. Given the historic fact that vehicles have been made primarily of steel, there are a number of other parameters that are highly correlated with vehicle mass. These factors include vehicle size (*e.g.*, track width and wheelbase).

   b. The precise weight point at which the safety penalty ends is difficult to pinpoint, because the fatality rate curve is so flat at that point. NHTSA can say with high confidence that the crossover point is in the range of 4,224 to 6,121 pounds. There is no reduced societal safety for reducing weight on vehicles that weigh more than this crossover point, because the reduced risk for other road users would exceed any reduced benefits for the occupants of the heavy vehicle.

4. The National Academy of Sciences has twice peer-reviewed NHTSA's work in this area. The 2002 NAS Report found that there was a safety penalty for reducing weight in all but the heaviest light trucks. The study stated that "the downsizing and weight reduction that occurred in the late 1970s and early 1980s most likely produced between 1,300 and 2,600 crash fatalities in 1993."
   a. Neither the Academy nor NHTSA is suggesting that all of the downsizing and weight reduction were a direct response to the CAFE standards. It is difficult to objectively quantify what amount of downsizing was a response to CAFE standards, and what was a response to other real or perceived market forces. However, the Academy stated that some of the downsizing was in response to CAFE standards.
   b. NHTSA does not accord the safety dissent, which represented the views of two of the 13 committee members, the same stature as the views expressed in the body of the report, which represents the views of 11 of the 13 committee members.

5. In response to the National Academy's unanimous 2002 recommendation, NHTSA updated its previous work on weight and safety in 2003 to reflect the most recent data. This update found that the trends were similar, and if anything the safety penalty was now higher for reducing weight in small cars. This update also found that there is a crossover weight, which occurs somewhere between 4,264 and 6,121 pounds, with a point estimate at 5,085 pounds, above which there is no safety penalty for reducing vehicle weight. This is because the added harm for other road users from the additional weight exceeds any benefits for the occupants of the vehicles. NHTSA embodied this finding in its CAFE rulemaking by restricting materials substitution in its development of stringency levels to vehicles over 5,000 pounds.
6. NHTSA published its update and asked for public comments on the updated document.
7. In response to the request for comments, NHTSA received two recent studies to review. After reviewing these studies, NHTSA concluded that both studies had inadvertently introduced significant biases in their analyses. NHTSA made public its review of these studies in November 2004.
    a. One of these studies was a 2002 study by DRI that purported to analyze mass, track width, and wheelbase as independent variables. DRI's 2002 paper indicated that reducing mass would be beneficial, while reducing track width and wheelbase would be harmful. If true, this meant that weight reduction would benefit safety if track width and wheelbase were maintained. NHTSA concluded that the DRI results were strongly biased

as a consequence of including 2-door cars in the analysis and explained why this was so.[435]

b. The other of these studies was a 2002 analysis by Ross and Wenzel that suggested that lighter cars have a higher fatality risk because they are the least expensive and, in many cases, the poorest quality cars. The implication of this analysis was that weight reduction is fairly harmless, as long as the lighter cars are of the same "quality" as the heavier cars they replace. NHTSA noted that the Ross and Wenzel analyses did not adjust for driver age and gender. Absent those adjustments, the analysis mingles the effects of what sort of people buy and drive the car with the intrinsic safety of the car, making its conclusions about the intrinsic safety of the car suspect, at best.

B. Response to Comments in this Rulemaking on Safety and Vehicle Weight

With this background, NHTSA will now address the comments it received on safety in response to its NPRM. First, however, it is important to understand how NHTSA has embodied the learning from the studies explained above in this final rule. The rule does not preclude manufacturers from reducing the weight of future vehicles. Instead, in calculating its stringency standards, NHTSA has not considered materials substitution as a methodology for improving fuel economy of vehicles of 5,000 pounds or less. NHTSA has done so based on available data in order not to encourage downsizing of vehicles in a way that would be likely to cause a significant number of deaths and

[435] As discussed below, DRI acknowledged this observation to be accurate and submitted a new 2005 analysis that excludes 2-door cars in response to NHTSA's suggestions.

injuries. At the same time, for vehicles above 5,000 pounds, where the data indicate no safety penalty is likely for reducing weight, NHTSA has considered materials substitution in its standard-setting analysis. The effect of this is to encourage weight reductions to improve fuel economy where doing so is not likely to endanger lives. We believe this careful drawing of a data-based line in our analysis is the best way to serve NHTSA's twin missions of safety and fuel economy.

As an overview, many commenters questioned the continuing validity of the 2002 NAS Report, the 2003 Kahane study, or both. NHTSA notes that both these reports were thoroughly peer-reviewed, something that cannot be said about many of the alternative sources to which we were referred. Having already gone through a more rigorous review gives a study enhanced credibility with NHTSA. This is not to say NHTSA will not review all studies on this subject of which we are aware; it is merely to note that those more recent studies will need to be very high quality to demonstrate that the 2002 NAS Report and the 2003 Kahane analyses are no longer valid.

1. Views of Other Government Agencies

We will begin by addressing the views of other government agencies on this subject. After our proposal was published and after the comment period had closed for the proposal, EPA published an Advance Notice of Proposed Rulemaking (ANPRM) on regulating greenhouse gas emissions under the Clean Air Act.[436] The ANPRM was accompanied by a Vehicle Technical Support Document – Mobile Source.[437] The Technical Support Document contains a discussion on pp. 15 -17 of the safety issues. EPA acknowledged the issue is complex, and noted that, on the one hand, the majority of

[436] 73 FR 44354 (July 30, 2008).
[437] Docket No. EPA-HQ-OAR-2008-0318-0084.

the NAS committee found there was a safety penalty, but on the other hand the dissent noted that there was uncertainty as to the size of the safety penalty. EPA noted that both the majority and the dissent qualified their statements, using words like "may" and "probably," so this "emphasizes the complexity and lack of consensus that typify these issues."

EPA also suggested that the issue is moot, because unlike in the 1970s:

- There are many advanced safety technologies available in 2008 that have little or no impact on fuel economy,[438] and
- Consumers today "place high value on vehicle attributes such as utility and occupant safety." Accordingly, EPA suggested that vehicle manufacturers would be unlikely to take the risk of marketing vehicles that consumers perceived to be less safe when the advanced safety technologies are readily available.

EPA concluded its discussion by saying that "Recent studies have also shown that many smaller vehicles have better overall societal safety performance than some larger vehicles," and referenced the 2002 Ross and Wenzel study that was submitted to NHTSA's docket as a comment on Dr. Kahane's 2003 study.

Agency response: EPA has assumed that vehicle makers will rely exclusively on advanced technologies rather than weight reduction to improve fuel economy. They cite no authority to demonstrate this, nor do they refer to any historical evidence to support it. The vehicle makers' decisions would presumably be based upon the level of fuel economy they had to achieve and the costs of the various strategies for achieving that level of fuel economy. To the extent that weight reduction can, for some vehicle models

[438] We understand EPA to be saying that there are safety technologies that do not change the weight of the vehicle. However, there is no express identification of the technologies to which they are referring.

and in certain redesigns, deliver the desired fuel economy for much lower costs, it is not clear why EPA believes this would not be chosen.

We also do not agree with EPA's implicit assumption that the NAS committee report is equivalent to the dissent. For one thing, the majority opinion is what is actually shown in the body of the report, while the dissent appears as Appendix A. One might say that both views were peer-reviewed by the NAS committee, and the dissent was rejected by 11 of the 13, while the committee view was approved by 11 of the 13 members, and peer-reviewed. In addition, it is surprising that Dr. Kahane's work in this area, which has been reviewed by the National Academy of Sciences in 1996 and 2002, and updated in 2003 in response to a request by the National Academy of Sciences is not mentioned anywhere in the EPA document. Instead, they cite the Ross and Wenzel study, which NHTSA publicly identified as having a fundamental flaw in 2004 – *i.e.*, that Ross and Wenzel did not control for driver age and gender.

NHTSA assumes that the superficial discussion of a subject that has so much literature publicly available reflects:

- the short time EPA had available to put together its technical support document,
- EPA's lack of involvement in the 20-year long analyses of this subject, and
- Perhaps the fact that its document was only an ANPRM, so the obvious superficiality in this area can be corrected if the rulemaking proceeds.

However, there is nothing in the EPA Vehicle Technical Support Document – Mobile Source that is persuasive with respect to the relationship between vehicle weight and safety.

CARB also commented on the relationship between vehicle weight and safety. CARB stated that the Kahane study "assumed that weight and size are completely correlated," and argued that NHTSA should have focused more closely on the DRI reports and other recent studies, which it said concluded that "safety is primarily a design issue, not a weight issue." CARB included with its comments an "expert report by David Greene," which it said concluded after reviewing the existing research that "there has been no relationship between fuel economy and traffic fatalities and that there should be none in the future."

CARB also commented that it believed that NHTSA was inconsistent by restricting materials substitution in its analysis to only vehicles over 5,000 pounds, but also stating in the NPRM that footprint-based standards would facilitate the use of lightweight materials that are not yet cost-effective, which could eventually improve both safety and fuel economy. CARB argued that "NHTSA should expand the applicability of weight reduction technologies to vehicles under 5,000 pounds," because weight reduction can be "a viable technology if accompanied by proper vehicle design to assure vehicle safety is not compromised."

Agency response: NHTSA has not and is not now claiming that weight and size are completely correlated. However, the available empirical data are derived from vehicles that are in use on the public roads, and weight and size are highly correlated in those vehicles, since they are all built primarily of steel. This is not to suggest that, for any given curb weight, there may not be some variations in the track widths and wheelbases of vehicle make-models at that curb weight. However, these variations are not random – they are nearly always correlated with the vehicle's market class or design group.

NHTSA agrees that, intuitively, substitution of strong, lightweight materials should be a less harmful way to downweight than reducing the size of the vehicle. However, there is not yet sufficient empirical evidence to conclude that material substitution is harmless, let alone beneficial to safety. NHTSA believes it will prove at least benign, but we do not regulate based on our unsubstantiated hopes and expectations. Instead, NHTSA will proceed cautiously until there is more convincing evidence that requiring investments by vehicle makers in greater fuel efficiency through use of lightweight materials will not have the unintended consequence of simultaneously reducing the safety protection afforded to the American people.

As for the DRI reports, NHTSA reviewed its 2002 report and publicly responded in 2004 that the DRI results were strongly biased as a result of including 2-door cars in the analysis. To DRI's credit, they reviewed their report and agreed that this flaw needed to be corrected. DRI submitted a new study which, they say, limited some of their analyses to 4-door cars excluding police cars. DRI further claimed that they could now mimic NHTSA's logistic regression approach for an analysis of model year 1991-98 4-door cars in calendar year 1995-1999 crashes. DRI claims that its new analysis still shows results directionally similar to its earlier work – increased risk for lower track width and wheelbase, reduced risk for lower mass – although DRI acknowledges that the wheelbase and mass effects are no longer statistically significant after removing the 2-door cars from the analysis.

NHTSA is puzzled by the updated DRI analysis. For example in MY 1991-1998, the average car weighing x + 100 pounds had a track width that was 0.34 inches larger and a wheelbase that was 1.01 inch longer. Thus, we could say that a "historical" 100-pound weight reduction would have been accompanied by a 0.34 inch track width reduction and a 1.01 inch wheelbase reduction. However, if one dissociates weight, track width, and wheelbase and treats them as independent parameters, DRI's logistic regression of model year 1991 – 1998 4-door cars excluding police cars attributes the following effects:

DRI – Parameter	**Effect on Fatalities**
Reduce mass by 100 pounds	379 <u>fewer</u> deaths
Reduce track width by 0.34 inches	1,000 more deaths
Reduce wheelbase by 1.01 inches	207 more deaths
Reduce mass by 100 lb., track by 0.34, and WB by 1.01 inches	828 more deaths

Now if we apply NHTSA's logistic regression analyses to NHTSA's database, exactly as described in the agency's response to comments on its 2003 report, except for limiting the data to model years 1991-98, instead of 1991-99, the results are not at all like DRI's. For NHTSA, mass still has the largest effect, exceeding track width, and it moves in the expected direction.

NHTSA – Parameter	**Effect on Fatalities**
Reduce mass by 100 pounds	485 <u>more</u> deaths
Reduce track width by 0.34 inches	334 more deaths
Reduce wheelbase by 1.01 inches	9 more deaths
Reduce mass by 100 lb., track by 0.34, and WB by 1.01 inches	828 more deaths

NHTSA obtains its estimates by adding the results from 12 individual logistic regressions: six types of crashes multiplied by two car-weight groups (less than 2,950 pounds; 2,950 pounds or more).[439] DRI has apparently not followed the same procedures, based on the widely differing results.

However, based on the evidence before us now, NHTSA is not persuaded by the DRI analysis. Even though NHTSA's analyses continue to attribute a much larger effect for mass than for track width or wheelbase in small cars, NHTSA has never said that mass *alone* is the single factor that increases or decreases fatality risk. There may not be a single factor, but rather it may be that mass and some of the other factors that are historically correlated with mass, such as wheelbase and track width, together are the factors. We can say that NHTSA's analyses do not corroborate the 2005 DRI analysis, suggesting that mass can be reduced without safety harm and perhaps with safety benefit.

We would like to note that we agree that it *would seem* the least harmful way to reduce mass would be from materials substitution, where one replaces a heavy material with a lighter one that delivers the same performance, or other designs that reduce mass while maintaining wheelbase and track width. However, we can not analyze data on that yet, because those changes have not happened to any substantial number of vehicles. We do know that mass has historically been correlated with wheelbase and track width, and that reductions in mass have also reduced those other factors. Until there is a more credible analysis than the 2005 DRI study that demonstrates that mass does not matter for safety, NHTSA concludes it should be guided by the decades' worth of studies suggesting that mass is the most important of the related factors.

[439] *See, e.g.,* Kahane (2003), Table 2 on P. xi

The report by Dr. David Greene that was submitted by CARB as part of its comments is a document submitted by Dr. Greene when he was an expert witness in a lawsuit.[440] Dr. Greene reiterates the arguments in his dissent to the 2002 NAS Report; to wit, mass alone should not have any safety effect except in crashes where two vehicles collide with each other. Therefore, all the empirical data showing higher fatality rates for lighter vehicles in single-vehicle crashes and elsewhere are due to something other than mass. Therefore, we may reduce mass without harming safety. To repeat, mass has been historically correlated with other factors, such as size and structural integrity. Unless we can determine precisely what the significant parameters are and demonstrate ways to reduce mass without affecting the significant parameters, NHTSA cannot simply ignore the empirical data showing higher fatality rates for lighter vehicles.

Dr. Greene's expert report refers to the Ross and Wenzel and DRI studies, which have been discussed at length above. Dr. Greene also refers to a study titled "The Effect of Fuel Economy on Automobile Safety: A Reexamination."[441] This report is a long-term (1966-2002) time-series analysis of the annual number of crash fatalities in the United States, the average fuel economy of the vehicles on the road that year, and some other factors such as the price of fuel, the national speed limit, population, and annual vehicle miles traveled. The conclusion is that national fatalities did not increase, in fact tended to decrease, from the early 1970s forward, while fuel economy improved. Therefore, fuel economy has not had an adverse effect on safety. Suffice it to say that this is an

[440] This is the same Dr. Greene who concluded in his 1997 report, cited above, that "it is probably reasonable to conclude that reducing vehicle mass to improve vehicle economy will require some trade-off with safety."
[441] Sanjana Ahmad and David L. Greene, 2005, "Effect of Fuel Economy on Automobile Safety: A Reexamination," *Transportation Research Record 1941*, Transportation Research Board of the National Academy of Sciences.

exceedingly “macro” level to examine the relationships between fuel economy and fatality risk. Long-term time-series analyses are unlikely to separate the effects of downsizing for the other demographic, economic, and technological trends that have had an impact on fatality rates over the period. For instance, seat belt use has risen from 14 percent to 82 percent, many life-saving safety features (*e.g.*, front and side airbags) have been added to vehicles, impaired driving is not as accepted, and so forth. It is general knowledge that traffic fatalities are now lower than 1970, primarily as a result of the major safety advances just mentioned. But the relevant question in the safety/fuel economy context is, “Would fatalities have been even lower if cars had not been downsized?” To analyze that relationship accurately, it would be necessary to compare the fatality risk of small and large vehicles, not just the trend in total fatalities, over this long period. As structured, this report is akin to saying, “Tobacco is harmless, because life expectancy in Europe today is significantly greater than it was in 1500, before the introduction of tobacco.”

With respect to CARB’s suggestion that NHTSA expand the applicability of weight reduction technologies to vehicles under 5,000 pounds, because weight reduction can be accompanied by proper vehicle design to assure vehicle safety is not compromised, the agency repeats its position that it may be possible to use materials substitution and other processes to reduce weight without reducing vehicle safety. However, there are no data or analyses that show this to be true today. NHTSA specifically does not find either the 2002 or 2005 DRI analyses to be demonstrative, since the former study was strongly biased by including 2-door cars and the latter study says it mimicked NHTSA’s database and NHTSA’s analysis method, but got results that are substantially different. Until NHTSA can see through sound data analysis, which is yet to be presented, that weight reduction can be accomplished without safety trade-offs, the agency will continue to set its CAFE standards at levels that do not encourage weight reduction in vehicles that weigh less than the safety crossover identified in Dr. Kahane's 2003 analyses. We recognize that this is more cautious than what California has requested, but we believe it is also more prudent than what California has requested.

We also note that the California CO_2 emissions standards for which California requested a waiver under the Clean Air Act sets up a program that uses the same "flat standards" approach for its standards that the 2002 NAS Report found gives rise to the safety concerns identified in that report. The consequences of this structure for the program have been identified by 2002 report: "If an increase in fuel economy is effected by a system that encourages either downweighting or the production and sale of more small cars, some additional traffic fatalities would be expected. Without a thoughtful restructuring of the program, that would be the trade-off that must be made if CAFE standards are increased by any significant amount."[442]

2. Comments from Other Parties

Several comments were received from parties other than government agencies on the weight-safety issue. NRDC argued that NHTSA should not have relied on only the Kahane study, because Wenzel and Ross had commented to NHTSA's 2005 light truck CAFE NPRM that "the relationship between car weight and safety is tenuous at best," and because Kahane himself stated that his study

> "does not claim that mass per se is the specific factor that increases or decreases fatality risk…" "In that sense, it is irrelevant whether mass, wheelbase, track width or some other attribute is the principal causal factor on fatality risk. If you

[442] 2002 NAS Report at 77.

> decrease mass, you will also tend to reduce wheelbase, track width and other dimensions of size."

NRDC stated that this may no longer be correct for future vehicle designs, and argued that NHTSA had recognized as much in the NPRM by stating that high-strength, light-weight materials may help manufacturers reduce vehicle weight without reducing size or safety. NRDC further argued that vehicle design, "which could in fact be enhanced with lightweight materials," is much more relevant to safety. Thus, NRDC concluded that NHTSA should apply material substitution to lighter vehicles in its analysis.

The comments received from Wenzel and Ross stand in direct contradiction to the 2002 NAS Report, which said, "Thus, the majority of this committee believes that the evidence is clear that past downweighting and downsizing of the light-duty vehicle fleet, while resulting in significant fuel savings, has also resulted in a safety penalty." The Wenzel and Ross comment was also based on their study, discussed earlier, which NHTSA said in 2004 is flawed, since it did not control for driver age and gender. Thus, the findings of Wenzel and Ross are not helpful since they mingle the effects of what sort of people buy and drive the car with the intrinsic safety of the car, making its conclusions about the intrinsic safety of the car suspect, at best.

NRDC is correct that Dr. Kahane and NHTSA have not claimed that mass alone is the single factor that is responsible for the safety factor, and that it may be demonstrated that weight can be removed without adversely affecting safety. However, as we said in response to the same point from CARB, when setting CAFE standards, NHTSA will continue to limit its consideration of weight reduction to vehicles over 5,000 pounds until there is a convincing demonstration that there is no safety penalty from removing weight from lighter vehicles.

Sierra Club *et al.* also commented that vehicle design is more important than weight to vehicle safety. This is the same point made by other commenters, and there are no analyses that demonstrate this proposition is true. Sierra Club also argued that NHTSA should not use the retrospective Kahane study to analyze future standards, because of the design improvements and because "[s]ubstitution of light weight, high strength materials such as low alloy steels and aluminum will decrease both primary and secondary vehicle weight while maintaining vehicle size and increasing crashworthiness." NHTSA believes that it would be irresponsible to set standards by ignoring the available data, based on the hope that a promising development will come to fruition. The available data indicate that there is a safety penalty for weight reductions in vehicles under a certain weight. When the assertions Sierra Club makes in its comments can be demonstrated to be true, NHTSA will reassess how its sets its fuel efficiency standards. However, that will occur in a subsequent CAFE rulemaking.

Sierra Club *et al.* also stated that "The industry's long history of consistent opposition to the CAFE law has relied on a flawed size/safety argument," which it suggested also affected Congress' action in establishing EISA. Sierra Club argued, however, that that argument was disproven by the fact that manufacturers can obviously build vehicles that "demonstrate size, safety, and fuel economy performance" such as the Prius or the hybrid Escape. Manufacturers continue to offer a full range of vehicles, and they strive to deliver safety, fuel economy, and value in all of their vehicles. However, the available data at the level of the entire fleet demonstrate that, below a certain weight range, there has been a safety penalty from downweighting vehicles. The introduction of new vehicle models does nothing to change that historical record and it is unknown how the new models will affect the fleet wide fatality risk in future years.

Sierra Club additionally repeated the oft-stated assertion that smaller cars continue to become safer as manufacturers "apply side airbags, design vehicles to better protect occupants, and utilize light weight materials that enhance safety." It is of course true that, with the advent of important safety features like side air bags and Electronic Stability Control, combined with higher levels of seat belt use, today's small vehicles should have a better safety record than those produced a decade ago. However, that is not really the question that is being considered in deciding on the safety penalty – the question is whether today's small vehicles have a safety penalty compared to today's vehicles that weigh 100 pounds more. Unless there are some safety technologies that are offered only on small cars, or that are more effective on small cars, the additional safety technologies will not affect the relative safety performance between vehicles with a 100-pound weight difference.

Sierra Club also argued that a study by the Center for Auto Safety and UCS "found that applying existing fuel-saving and safety technology to a conventional Ford Explorer would result in a 71 percent improvement in fuel economy and 2,900 fewer traffic fatalities if all SUVs met equivalent safety standards," while "At the same time, the redesigned vehicle resulted in greater consumer savings and lower global warming emissions as a result of the improved fuel economy."[443] The document generated by the Center for Auto Safety and UCS does not address the safety penalty as weight is reduced.

[443] Sierra Club *et al.* cited "Building a Better SUV: A Blueprint for Saving Lives, Money and Gasoline," by CAS and UCS. This 2003 pamphlet is accessible online at http://www.ucsusa.org/assets/documents/clean_vehicles/building_a_better_suv_web.pdf (last accessed October 28, 2008).

This document asserts that if several safety and fuel-savings technologies were used on a 2001 Ford Explorer, it would achieve greater fuel economy and have a better safety record. The safety and fuel savings benefits, along with the costs, are extrapolated from different sources. The paper does state that the redesign would reduce the test weight of the vehicle by 10 percent, to 4100 pounds (p. 10). However, the question of the safety consequences of reducing the vehicle mass by 400 pounds cannot be answered by any data, since the redesigned vehicle does not exist. As such, this document adds nothing to the available literature on the relationship of weight and safety in light trucks.

Sierra Club additionally cited studies on materials by the Aluminum Association's Auto and Light Truck Group, Automotive Composites Alliance, and World Autosteel as offering "evidence that proper application of weight saving materials from engine blocks to hoods and beyond provide opportunities for broader consideration of weight reduction." NHTSA understands that materials substitution is possible. The question here is whether weight reduction through materials substitution should be considered in establishing the CAFE standards. As explained previously, NHTSA is not considering weight reduction for vehicles below 5,000 pounds in this round of CAFE rulemaking, because there has been no demonstration that there would not be an adverse safety effect from doing so. In subsequent CAFE rulemakings, NHTSA will re-examine what has been demonstrated and decide whether its previous position should be adjusted. However, based on the data and analyses available now, NHTSA has decided not to consider weight reduction for vehicles below 5,000 pounds in setting the standards. Sierra Club specifically identified the Jaguar XJ as an "[a]luminum intensive vehicle" that "demonstrate[s] that properly designed lighter weight vehicles can excel at safety."

This is just a restatement of Sierra Club's prior comment that the Toyota Prius and the hybrid Ford Escape show there is no safety penalty, and NHTSA's response is the same as shown above. Sierra Club concluded that "Since vehicle safety is an important consideration in and of itself, NHTSA should use its legal authority to set tighter safety standards for the purpose of addressing important public safety considerations." This is an argument put forward with the best of intentions, but it is not really germane to the safety penalty issue. If all vehicles have new safety standard requirements, they would all have a somewhat reduced absolute fatality risk. However, the safety penalty arises relative to peer vehicles. Unless there is some safety standard that is most effective for small vehicles and less effective for larger vehicles, new safety standards will not affect the relative safety risk between larger and smaller vehicles.

The Aluminum Association also commented that vehicle safety is more tied to vehicle design (using aluminum) than to vehicle weight. The Aluminum Association suggested that the Kahane study is outdated, as it "was retrospective and looked at 1990-era vehicles," and not predictive of the future. The Aluminum Association argued that vehicles in the MY 2011-2015 time frame will be much safer, subject to increasing numbers of safety standards and new safety initiatives for rollover and compatibility, and subject also to attribute-based CAFE standards, which the NPRM had suggested would improve vehicle safety. The Aluminum Association argued that the vehicles evaluated in the Kahane study were not subject to these factors, and thus concluded that "the historical proposition that lighter vehicles must be smaller (and potentially less safe) is no longer valid." To repeat, NHTSA hopes that the views expressed in the Aluminum Association comments can be shown to be true from those 2011-2015 vehicles. However, until there is an analysis showing this to be true, NHTSA will not consider weight reductions for vehicles below 5,000 pounds, since the data show that there has been a safety penalty for those vehicles from weight reduction in the past. We acknowledge this is a cautious position, but we believe NHTSA, as the United States government agency with authority over both motor vehicle fuel economy and motor vehicle safety, has a special obligation to ensure that the fuel economy standards are established in ways that do not risk the safety of the American public.

C. Comments on Other Issues Related to Safety

1. Vehicle compatibility design issues

Other commenters addressed vehicle compatibility design specifically, rather than design overall. Public Citizen, Sierra Club *et al.*, and the Aluminum Association commented that NHTSA should consider vehicle safety and downweighting in terms of compatibility in multi-vehicle crashes, rather than in terms of individual vehicle weight. Public Citizen suggested that NHTSA's decision not to include downweighting for lighter vehicles was "inconsistent with its own research on incompatibility," and stated that because Senator Feinstein had attempted to include provisions in EISA requiring NHTSA to undertake rulemakings to improve vehicle compatibility but had not been successful, NHTSA should initiate such rulemaking on its own.

Compatibility is a safety concern that NHTSA has been investigating for some time now. Moreover, the commenters' point that any compatibility benefits should be weighed against any disbenefits associated with downweighting is logically correct. However, NHTSA research on compatibility has shown that compatibility is substantially influenced by factors other than mass, including vehicle geometry, stiffness, and crush space. While we do not know the precise effect of these factors, it is fair to say that simply downweighting heavier vehicles would *not* effectively address the compatibility issue. Thus, there are no currently available analyses that would allow NHTSA or anyone to quantify the compatibility benefits simply from weight reduction. In addition, NHTSA has taken action to address compatibility for existing vehicles. Beginning September 1, 2010, new requirements for head protection in side impact crashes will start being phased-in for all light vehicles sold in the United States. This will require a first-in-the-world pole test, and become the first side impact standard in the world to require that performance be assessed with both a mid-sized adult male and a small adult female. Even with the huge benefits of Electronic Stability Control factored into the analysis, NHTSA estimates this technology will save 1,029 lives each year once implemented on the fleet.[444] However, as explained above, these absolute benefits do not change the higher relative safety risk lighter vehicles have in collisions with heavier vehicles.

Sierra Club *et al.* commented that "the disparity in the weights of vehicles is much more important to occupant safety than the average weight of all vehicles sharing the road." Sierra Club stated that the disparity in vehicle weight among passenger cars has decreased since 1975, and that "[o]verall the passenger fleet has homogenized toward a 3,500 pound vehicle." Sierra Club then argued that relative upweighting with improvements in fuel economy among small cars have provided a net safety gain in the vehicle fleet, which would be even greater "but for the super-sizing of pickups and SUVs in this time frame." However, Sierra Club argued that "[t]he days of the supersized SUVs and pickups are over due to higher fuel prices," and that "[w]hen the next EPA

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[444] *Final Regulatory Impact Analysis, FMVSS 214 Amending Side Impact Dynamic Test Adding Oblique Pole Test*, Docket No. NHTSA-2007-29134-0004, Table V-A on p. V-2.

Trends Report comes out, the light duty truck fleet will have been homogenized to a safer, more fuel efficient fleet as was the passenger car fleet earlier, eliminating the more severe crashes." Sierra Club concluded that NHTSA should have accounted for the safety benefits of this mix shift in its analysis. No analysis or citations were provided to demonstrate the validity of these assertions, so NHTSA has not adjusted its proposal to reflect unsupported theories.

The Aluminum Association cited the DRI analysis with regard to vehicle compatibility, which it described as showing "that vehicle crash compatibility can be improved by providing increased crush space and better energy management; and with the size-based approach, if there was a 20% weight reduction across the vehicle size classes, heavier vehicles would shed significantly more weight than smaller vehicles, also improving fleet compatibility." As explained above, NHTSA does not find the DRI analyses compelling.

2. Whether manufacturers downweight in response to increased CAFE stringency

The Alliance, Subaru, Washington Legal Foundation, and the American Iron and Steel Institute suggested that the stringency of the standards, as measured by their rate of increase (particularly in the earlier years covered by the rulemaking), could encourage manufacturers to employ downweighting as a means of compliance, which could lead to adverse safety consequences. Thus, even though NHTSA did not include material substitution or downweighting for lighter vehicles in its analysis, commenters indicated that downweighting was nonetheless a likely response to the proposed standards.

The CAFE standards are now established as a continuous function varying according to the size of the vehicle's footprint. To the extent the vehicle manufacturers choose to downweight their vehicles by making them smaller, they are faced with a higher CAFE target. To the extent the function is not artificially constrained, it will require approximately equal amounts of additional technology for each point on the curve. For example, if an additional $200 worth of fuel savings technology have to be added to a vehicle to meet its fuel economy target, then downsizing it will still require at least $200 in additional fuel savings technology. In the latter case, the manufacturer would also have the cost of downsizing the model. Accordingly, NHTSA is confident that the attribute-based system does not bestow any benefits for downsizing a vehicle model.

The CAFE program is not intended to ensure that no vehicle maker ever downsizes a vehicle. If a vehicle maker decides to downsize a model, it would be because the manufacturer perceives that to be more effective, taking all factors into account, than other strategies for increasing fuel economy in that model. NHTSA does not want to constrain that choice – we just want to be sure that an equivalent level of fuel-saving technology will be used on the redesigned vehicle.

We understand that this leaves open the possibility that manufacturers could reduce the vehicle weight, but keep the vehicle size constant. The obvious way to do this would be through materials substitution, where one replaces a heavy material with a lighter one that delivers the same performance. NHTSA is intentionally not discouraging materials substitution, because we agree that this approach is conceptually appealing. Although there are no data yet to show this can minimize or perhaps eliminate the safety penalty, NHTSA does not believe there is reason to structure its CAFE program to discourage such choices. If manufacturers choose to do this to meet the MY 2011-2015 standards, we will consider that data in deciding how to deal with the safety penalty in subsequent fuel economy rulemakings.

Public Citizen argued, in contrast, that downweighting of lighter vehicles is not a common compliance strategy, and that manufacturers had primarily responded to NHTSA's earliest CAFE standards in the 1980s by applying technologies, with "only 15 percent came from weight reductions, and then weight was only removed from the heaviest vehicles." NHTSA notes that the 1992 study cited by Public Citizen concerning manufacturers' reactions to the early 1980s passenger car standards is now 16 years old. Since that date, the 2002 NAS Report concluded a decade later that some of the downsizing and downweighting that occurred between the late 1970s and 1993 was due to CAFE standards and that "the evidence is clear that past downweighting and downsizing of the light-duty vehicle fleet, while resulting in significant fuel savings, has also resulted in a safety penalty. In 1993, it would appear that the safety penalty included between 1,300 and 2,600 motor vehicle crash deaths that would not have occurred had vehicles been as large and heavy as in 1976." We find the NAS report more persuasive than the 1992 study cited by Public Citizen.

Public Citizen went on to suggest that NHTSA was "reinforc[ing] the common myth that fuel economy standards reduce vehicle safety by promoting downweighting." Again NHTSA notes that Public Citizen provides no evidence to support its view that this is a "myth." It is worth noting that the NAS 2002 report is also reinforcing that "myth."

3. Whether flat standards are more or less harmful to safety than footprint-based standards

The Alliance, the Aluminum Association, and the Washington Legal Foundation agreed with the agency's assessment that a footprint-based standard is safer than a flat standard. Public Citizen, in contrast, suggested that under the flat standards of the 1980s, manufacturers primarily responded by applying additional technologies, and only reduced weight from the heaviest vehicles, which would suggest no safety risk from downweighting due to flat standards.

Public Citizen's repeated citations of a 1992 study do not make it any more relevant. A decade after that study, a NAS panel found that manufacturers downweighted and downsized the fleet, partly in response to the CAFE standards. This directly contradicts the 1992 study cited by Public Citizen. As of 2008, the National Academy of Sciences has published a seminal report declaring that there is a safety concern with flat standards. The fact that two of the 13 members dissented does not diminish one whit the import of that. Informed by this conclusion, the Congress of the United States passed and the President of the United States signed a law that prohibits NHTSA from establishing flat CAFE standards, except for the required minimum standard for domestic passenger cars. With the passage of this law, the debate is over and Federal fuel economy regulations will be attribute-based, not flat standards, unless the law is changed.

4. Whether NHTSA should set identical targets for passenger cars and light trucks for safety reasons

Public Citizen suggested that the fact that fuel economy targets may be different for identical-footprint cars and light trucks encourages manufacturers to build a vehicle as a truck instead of as a car, and argued that NHTSA should change the regulatory definitions of passenger cars and light trucks to improve safety. Public Citizen also argued that the attribute-based CAFE standards "eliminate[] the leveling effect of the corporate average (that is, balancing lighter vehicles against heavier ones)."

Regardless of the merits of Public Citizen's comment, the law specifies that NHTSA must establish separate standards for cars and light trucks. The agency believes that this requirement also mandates that the agency consider the capabilities of the car and light truck fleets separately. The standards for the light truck fleet (and thus the footprint/mpg targets for that fleet) tend to be lower than those of the passenger car fleet because light trucks simply do not have the capability to reach standards as high as the passenger car standards. NHTSA does not believe it could establish identical separate standards, because identical standards would not be "maximum feasible" for both cars and light trucks. NHTSA has addressed the regulatory definitions for passenger cars and light trucks in Section IX. We believe we have made appropriate changes.

5. Whether NHTSA should have considered the 2002 NAS Report dissent in deciding not to apply material substitution for vehicles under 5,000 pounds

CBD stated that NHTSA had "misrepresented" the findings of the 2002 NAS Report by stating only the conclusion of the majority and not additionally stating the finding of two dissenting members "that weight reduction for vehicles greater than 4,000 lbs. curb weight would result in a safety benefit, as was discussed in detail in the recent

Ninth Circuit opinion." Public Citizen also referred to the NAS dissent in arguing that "Kahane's study oversimplifies the relationship between weight and safety, obfuscates findings which show that reducing weight from only the heaviest vehicles actually improves safety, and overlooks the relationship between the difference in vehicle weight, rather than simply the weight of the vehicle." Sierra Club *et al.* also referred to the NAS dissent in stating that "According to K.G. Duleep, who served as a consultant to the NAS Committee, had the NAS incorporated appropriate weight reductions into the ranges of possible fuel economy improvements, in addition to the NAS report's mostly drive train improvements, its total fuel economy recommendations would have been 20% higher."

The reason NHTSA does not accord the same significance to the dissent as to the majority is explained at length above. Essentially, when 11 members of a committee support a position and present it in the body of the report, that is given more weight than the opinion of two members that appears in an appendix to the report. NHTSA believes that the information in the report is the information that is put out with the full imprimatur of the National Academy committee. For this reason, we accord it greater significance than the Appendix to the report.

D. NHTSA Has Rationally Considered Safety Issues in Setting Fuel Efficiency Standards

NHTSA has explained here why and how it has considered the likely safety effect of the fuel efficiency standards in this final rule. We believe our dual statutory missions to set both safety and fuel efficiency standards can and must be implemented in an integrated and harmonious manner. As vital as improved fuel efficiency standards are to saving fuel and reducing carbon dioxide emissions, the lives of those who operate and ride in the nation's motor vehicles is equally important. We believe we have found a rational way of accommodating both important interests by relying on available data to determine the point at which weight reductions in vehicles will likely have an untenable safety impact. Below that point, our stringency levels do not encourage weight reduction, but certainly require substantial improvements in fuel efficiency. Above that point, our standards validate weight reduction as a methodology to improve fuel economy because data indicate any effect on the safety of occupants of those vehicles would be less than the safety benefits to other road users. While others are welcome to disagree with this approach, we believe it is soundly based on current knowledge and that it best serves the safety and fuel economy interests of the American public.

IX. The final fuel economy standards for MYs 2011-2015

For both passenger cars and light trucks, the agency is determining final CAFE standards estimated, as for the previously-promulgated reformed MY 2008-2011 light truck standards, to maximize net benefits to society. Before setting these final standards the agency also considered under NEPA the environmental impacts of these standards, as detailed in the FEIS.

A. Final passenger car standards

We have determined that the final standards for MY 2011-2015 passenger cars result in required fuel economy levels that are technologically feasible, economically practicable, and set by taking into account the effect of other motor vehicle standards of the Government on fuel economy, the need of the United States to conserve energy, and additional environmental considerations under NEPA. Values for the parameters defining the target functions for these final standards for cars are as follows:

Parameter	Model Year				
	2011	2012	2013	2014	2015
A	31.20	33.30	35.80	36.80	38.70
B	24.00	25.20	26.60	27.20	28.20
C	51.41	51.41	51.41	51.41	51.41
D	1.91	1.91	1.91	1.91	1.91

Where, per the adjusted continuous function formula above in Section VI:

: *a* = the maximum fuel economy target (in mpg)

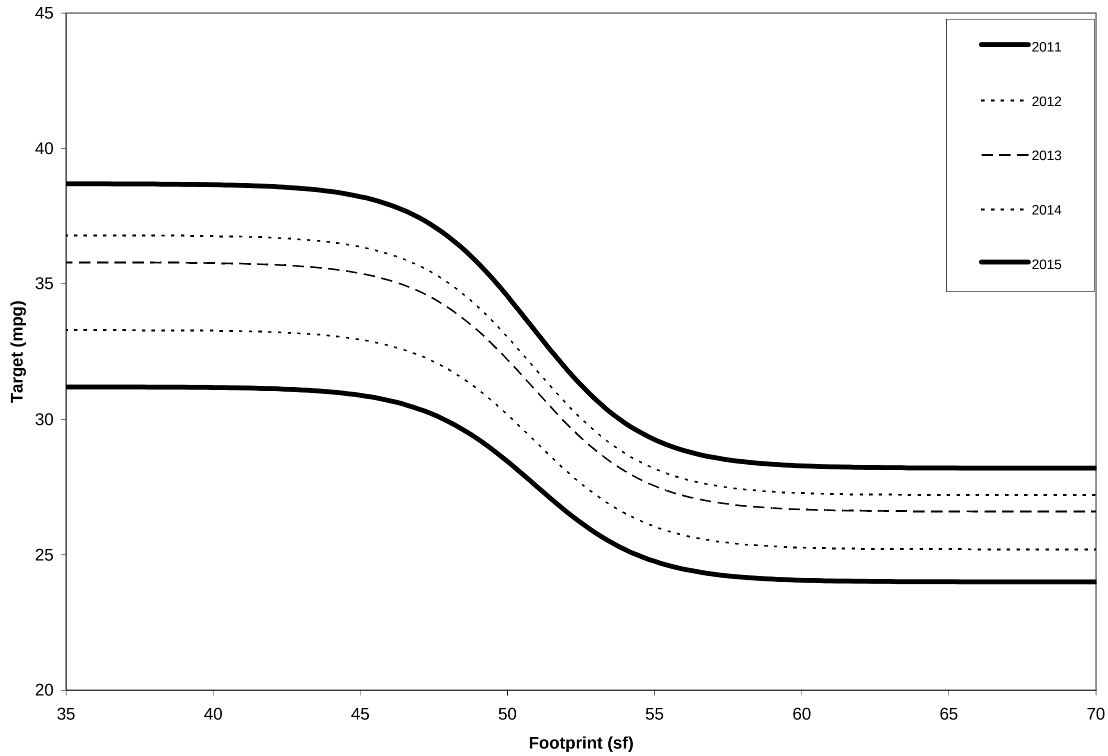
b = the minimum fuel economy target (in mpg)

c = the footprint value (in square feet) at which the fuel economy target is midway between *a* and *b*

d = the parameter (in square feet) defining the rate at which the value of targets decline from the largest to smallest values

The resultant target functions have the following shapes:

Figure IX-1. Passenger Car Curve Target Functions



Based on the product plan information provided by manufacturers in response to the May 2008 request for information and the incorporation of publicly available supplemental data and information, NHTSA has estimated the required average fuel economy levels under the final standards for MYs 2011-2015 passenger cars as follows:

Table IX-1. Required CAFE Levels (mpg) for Passenger Cars

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	30.2	32.2	34.5	35.5	37.2
Chrysler	28.6	29.9	32.6	33.6	35.2
Daimler	28.9	30.7	32.8	33.7	35.3
Ferrari	30.7	32.8	35.2	36.1	38.0
Ford	30.1	32.3	34.2	35.3	37.0
General Motors	30.0	31.8	33.9	34.8	36.5
Honda	30.6	32.6	35.0	35.9	37.8
Hyundai	30.3	32.3	34.6	35.5	37.2
Maserati	27.4	29.0	30.9	31.7	33.1
Mitsubishi	30.9	33.0	35.5	36.4	38.3
Nissan	30.5	32.5	34.9	35.9	37.7
Porsche	31.2	33.3	35.8	36.8	38.7
Subaru	30.9	33.0	35.4	36.4	38.3
Suzuki	31.0	33.0	35.5	36.5	38.3
Tata	27.5	29.1	30.9	31.8	33.0
Toyota	30.6	32.6	35.0	36.0	37.8
Volkswagen	30.9	32.9	35.4	36.3	38.2
Total/Average	30.2	32.1	34.4	35.4	37.1

B. Final light truck standards

NHTSA is also finalizing light truck fuel economy standards for MYs 2011-2015. In taking a fresh look at what truck standard should be established for MY 2011, as required by EISA, NHTSA used the newer set of assumptions that it had developed for the final standards. These assumptions differ from those used by the agency in setting the final MY 2011-2015 passenger car and light truck standards. The agency used the EIA High Price Case projections for available gasoline prices, which are on average approximately $0.40 per gallon higher than the projections used in the NPRM. Other differences in assumptions include more current product plan information, an updated technology list and updated costs and effectiveness estimates and penetration rates for technologies, and updated values for externalities such as carbon dioxide emission reductions.

The final standards are “optimized” for MY 2011-2015 light trucks, the process for establishing them is described at length above, but which may be briefly described as maximizing net social benefits plus anti-backsliding measures. We have determined that the final light truck standards for MYs 2011-2015 represent the maximum feasible fuel economy level for that approach. In reaching this conclusion, we have balanced the express statutory factors and other relevant considerations, such as safety and effects on employment, and have considered the NEPA analysis and conclusions in the FEIS with regard to the chosen agency action.

The final standards are determined by a continuous function specifying fuel economy targets applicable at different vehicle footprint sizes, the equation for which is given above in Section VI. Values for the parameters defining the target functions defining these final standards for light trucks are as follows:

Parameter	Model Year				
	2011	2012	2013	2014	2015
A	27.10	28.10	29.50	30.30	30.50
B	21.10	21.70	22.60	23.00	23.20
C	56.41	56.41	56.41	56.41	56.41
D	4.28	4.28	4.28	4.28	4.28

Where: a = the maximum fuel economy target (in mpg)

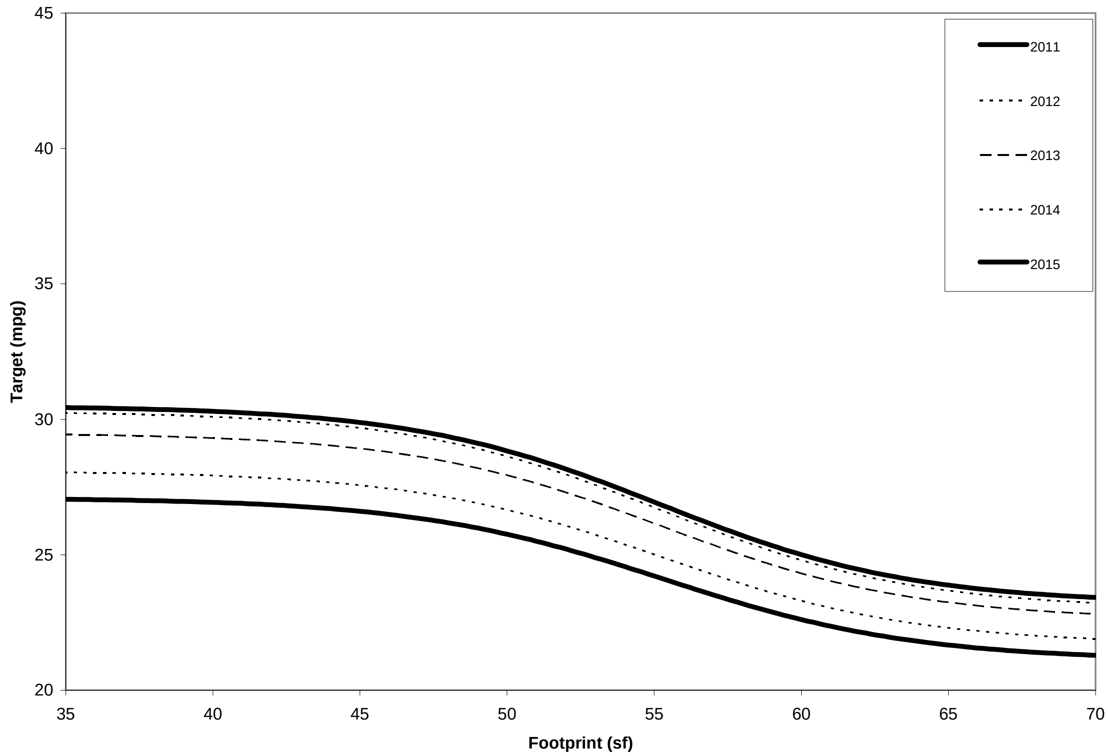
b = the minimum fuel economy target (in mpg)

c = the footprint value (in square feet) at which the fuel economy target is midway between a and b

d = the parameter (in square feet) defining the rate at which the value of targets decline from the largest to smallest values

The resultant target functions have the following shapes:

Figure IX-2. Light Truck Curve Target Functions



Based on the product plans provided by manufacturers in response to the May 2008 request for information and the incorporation of publicly available supplemental data and information, the agency has estimated the required average fuel economy levels under the final optimized standards for MYs 2011-2015 as follows:

Table IX-2. Required CAFE Levels (mpg) for Light Trucks

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	25.7	26.6	27.8	28.5	28.7
Chrysler	24.2	24.9	26.0	26.8	27.2
Daimler	24.5	25.3	26.5	27.1	27.3
Ford	23.6	24.8	25.5	26.0	26.6
General Motors	23.3	24.4	25.6	26.1	26.3
Honda	25.4	26.3	27.5	28.2	28.4
Hyundai	25.3	25.9	27.0	27.3	27.8
Mitsubishi	26.7	27.5	28.9	29.6	29.8
Nissan	24.0	24.9	26.1	26.6	26.8
Porsche	25.5	26.4	27.6	28.3	28.5
Subaru	26.6	27.6	28.9	29.7	29.9
Suzuki	26.4	27.3	28.6	29.4	29.6
Tata	26.1	26.9	28.2	28.9	29.1
Toyota	24.8	25.5	26.6	27.4	27.6
Volkswagen	24.9	25.8	27.0	27.6	27.8
Total/Average	24.1	25.1	26.1	26.7	27.1

We note that a manufacturer's required fuel economy level for a model year under the final standards would be based on its actual production numbers in that model year. Therefore, its official required fuel economy level would not be known until the end of that model year. However, because the targets for each vehicle footprint would be established in advance of the model year, a manufacturer should be able to estimate its required level accurately.

C. Energy and Environmental Backstop

As discussed in the NPRM, EISA requires each manufacturer to meet a minimum fuel economy standard for domestically manufactured passenger cars in addition to meeting the standards set by NHTSA. The minimum standard "shall be the greater of (A) 27.5 miles per gallon; or (B) 92 percent of the average fuel economy projected by the Secretary for the combined domestic and non-domestic passenger automobile fleets manufactured for sale in the United States by all manufacturers in the model year…."[445]

[445] 49 U.S.C. § 32902(b)(4).

The agency must publish the projected minimum standards in the Federal Register when the passenger car standards for the model year in question are promulgated.

NHTSA calculated 92 percent of the final projected passenger car standards as the minimum standard, which is presented below. The final calculated minimum standards will be updated to reflect any changes in the projected passenger car standards.

Model year	Minimum Standard
2011…………………………………...	27.8
2012…………………………………...	29.5
2013…………………………………...	31.6
2014…………………………………...	32.6
2015…………………………………...	34.1

The agency would like to note that EISA requires the minimum domestic passenger car standard to be the *greater of* 27.5 mpg or the calculated 92 percent, the calculated minimum standard. In all five model years, the percentage-based value exceeded 27.5 mpg. We also note that the minimum standards apply only to *domestically manufactured* passenger cars, not to non-domestically manufactured passenger cars or to light trucks.

In *CBD*, the Ninth Circuit agreed with the agency that EPCA, as it was then written, did not explicitly require the adoption of a backstop, *i.e.*, a minimum CAFE standard that is fixed. A fixed minimum standard is one that does not change in response to changes in a manufacturer's vehicle mix.

The Court said, however, that the issue was not whether the adoption was expressly required, but whether it was arbitrary and capricious for the agency to decline to adopt a backstop. The Court said that Congress was silent in EPCA on this issue. The Court concluded that it was arbitrary and capricious for the agency to decline to adopt a backstop because it did not, in the view of the Court, address the statutory factors for determining the maximum feasible level of average fuel economy.

NHTSA explained in the NPRM that it believes that it considered and discussed the express statutory factors such as technological feasibility and economic practicability and related factors such as safety in deciding not to adopt a backstop. The agency stated that further discussion is not warranted because Congress has spoken directly on this issue since the 9th Circuit's decision by enacting EISA. Congress expressly mandated that CAFE standards for automobiles be attribute-based and they must adjust in response to changes in vehicle mix. This mandate precludes the agency from adopting a fixed minimum standard, except in the one case in which Congress mandated a fixed and flat[446] minimum standard for domestic passenger cars—not in the cases of nondomestic passenger cars or light trucks.

Given the clarity of the requirement for attribute-based standards and the equally clear narrow exception to that requirement, NHTSA concluded that had Congress intended backstops to be established for either of the other two compliance categories, it would have required them. Absent explicit statutory language that provides the agency authority to set flat standards, the agency explained that the setting of a supplementary minimum flat standard for the other two compliance categories would be contrary to the requirement to set an attribute-based standard under EISA.

The agency noted, however, that the curve of an attribute-based standard has several features that limit backsliding, some of which NHTSA added as it refined the Volpe model for the purpose of this rulemaking, and some of which (such as the lower asymptote, which serves as a backstop) are inherent in the logistic function. NHTSA

[446] A flat standard is one that requires each manufacturer to achieve the same numerical level of CAFE.

stated that it believed that these features help address the concern that has been expressed regarding the possibility of vehicle upsizing without compromising the benefits of reform. NHTSA also noted that the 35 mpg requirement in and of itself serves as a backstop, because the agency must set the standards high enough to ensure that the average fuel economy level of the combined car and light fleet is making steady progress toward and achieves the statutory requirement of at least 35 mpg by 2020. NHTSA explained that if the agency finds that this requirement might not be achieved, it will consider setting standards for model years 2016 through 2020 early enough and in any event high enough to ensure reaching the 35 mpg requirement.

The Attorneys General, Sierra Club *et al.*, UCS, and ACEEE opposed NHTSA's decision not to adopt a backstop for imported passenger cars and light trucks and argued that the agency must adopt backstop standards, while AIAM and NADA supported the agency's decision. The Attorneys General argued that because Congress had not changed the definition of "maximum feasible fuel economy," NHTSA remained "obligated" by the Ninth Circuit opinion to consider a backstop for those additional fleets. The Attorneys General stated that the possibility that attribute-based standards "will cause a 'race to the bottom'" still existed, and that the agency must therefore consider a backstop.

Sierra Club *et al.* also argued that NHTSA had misinterpreted Congress' intent in EISA. Sierra Club stated that Congressman Markey's extended remarks inserted into the Congressional Record was clear evidence of Congress' intent with regard to the backstop. Sierra Club also argued that a September 2007 letter from the United Auto Workers to Speaker Nancy Pelosi and Majority Leader Harry Reid, which suggested that the domestic minimum passenger car standard was intended to protect jobs in the U.S., was evidence that "the provision in EISA is tied to employment, not oil conservation." Sierra Club concluded that NHTSA is not precluded from adopting backstop standards for imported passenger cars and light trucks, and is required to do so by the Ninth Circuit opinion. Sierra Club additionally cited EPA's ANPRM, which it stated indicates that EPA will pursue an "environmental backstop."

UCS agreed that the 35-in-2020 requirement is a kind of backstop, and that the ratable-increase requirement between MY 2011 and 2020 is an "implied" backstop, but nevertheless argued that NHTSA should implement a regulated backstop for the other fleets. UCS commented that "the same concerns of the Ninth Circuit court persist," because "there is no mechanism to ensure the market does not undermine [the proposed] standards." UCS stated that this could occur because "if maximum feasible fuel economy levels are found to exceed 35 mpg, the legislated minimum will not ensure those levels (and, thus, maximum feasible energy savings) are achieved."

ACEEE commented that the lower asymptote is not an adequate backstop, because the lower asymptote in 2015 resulted in "a combined value of 27.5 mpg, assuming a 48% sales share for cars," which ACEEE said "is scarcely higher than today's combined standard and certainly does not constitute ratable progress toward achieving 35 mpg in 2020." ACEEE argued that the lower asymptotes could not guarantee that "oil savings from the CAFE program will not fall short of the savings anticipated with the passage of the law." ACEEE stated that to ensure ratable progress toward an average of at least 35 mpg in 2020 and to mitigate "the dangers of upsizing and otherwise gaming the standards," NHTSA should commit to "mid-course corrections" between MY 2011 and 2020 as necessary.

In contrast, AIAM supported NHTSA's decision not to adopt a backstop for imported passenger cars and light trucks. AIAM argued that a backstop for those fleets would "defeat the purpose of the attribute format by limiting the flexibility of manufacturers to respond to shifts in market demand," and that the lower asymptote "provides a disincentive to upsizing of vehicles [in that footprint range], since the standard would become increasingly difficult to meet." AIAM also suggested that a backstop would not likely increase fuel savings since consumers appear to be moving away from large cars and trucks.

While NADA agreed with NHTSA regarding the clarity of Congress' decision not to adopt backstops, it also argued that NHTSA "should not attempt to artificially create backstops" through the lower asymptotes of the car and light truck curves. NADA stated that NHTSA should instead "let the curves end in conformance with the largest vehicle's footprint."

NHTSA respectfully disagrees with the characterization raised by the Attorneys General and other commenters that it "did not consider" a backstop in the NPRM. As made clear by the NPRM and as discussed above, the opposite is true. The agency also respectfully disagrees with UCS' characterization of the Ninth Circuit *CBD* opinion as it concerns the backstop issue. As NHTSA explained in the NPRM, Congress' enactment of EISA resolved the backstop issue by clearly specifying a flat minimum standard for domestic passenger cars, and requiring that all other CAFE standards be attribute-based. Congress could have but did not enact a backstop for imported passenger cars and light trucks; it was obviously aware of this issue from the 2006 light truck final rule and the *CBD* decision, but did not act.

NHTSA also respectfully disagrees with the commenters' characterization of EISA's legislative history with regard to the backstop issue. No Senate, House, or conference reports were created during the legislative process that culminated in EISA. The floor statements during Congressional consideration of EISA are also sparse. In any event, however, floor statements, regardless of who made them, are entitled to less weight than conference reports because, in the views of many courts, they do not represent statements on the final terms of a bill agreed to by both houses. *See, e.g.*, *In re Burns*, 887 F.2d 1541 (11th Cir. 1989), in which the Court of Appeals was called upon to interpret provisions of the Bankruptcy Act which were arguably ambiguous. The Court noted that "[w]hatever degree of solicitude is due to legislative history materials in the usual cast, '[s]trict adherence to the language and structure of the Act is particularly appropriate where, as here, a statute is the result of a series of carefully crafted compromises.'" *Id.* at 1545 (citing *Community for Creative Non-Violence v. Reid*, 490 U.S. 730, n. 14 (1989)). "Accordingly, the best indicators of congressional intent in this narrow instance are the language and structure of the Code itself, not the accompanying statements of legislators that carry the potential for reclaiming that which was yielded in the actual drafting compromise." *Id*. *See also In re Kelly*, 841 F.2d 908, 913 n. 3 (9th Cir. 1988) ("Stray comments by individual legislators, not otherwise supported by statutory language or committee reports, cannot be attributed to the fully body that voted on the bill. The opposite inference is far more likely.")

Various members, including Representative Markey, also inserted material into the *Congressional Record* after floor action. There is no indication that the material inserted into the record was raised, debated, or otherwise before the full House or Senate during floor consideration. Materials inserted by members after congressional action are not indicative of congressional intent. Instead, "[t]he intent of Congress as a whole is more apparent from the words of the statute itself than from a patchwork record of statements inserted by individual legislators and proposals that may never have been adopted by a committee, much less an entire legislative body – a truth which gives rise to 'the strong presumption that Congress expresses its intent through the language it chooses.'" *Sigmon Coal Co., Inc. v. Apfel*, 226 F.3d 291, 304-05 (4th Cir 2000) (quoting *INS v. Cardoza-Fonseca*, 480 U.S. 421, 432 n. 12 (1987)), *aff'd sub. nom., Barnhart v. Sigmon Coal Co., Inc.*, 534 U.S. 438 (2002). The Supreme Court in *Sigmon* similarly held that "[f]loor statements from two Senators cannot amend the clear and unambiguous language of a statute." Guided by the Supreme Court's guidance on this issue, "[w]e see no reason to give greater weight to the views of two Senators than to the collective votes of both Houses, which are memorialized in the unambiguous statutory text." 534 U.S. at 457. "We are not aware of any case . . . in which we have given authoritative weight to a single passage of legislative history that is in no way anchored in the text of the statute." *Shannon v. United States*, 512 U.S. 573, 583 (1994).

The agency has also reviewed the various bills that were introduced in Congress in 2007 that formed the basis of the legislation that became EISA. These bills show that Congress appears to have considered, but ultimately rejected, varying backstop approaches for imported passenger cars, and that it never considered a backstop approach for light trucks.

For example, S. 357 would have amended 49 U.S.C. § 32902(b)(4) to have a backstop applicable to both domestic and imported passenger cars, but not light trucks, based upon the fuel economy projected for the combined domestic and imported passenger car fleets manufactured by all manufacturers in that model year. This language was not included in EISA. S. 357 stated:

> (4) FUEL ECONOMY BASELINE FOR PASSENGER AUTOMOBILES – Notwithstanding the maximum feasible average fuel economy level established by regulations prescribed under subsection (c), the minimum fleetwide average fuel economy standard for passenger automobiles manufactured by a manufacturer in a model year for that manufacturer's domestic fleet and foreign fleet, as calculated under section 32904 as in effect before the date of the enactment of the Ten-in-Ten Fuel Economy Act, shall be the greater of –
>
> > (A) 27.5 miles per gallon; or
> >
> > (B) 92 percent of the average fuel economy projected by the Secretary for the combined domestic and foreign fleets manufactured by all manufacturers in that model year.

Similarly, H.R. 1506 would have amended 49 U.S.C. § 32902(c) to have a backstop applicable to both domestic and imported passenger cars, but not light trucks, based upon the fuel economy projected for the combined domestic and foreign fleets manufactured by all manufacturers in that model year. Again, this language was not included in EISA. H.R. 1506 stated:

> (C) Notwithstanding subparagraphs (A) and (B), the fleetwide average fuel economy standard for automobiles manufactured by a manufacturer in a model year for that manufacturer's domestic fleet and for its foreign fleet as calculated under section 32904 as in effect before the date of enactment of the Fuel Economy Reform Act shall not be less than 92 percent of the average fuel economy projected by the Secretary for the combined domestic and foreign fleets manufactured by that manufacturer in that model year.

Finally, H.R. 2927 would have amended 49 U.S.C. § 32902(b)(4) to have a backstop applicable only to domestic passenger cars, not foreign passenger cars and not light trucks, based upon the fuel economy projected for the combined domestic and foreign fleets manufactured by all manufacturers in that model year. Again, this language was not included in EISA. H.R. 2927 stated:

(4)(A) Notwithstanding any other provision of this section, for any model year in which the Secretary prescribes average fuel economy standards for passenger automobiles on the basis of vehicle attributes pursuant to subsection (k), the average fuel economy standard for passenger automobiles manufactured by a manufacturer in that model year shall also provide for an alternative minimum standard that shall apply only to a manufacturer's domestically manufactured passenger automobiles, as calculated under section 32904 as in effect on June 24, 2007.

(B) The alternative minimum standard referred to in subparagraph (A) shall be the greater of –

(i) 27.5 miles per gallon; or

(ii) 92 percent of the average fuel economy projected by the Secretary for the combined domestic and foreign fleets manufactured for sale in the United States by all manufacturers in that model year, which projection shall be published in the Federal Register when the standard for that model year is promulgated in accordance with this section.

(C) The alternative minimum standard under this paragraph shall apply to a manufacturer's domestically manufactured passenger automobiles only if the passenger automobile standard established on the basis of vehicle attributes pursuant to this subsection, excluding any credits transferred by the manufacturer pursuant to section 32903(g) from other categories of automobiles described in such section, would allow that manufacturer to comply with a less stringent passenger automobile standard than the alternative minimum standard.

The agency also disagrees that there is any indication that the September 2007 UAW letter to Speaker Pelosi and Majority Leader Reid, relied upon by the Sierra Club, constitutes the legislative intent for including the EISA backstop requirement for domestically-manufactured passenger cars in addition to meeting the standards set by NHTSA, *i.e.*, tied to employment concerns and not energy conservation. The UAW's letter, by itself and without any supporting statement or information in the legislative history, cannot reasonably be presumed to constitute that the intent of the backstop was employment.

In view of the various bills that were before the Congress, NHTSA believes it is clear that Congress was well aware of alternative approaches to a potential backstop, but chose not to implement them. Moreover, Congress was aware of the *CBD* decision during consideration of EISA. Accordingly, NHTSA believes that the language of EISA, consistent with applicable case law, is the best indication of Congressional intent. Given the clarity of the requirement for attribute-based standards and the equally clear narrow exception to that requirement – and the fact that Congress appears in S. 357, H.R. 1506, and H.R. 2927 to have considered, and rejected, varying backstop approaches for imported passenger cars and never considered a backstop approach for light trucks, the agency concludes that had Congress intended backstops to be established for either of the other two compliance categories, it would have required them. Congress did not, however, choose to do so. The agency thus believes that Congress has spoken to the backstop issue. Moreover, absent explicit statutory language that provides the agency authority to set flat standards, the agency believes that the setting of any supplementary minimum flat standard for the other two compliance categories would be contrary to the requirement to set an attribute-based standard under EISA.

Congressional intent notwithstanding, the agency notes that the 35 mpg requirement in and of itself serves as a "backstop" as well, as UCS noted in its comments. NHTSA also agrees with the ACEEE comment insofar as the agency will continue to monitor manufacturer progress toward meeting the required fuel economy stringencies. The agency must set the standards high enough to ensure that the average fuel economy level of the combined car and light truck fleet is increasing ratably toward and achieves the statutory requirement of at least 35 mpg by 2020. If the agency finds that this requirement might not be achieved, it will consider setting standards for MYs 2016-2020 early enough and in any event high enough to ensure reaching the 35 mpg requirement.

However, NHTSA disagrees with the AIAM comments that a backstop standard would defeat the purpose of the attribute-based CAFE system by limiting the flexibility of manufacturers to respond to shifts in market demand. NHTSA also disagrees with NADA's comment that, beyond Congress explicitly enacting a backstop for domestically-manufactured passenger cars at 27.5 mpg or 92 percent of the industry-wide domestic passenger car fleet in any given model year, whichever is higher, the agency cannot impose additional anti-backsliding measures. EPCA requires the agency to balance the four statutory factors when determining maximum feasible CAFE standards, and the agency has considered these factors – particularly the need of the nation to conserve energy – in deciding whether to adopt additional measures that operate as "backstops." Thus, in balancing the four EPCA factors under 49 U.S.C. § 32902(f), the agency has adopted in these standards additional measures which operate as "backstops" applicable to all CAFE-regulated vehicles. First, as set forth in Section VI above, the curves set for MYs 2011-2015 have features that limit backsliding, some of which were added by NHTSA as the agency refined and modified the Volpe model for purposes of this rulemaking. Second, the lower asymptote, which serves as a backstop, is inherent in the logistic function. While the agency respectfully disagrees with ACEEE's comment regarding the sufficiency of the lower asymptote as a backstop, as discussed above, it is not the only "backstop" embodied in this rule.

In conclusion, all of these backstop and anti-backsliding mechanisms are consistent with the attribute-based approach of Reformed CAFE, and address the concern that the commenters have expressed regarding the possibility of vehicle upsizing and a "race to the bottom" consistent with Congress' mandate that the CAFE standards be attribute-based.

D. Combined Fleet Performance

The combined industry wide average fuel economy (in mpg) levels for both cars and light trucks, if each manufacturer just met its obligations under the final "optimized" standards for each model year, would be as follows:

MY 2011: 27.3 mpg, or 325.5 grams CO_2 per mile
MY 2012: 28.7 mpg, or 309.7 grams CO_2 per mile
MY 2013: 30.3 mpg, or 293.3 grams CO_2 per mile
MY 2014: 31.0 mpg, or 286.7 grams CO_2 per mile
MY 2015: 31.8 mpg, or 279.5 grams CO_2 per mile

The annual average increase during this five year period is approximately 4.7 percent. Due to the uneven distribution of new model introductions during this period and to the fact that significant technological changes can be most readily made in conjunction with those introductions, the annual percentage increases are not evenly distributed across the model years. Looking forward, in order for the combined industry wide average fuel economy to reach at least 35 mpg by MY 2020, that level would only have to increase an average of 1.9 percent per year for MYs 2016 through 2020.

E. Estimated technology utilization under final standards

NHTSA anticipates that manufacturers will significantly increase the use of fuel-saving technologies in response to the final standards for passenger cars and light trucks. Although it is impossible to predict exactly how manufacturers will respond, since manufacturers may choose to apply any technologies in order to achieve compliance with the standards, the Volpe model provides estimates of technologies manufacturers could apply in order to comply with the final standards. The final Regulatory Impact Analysis

(FRIA) presents estimated increases in the industry-wide utilization of each technology included in the agency's analysis. Tables IX-3 and IX-4 show rates at which the seven largest manufacturers' product plans indicated plans to use some selected technologies, as well as rates at which the Volpe model estimated that the same technologies might penetrate these manufacturers' passenger car and light truck fleets in response to the baseline and final standards. Although the agency has evaluated planned and estimated technology utilization among all manufacturers, and has developed the final standards taking every manufacturer into account, technology utilization among the seven largest manufacturers remains an important measure. Among smaller manufacturers, technology utilization rates are often distorted by narrow product lines and, among European manufacturers, a greater willingness to pay civil penalties rather than adding technology.

The average penetration rate is the percentage of the entire fleet to which the technology is applied. For example, Tables IX-3 and IX-4 show that these manufacturers could apply hybrid powertrains to 15 percent of the entire passenger car fleet in MY 2015, as opposed to the 7 percent shown in their product plans. However, not all manufacturers begin with the same technology penetration rates, and not all manufacturers are affected equally by the final standards. The next column shows the maximum penetration rate among the seven manufacturers with a significant market share (Chrysler, Ford, GM, Honda, Hyundai, Nissan, and Toyota). For example, the Volpe model estimated that one of these manufacturers would apply hybrid electric powertrains to 37 percent of its passenger car fleet to comply with the final MY 2015 standard.

As Tables IX-3 and IX-4 demonstrate, the Volpe model estimated that manufacturers might need to apply significant numbers of advanced engines, advanced transmissions, and hybrid powertrains in order to comply with the final standards. (The hybrid powertrains include not only "micro hybrids" and integrated starter generators, but also strong hybrids including power split hybrids, 2-mode hybrids, and plug-in hybrids.) For example, the Volpe model estimated that one of the seven largest light truck manufacturers could be including diesel engines in 18 percent of its light trucks by MY 2015 in response to the final standards.

Table IX-3. Estimated Technology Penetration Rates in MY 2015 for Passenger Cars

Passenger Cars						
	Average Among Seven Largest Manufacturers			**Maximum Among Seven Largest Manufacturers**		
Technology	Product Plan	Adjusted Baseline	Final Standard	Product Plan	Adjusted Baseline	Final Standard
Dual Clutch or Automated Manual Transmission	8%	8%	43%	69%	69%	69%
Stoichiometric Gasoline Direct Injection	30%	30%	37%	80%	80%	80%
Turbocharging & Downsizing	11%	11%	16%	47%	47%	47%
Diesel Engine	0%	0%	4%	1%	1%	16%
Hybrid Electric Vehicles	9%	9%	17%	14%	14%	37%

Table IX-4. Estimated Technology Penetration Rates in MY2015 for Light Trucks

Light Trucks						
	Average Among Seven Largest Manufacturers			**Maximum Among Seven Largest Manufacturers**		
Technology	Product Plan	Adjusted Baseline	Final Standard	Product Plan	Adjusted Baseline	Final Standard
Dual Clutch or Automated Manual Transmission	9%	13%	66%	39%	39%	96%
Stoichiometric Gasoline Direct Injection	30%	30%	40%	56%	56%	60%
Turbocharging & Downsizing	13%	13%	17%	48%	48%	48%
Diesel Engine	4%	8%	10%	10%	18%	18%
Hybrid Electric Vehicles	4%	5%	14%	12%	12%	23%

The agency considers the estimates of technology application and penetration rates as a way of determining the economic practicability and technological feasibility of the final standards, but again, we note that manufacturers may always comply with the standards by applying different technologies in different orders and at different rates.

F. Costs and benefits of final standards

1. Benefits

NHTSA estimates that the final standards for passenger cars would save approximately 12 billion gallons of fuel and prevent 111 million metric tons of tailpipe CO_2 emissions over the lifetime of the passenger cars sold during those model years, compared to the fuel savings and emissions reductions that would occur if the standards remained at the adjusted baseline (*i.e.*, the higher of manufacturer's plans and the manufacturer's required level of average fuel economy for MY 2010).

NHTSA also estimates that the value of the total benefits of the final passenger car standards would be $28.1 billion[447] over the lifetime of the 5 model years combined. This estimate of societal benefits includes direct impacts from lower fuel consumption as well as externalities, and also reflects offsetting societal costs resulting from the rebound effect. Direct benefits to consumers, including fuel savings, consumer surplus from additional driving, and reduced refueling time, account for 88 percent ($27.0 billion) of the $30.7 billion in gross[448] consumer benefits resulting from increased passenger car CAFE. Petroleum market externalities account for roughly 10 percent ($3.0 billion). Environmental externalities, *i.e.*, reduction of air pollutants, account for roughly 3 percent ($0.8 billion), about 35 percent ($0.3 billion) of which is the result of greenhouse gas (primarily CO_2) reduction. Increased congestion, noise and accidents from increased driving will offset approximately $2.7 billion of the $30.7 billion in consumer benefits, leaving net consumer benefits of $28.1 billion.

The following table sets out the relative dollar value of the various benefits of this rulemaking on a per gallon saved basis and averaging across the passenger car and light truck fleets:

[447] The $28.1 billion estimate is based on a 7 percent discount rate for valuing future impacts. NHTSA estimated stringencies that would maximize net societal benefits using both 7 percent and 3 percent discount rates. For the reader's reference, total consumer benefits for passenger car CAFE improvements total $40 billion using a 3 percent discount rate.

[448] Gross consumer benefits are benefits measured prior to accounting for the negative impacts of the rebound effect. They include fuel savings, consumer surplus from additional driving, reduced refueling time, reduced petroleum market externalities, reduced criteria pollutants, and reduced greenhouse gas production. Negative impacts from the rebound effect include added congestion, noise, and crash costs due to additional driving.

Table IX-5. Economic Benefits and Costs per Gallon of Fuel Saved (Undiscounted)

Category	Variable	Value (2007 $ per gallon)
Benefits	Savings in Fuel Production Cost	$2.90
	Reduction in Oil Import Externalities	$ .36
	Value of Additional Rebound-Effect Driving	$ .35
	Net Reduction in Criteria Pollutant Emissions	$ .11
	Value of Reduced Refueling Time	$ .11
	Reduction in CO_2 Emissions	$ .04[449]
	Gross Benefits	**$3.87**
Costs	Externalities from Additional Rebound-Effect Driving	$0.29
Net Benefits	**Net Benefits**	**$3.58**

NHTSA further estimates that the final standards for light trucks would save approximately 11 billion gallons of fuel and prevent 106 million metric tons of tailpipe CO_2 emissions over the lifetime of the light trucks sold during those model years, compared to the fuel savings and emissions reductions that would occur if the standards remained at the adjusted baseline.

For light trucks, NHTSA estimates that the value of the total benefits of the final standards would be $26.1 billion[450] over the lifetime of the 5 model years of light trucks combined. This estimate of societal benefits includes direct impacts from lower fuel consumption as well as externalities and also reflects offsetting societal costs resulting from the rebound effect. Direct benefits to consumers, including fuel savings, consumer surplus from additional driving, and reduced refueling time, account for 78 percent ($24.1 billion) of the $28.1 billion in gross consumer benefits resulting from increased

[449] Based on a value of $2.00 per ton of carbon dioxide.

[450] The $26.1 billion estimate is based on a 7 percent discount rate for valuing future impacts. NHTSA estimated stringencies that would maximize net societal benefits using both 7 percent and 3 percent discount rates. For the reader's reference, total consumer benefits for light truck CAFE improvements are $39 billion under a 3 percent discount rate.

light truck CAFE. Petroleum market externalities account for roughly 9 percent ($2.7 billion). Environmental externalities, *i.e.*, reduction of air pollutants, account for roughly 4 percent ($1.2 billion), about 19 percent of which is the result of greenhouse gas (primarily CO_2) reduction ($0.2 billion). Increased congestion, noise and accidents from increased driving will offset roughly $1.9 billion of the $28.0 billion in consumer benefits, leaving net consumer benefits of $26.1 billion.

2. Costs

The total costs for manufacturers just complying with the standards for MY 2011-2015 passenger cars would be approximately $21 billion, compared to the costs they would incur if the standards remained at the adjusted baseline. The resulting vehicle price increases to buyers of MY 2015 passenger cars would be recovered or paid back[451] in additional fuel savings in an average of 5.9 years (average 2015 per car price increase, excluding civil penalties owed by manufacturers estimated to owe them, was $959), assuming fuel prices ranging from $3.14 per gallon in 2016 to $3.62 per gallon in 2030.[452] The average cost per vehicle for added fuel economy technologies to comply with the MY 2011-2015 passenger car standards ranges from $64 in MY 2011 to $958 in MY 2015.

The total costs for manufacturers just complying with the standards for MY 2011-2015 light trucks would be approximately $16 billion, compared to the costs they would incur if the standards remained at the adjusted baseline. The resulting vehicle price increases to buyers of MY 2015 light trucks would be paid back in additional fuel savings

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[451] See Section V.B.5 above for discussion of payback period.
[452] The fuel prices (shown here in 2006 dollars) used to calculate the length of the payback period are those projected (Annual Energy Outlook 2008, final release) by the Energy Information Administration over the life of the MY 2011-2015 light trucks, not current fuel prices.

in an average of 4.2 years (average 2015 per truck price increase, excluding civil penalties owed by manufacturers estimated to owe them, is $644) assuming fuel prices ranging from $3.14 to $3.62 per gallon. The average cost per vehicle for added fuel economy technologies to comply with the MY 2011-2015 light truck standards ranges from $126 in MY 2011 to $644 in MY 2015.

Table IX-6. Average Costs per Vehicle for Added Fuel Economy Technology to Comply with CAFE Standards

	Model Year				
	2011	**2012**	**2013**	**2014**	**2015**
Passenger Cars	64	180	508	681	958
Light Trucks	126	372	579	553	644
Combined Fleet	91	260	539	625	816

Comparison of estimated benefits to estimated costs

The table below compares the incremental benefits and costs for the car and light truck CAFE standards, in millions of dollars.

Table IX-7. Passenger Cars

	Model Year					Total
	2011	2012	2013	2014	2015	2011-2015
Benefits	1,027	2,742	5,885	8,026	10,371	28,052
Costs	496	1,549	4,423	6,003	8,040	20,511
Net Benefits	531	1,193	1,463	2,023	2,331	7,541

Table IX-8. Light Trucks

	Model Year					Total
	2011	2012	2013	2014	2015	2011-2015
Benefits	921	3,771	6,180	6,807	8,454	26,132
Costs	649	2,548	4,040	3,870	4,791	15,898
Net Benefits	272	1,223	2,140	2,936	3,663	10,234

The average annual per vehicle cost increases are shown in the FRIA.

G. Environmental impacts of final standards

On October 17, 2008, the EPA published a Notice of Availability of NHTSA's Final Environmental Impact Statement (FEIS), which, as required by the National Environmental Policy Act (NEPA), 42 U.S.C. 4321 *et seq.*, analyzed the potential environmental impacts of alternative mpg levels being considered by the agency. 73 FR 61859. In response to comments on the DEIS, the FEIS also, among other things, analyzed how the agency's alternatives were affected by variations in certain economic assumptions. The agency carefully considered and analyzed each of the individual economic assumptions to determine which assumptions most accurately represent future economic conditions. For a discussion of the economic assumptions relied on by the agency in this final rule, see Section V. The economic assumptions used by the agency in this final rule correspond to the Mid-2 Scenario set of assumption analyzed in the FEIS. *See* FEIS § 2.2. The Optimized Alternative utilizing the Mid-2 Scenario economic assumptions, which were prompted in part by public comments, is squarely within the spectrum of alternatives set forth in the DEIS and the FEIS, and all relevant environmental impacts associated with the Optimized Alternative have been considered by NHTSA. The environmental impacts calculated to result under the Optimized Alternative utilizing the Mid-2 Scenario economic assumptions were presented in Appendix B of the FEIS, and discussed in Chapters 3 and 4 of the FEIS. As such, the tables that follow in this section were developed from the tables provided in Appendix B of the FEIS.

Table IX.G-1 lists the impact on fuel consumption for passenger cars and light trucks from 2020 to 2060 (a period in which an increasing proportion of the fleet would consist of MY 2011-2015 cars and light trucks). The table lists the total fuel consumption for passenger cars and light trucks, including both gasoline and diesel, under the No Action Alternative (Baseline), and under the final standards chosen by the agency (the Optimized Alternative).

Table IX.G-1

Final Standards Annual Fuel Consumption and Fuel Savings (billion gallons)

Calendar Year	No Action/Baseline (Passenger Car)	Passenger Car	No Action/Baseline (Light Truck)	Light Truck
Fuel Consumption				
2020	62.1	59.2	77	74.6
2030	71.1	65.5	84.3	79.9
2040	81.4	74.8	95.8	90.4
2050	93.2	85.7	109.4	103.1
2060	106.2	97.5	124.6	117.4
Fuel Savings Compared to No Action				
2020	--	2.9	--	2.4
2030	--	5.6	--	4.3
2040	--	6.6	--	5.4
2050	--	7.6	--	6.3
2060	--	8.6	--	7.2

An important measure of the impact of the CAFE standards is the impact on the cumulative fuel consumption of the vehicle fleet from the onset of the new standards. For this analysis, NHTSA assumed that passenger car and light truck CAFE standards would continue to increase over MY 2016-2020 at their average annual rate of increase over MY 2011-2015.[453] CAFE standards for MY 2020 are assumed to apply to all subsequent model years. This assumption results in emissions reductions and fuel savings that continue to grow as new vehicles meeting the CAFE standards estimated for

[453] For purposes of this analysis, which was performed for illustrative purposes only, NHTSA assumed that MY 2016-2020 standards would continue to grow at the same rate as MY 2011-2015 standards. The agency recognizes, however, that only a 1.9 percent increase, on average, is necessary each year to reach 35 mpg in 2020, given the final MY 2015 standards.

MY 2020 are added to the fleet in each subsequent model year, reaching their maximum values when all passenger cars and light trucks in the U.S. fleet meet these standards.

The impact of the CAFE standards, by affecting petroleum consumption, total energy consumption, and emissions, would ultimately determine many of the indirect environmental impacts of adopting these CAFE standards. As such, Table IX.G-2 shows the cumulative fuel consumption of passenger cars and light trucks under the Baseline, and under the final standards chosen by the agency (the Optimized Alternative). As in the previous table, total fuel consumption includes gasoline and diesel.

Table IX.G-2

Final Standards Cumulative Annual Fuel Consumption and Cumulative Fuel Savings (billion gallons)

Calendar Year	Passenger Car; No Action/ Baseline	Passenger Car; Final Standard	Light Truck; No Action/Baseline	Light Truck; Final Standard
Cumulative Fuel Consumption				
2010-2020	652.7	635.8	845.9	829.4
2010-2030	1,322.10	1,215.10	1,649.40	1,535.30
2010-2040	2,088.50	1,841.10	2,553.10	2,278.40
2010-2050	2,966.70	2,554.10	3,584.10	3,112.00
2010-2060	3,970.20	3,368.70	4,760.90	4,060.00
Cumulative Fuel Savings Compared to No Action Alternative				
2010-2020	--	16.9	--	16.5
2010-2030	--	107	--	114.1
2010-2040	--	247.5	--	274.8
2010-2050	--	412.7	--	472.1
2010-2060	--	601.5	--	700.9

NHTSA analyzed air quality impacts by estimating the total emissions of each criteria air pollutant and mobile source air toxic (MSAT) attributable to passenger cars and light trucks that would occur under each alternative, and assessing the changes in emissions of each pollutant from its Baseline value that would occur under each alternative. Emissions include those occurring while vehicles are operated ("tailpipe" emissions), which are primarily a product of fuel combustion, as well as those that occur throughout the processes of producing and distributing the fuel they consume ("upstream" emissions).[454] Emissions from vehicle operation are estimated by multiplying the total number of miles that cars and light trucks are driven annually by emissions factors for each pollutant, measured in grams of pollutant emitted per mile traveled. Emissions of each pollutant from fuel production and distribution are estimated by multiplying the total volume of fuel consumed by cars and light trucks by emissions per gallon occurring throughout the fuel supply system, including petroleum extraction and transportation, fuel refining, storage, and distribution to retail outlets.[455]

As indicated previously, the impact of each action alternative was estimated by calculating the difference between emissions under that alternative and emissions under the Baseline alternative. Because each action alternative results in an increase in the number of miles driven by passenger cars and light trucks through the "rebound" effect, tailpipe emissions of each pollutant increase under each action alternative, and alternatives that require higher fuel economy levels produce larger increases in vehicle use and thus in tailpipe emissions. In contrast, each action alternative reduces the volume of fuel that must be supplied from its level under the Baseline alternative, thus reducing emissions throughout the fuel production and distribution process. The net effect of each action alternative on emissions of a pollutant is equal to the increase in tailpipe emissions resulting from added rebound-effect driving, minus the reduction in upstream emissions resulting from the lower volume of fuel that must be supplied; thus it depends on the

[454] In the case of volatile organic compounds (VOC), emissions from vehicle operation also include evaporative emissions that occur when vehicles are parked or stored.
[455] Evaporative VOC emissions that occur at retail fueling stations are included in the estimates of VOC emissions from vehicle operation.

relative magnitude of these two effects. Although their relative magnitude differs among individual pollutants, the reduction in upstream emissions of most pollutants outweighs the increase in tailpipe emissions, resulting in a net reduction in their total emissions. For further explanation of the air quality methodology, *see* FEIS § 3.3.2.

Table IX.G-3 presents the total nationwide emissions of each criteria air pollutant from passenger cars and light trucks under the Baseline alternative for selected analysis years, and compares these to emissions levels expected to result from the final CAFE standards. The emissions reported in the table for the Baseline alternative and the final CAFE standards include both tailpipe and upstream emissions, and the changes from Baseline emission levels resulting from the final standards represent the net effects of changes in tailpipe and upstream emissions of each pollutant. As these estimated changes indicate, total nationwide emissions of each criteria pollutant are projected to decline as a consequence of the final CAFE standards, as the reductions in upstream emissions due to the lower volume of fuel consumption and supply more than offset the increases in tailpipe emissions resulting from additional driving.

Table IX.G-3 Final CAFE Standards Nationwide Criteria Pollutant Emissions from Passenger Cars and Light Trucks (tons/year)			
Pollutant and Year	**No Action/Baseline**	**Final CAFE Standards**	**Changes from Baseline**
Carbon Monoxide (CO)			
2015	18,861,709	18,811,274	-50,435
2020	16,619,854	16,436,732	-183,122
2025	16,403,499	16,068,721	-334,778
2035	17,713,991	17,172,587	-541,404
Nitrogen Oxides (NOx)			
2015	2,148,052	2,143,883	-4,169
2020	1,530,682	1,516,796	-13,886
2025	1,292,315	1,267,998	-24,317
2035	1,228,251	1,189,619	-38,632
Particulate Matter (PM2.5)			
2015	74,919	74,456	-462
2020	75,571	74,399	-1,173
2025	79,258	77,507	-1,751
2035	89,447	87,053	-2,394
Sulfur Oxides (SO_x)			
2015	194,594	191,923	-2,672
2020	199,331	192,187	-7,143
2025	210,380	199,540	-10,841
2035	238,442	223,601	-14,841
Volatile Organic Compounds (VOC)			
2015	2,107,357	2,097,887	-9,470
2020	1,738,318	1,711,101	-27,217
2025	1,646,853	1,602,197	-44,656
2035	1,709,979	1,638,616	-71,363

The analysis methodology for cumulative air quality impacts is identical to that described above, with the exception that the analysis of cumulative impacts assumes that CAFE standards for both passenger cars and light trucks will continue to increase for MY 2016-2020 in order to comply with the EISA requirement that they achieve a combined fleet average of at least 35 mpg by 2020. The MY 2016-2020 standards are thus a reasonably foreseeable future action as defined under NEPA. For further explanation of the air quality cumulative impacts methodology, *see* FEIS § 4.3.2. Table IX.G-4 presents nationwide total emissions of each criteria pollutant from passenger cars and light trucks during selected future years under the Baseline alternative, as well as with the final CAFE standards for MY 2011-15 together with the continued increases in CAFE standards projected for MY 2016-20. The table also shows the net changes in nationwide emissions from passenger cars and light trucks from the Baseline alternative that are projected to result from the final CAFE standards for MY 2011-15 in combination with the further increases projected for MY 2016-20. As was the case for the final CAFE standards for MY 2011-15 by themselves, nationwide emissions of each criteria pollutant are projected to decline from the Baseline alternative, as the reductions in upstream emissions due to the lower volume of fuel consumption and supply more than offset the increases in tailpipe emissions resulting from additional driving. With the exception of carbon monoxide (CO), the reductions in emissions shown in Table IX.G-4 are larger in each analysis year than those reported in the previous table, reflecting the additional reductions in emissions attributable to the continuing increases in passenger car and light truck CAFE standards projected for MY 2016-20.

Table IX.G-4

Final CAFE Standards
Cumulative Nationwide Criteria Pollutant Emissions from Passenger Cars and Light Trucks (tons/year) with MY 2011-2015 Standards and Potential MY 2016-2020 Standards

Pollutant and Year	No Action/Baseline	Final CAFE Standards Plus Projected Increases for MY 2016-2020	Changes from Baseline
Carbon Monoxide (CO)			
2015	18,861,709	18,811,270	-50,438
2020	16,619,854	16,456,238	-163,615
2025	16,403,499	16,147,526	-255,973
2035	17,713,991	17,376,352	-337,639
Nitrogen Oxides (NOx)			
2015	2,148,052	2,143,871	-4,181
2020	1,530,682	1,509,337	-21,345
2025	1,292,315	1,249,274	-43,041
2035	1,228,251	1,158,035	-70,216
Particulate Matter (PM2.5)			
2015	74,919	74,455	-464
2020	75,571	73,673	-1,898
2025	79,258	75,602	-3,656
2035	89,447	83,564	-5,884
Sulfur Oxides (SO_x)			
2015	194,594	191,916	-2,678
2020	199,331	187,612	-11,718
2025	210,380	187,381	-23,000
2035	238,442	201,233	-37,210
Volatile Organic Compounds (VOC)			
2015	2,107,357	2,097,871	-9,486
2020	1,738,318	1,701,288	-37,030
2025	1,646,853	1,577,246	-69,608
2035	1,709,979	1,597,203	-112,776

In addition to the criteria pollutants analysis, the air quality analysis also assesses the impacts of the CAFE standards in relation to some hazardous air pollutants from mobile sources (also known as mobile source air toxics [MSATs]). The MSATs included in this analysis are acetaldehyde, acrolein, benzene, 1, 3-butadiene, diesel particulate matter (DPM), and formaldehyde. EPA and the Federal Highway Administration have identified these air toxics as the MSATs of concern for impacts of highway vehicles. Table VII.G-5 presents the total national emissions of air toxics from passenger cars and light trucks for the Baseline for each of the criteria pollutants and analysis years. Emissions of benzene, 1,3-butadiene, and DPM are higher under the Baseline and decrease in each analysis year under the final CAFE standards. Emissions of acetaldehyde, acrolein, and formaldehyde, on the other hand, increase under the final CAFE standards. For additional detail on this analysis *see* FEIS § 3.3.3; Chapter 5.

Table IX.G-5 Final CAFE Standards Nationwide Toxic Air Pollutant Emissions from Passenger Cars and Light Trucks (tons/year)			
Pollutant and Year	**No Action/Baseline**	**Emissions Levels**	**Changes from Baseline**
Acetaldehyde			
2015	11,165	11,176	10
2020	8,634	8,641	7
2025	7,613	7,603	-9
2035	7,364	7,321	-43
Acrolein			
2015	530	535	5
2020	393	407	14
2025	336	358	22
2035	315	346	30
Benzene			
2015	60,125	59,956	-169
2020	47,458	46,927	-531
2025	42,930	42,008	-922
2035	42,626	41,113	-1,513
1,3-Butadiene			
2015	6,134	6,133	-1
2020	4,698	4,689	-10
2025	4,092	4,068	-24
2035	3,885	3,834	-52
Diesel Particulate Matter (DPM)			
2015	88,405	87,202	-1,203
2020	90,085	86,885	-3,200
2025	94,782	89,932	-4,850
2035	107,203	100,571	-6,631
Formaldehyde			
2015	16,197	16,235	37
2020	12,928	13,003	75
2025	11,716	11,816	100
2035	11,694	11,822	128

Table IX.G-6 presents the cumulative effects of the final CAFE standards for MY 2011-15 and the continuing increases projected for MY 2016-20 on nationwide emissions of toxic air pollutants from passenger cars and light trucks. Projected changes in emissions of toxic air pollutants reflect the net effect of reductions in upstream emissions from lower fuel production and increases in tailpipe emissions due to added rebound-effect driving. These changes also reflect increases in the proportion of diesel vehicles in later model years as manufacturers comply with progressively more stringent CAFE standards, since diesel vehicles (and refining of diesel fuel) produce emissions of MSATs at significantly different rates than do gasoline vehicles (and gasoline refining). Emissions of benzene, 1,3-butadiene, and DPM are higher under the Baseline and decrease in each analysis year under the final CAFE standards. Emissions of acetaldehyde, acrolein, and formaldehyde, on the other hand, increase under the final CAFE standards. For additional detail on this analysis *see* FEIS § 4.3.3; Chapter 5.

Table IX.G-6

**Final CAFE Standards
Cumulative Nationwide Toxic Air Pollutant Emissions
from Passenger Cars and Light Trucks (tons/year)
with MY 2011-2015 Standards and Potential MY 2016-2020 Standards**

Pollutant and Year	No Action/Baseline	Final CAFE Standards Plus Projected Increases for MY 2016-2020	Change from Baseline
Acetaldehyde			
2015	11,165	11,176	10
2020	8,634	8,637	3
2025	7,613	7,603	-9
2035	7,364	7,347	-17
Acrolein			
2015	530	535	5
2020	393	410	16
2025	336	364	28
2035	315	361	45
Benzene			
2015	60,125	59,956	-169
2020	47,458	46,811	-647
2025	42,930	41,741	-1,188
2035	42,626	40,748	-1,878
1,3-Butadiene			
2015	6,134	6,133	-1
2020	4,698	4,687	-11
2025	4,092	4,071	-21
2035	3,885	3,854	-31
Diesel Particulate Matter (DPM)			
2015	88,405	87,198	-1,206
2020	90,085	84,461	-5,623
2025	94,782	83,491	-11,291
2035	107,203	88,723	-18,480
Formaldehyde			
2015	16,197	16,235	37
2020	12,928	12,949	21
2025	11,716	11,692	-24
2035	11,694	11,630	-64

There will be reductions in adverse health effects nationwide with the final MY 2011-2020 CAFE standards compared to the Baseline, as shown in Table IX.G-7. These reductions primarily reflect the projected $PM_{2.5}$ reductions, because $PM_{2.5}$ tends to be the largest contributor to adverse health effects. Data are not available to estimate reliably the number of adverse health effects due to other pollutants. Table IX.G-8 lists the corresponding reductions in health costs under the final CAFE standards compared to the Baseline. The MY 2011-2015 CAFE standards will reduce annual health costs by approximately $536 million in 2035. *See* § 3.3.2.4.2 of the FEIS for a description of NHTSA's approach to providing these quantitative estimates of adverse health effects of conventional health pollutants associated with the final CAFE standards.

Table IX.G-7

Final CAFE Standards
Nationwide Changes in Health Outcomes from Criteria Pollutant Emissions from Passenger Cars and Light Trucks (cases/year)

Health Outcome and Year	No Action/Baseline	Cases per Year
Mortality (ages 30 and older)		
2015	0 a/	-35 b/
2020	0	-90
2025	0	-134
2035	0	-184
Chronic Bronchitis		
2015	0	-31
2020	0	-78
2025	0	-117
2035	0	-160
Emergency Room Visits for Asthma		
2015	0	-7
2020	0	-19
2025	0	-28
2035	0	-38
Work Loss Days		
2015	0	-6,319
2020	0	-16,030
2025	0	-23,936
2035	0	-32,723

a/ Changes in health outcome for the No Action Alternative are shown as zero because the No Action Alternative is the baseline to which the emissions for the other alternatives are compared.
b/ Negative changes indicate reductions; positive emissions changes are increases.

Table IX.G-8

Final CAFE Standards
Nationwide Changes in Health Costs from Criteria Pollutant Emissions from Passenger Cars and Light Trucks (US million dollars/year)

Year	No Action/Baseline	Change in Health Care Costs ($/year)
2015	0 a/	-55 b/
2020	0	-224
2025	0	-363
2035	0	-536

a/ Changes for the No Action Alternative are shown as zero because the No Action Alternative is the baseline to which the emissions for the other alternatives are compared.
b/ Negative changes indicate economic benefit; positive emissions changes are economic costs.

Table IX.G-9 lists the net changes in health outcomes attributable to the cumulative effects of the final MY 2011-15 standards and potential increases in CAFE standards for MY 2016-20 on nationwide emissions in each analysis year. Compared to the Baseline, the cumulative health impacts of vehicle emissions due to the final MY 2011-2015 CAFE standards would result in 451 fewer mortalities, and 80,409 fewer work-loss days in 2035.

Table IX.G-9

Final CAFE Standards Nationwide Changes in Health Outcomes from Criteria Air Pollutant Emissions from Passenger Cars and Light Trucks – Cumulative Effects with MY 2011-2015 Standards and Potential MY 2016-2020 Standards (cases/year)

Health Outcome And Year	No Action	Cases per Year
Mortality (ages 30 and older)		
2015	0 a/	-36 b/
2020	0	-146
2025	0	-280
2035	0	-451
Chronic Bronchitis		
2015	0	-31
2020	0	-127
2025	0	-244
2035	0	-392
Emergency Room Visits for Asthma		
2015	0	-7
2020	0	-30
2025	0	-58
2035	0	-94
Work Loss Days		
2015	0	-6,338
2020	0	-25,942
2025	0	-49,966
2035	0	-80,409

a/ Changes in health outcome for the No Action Alternative are shown as zero because the No Action Alternative is the baseline to which the emissions for the other alternatives are compared.

b/ Negative changes indicate reductions; positive emissions changes are increases.

Table IX.G-10 lists the nationwide changes in health care costs resulting from reduced emissions from passenger cars and light trucks as a consequence of the final CAFE standards for MY 2011-15 and potential further increases for MY 2016-20. As with health outcomes, the economic impacts of the final CAFE standards decrease across successive years compared to the health costs of emissions under the Baseline.

Table IX.G-10

Final CAFE Standards
Nationwide Changes in Health Costs from Criteria Pollutant Emissions from Passenger Cars and Light Trucks – Cumulative Effects with MY 2011-2015 Standards and Potential MY 2016-2020 Standards (US million dollars/year)

Year	No Action/Baseline	Change in Health Care Costs ($/year)
2015	0 a/	-55 b/
2020	0	-356
2025	0	-705
2035	0	-1,145

a/ Changes for the No Action Alternative are shown as zero because the No Action Alternative is the baseline to which the emissions for the other alternatives are compared.
b/ Negative changes indicate economic benefit; positive emissions changes are economic costs.

NHTSA's FEIS also analyzed the effects of the proposed agency action and a range of alternative agency actions on the global climate. This involved analyzing first, the effects of the alternative CAFE standards on greenhouse gas (GHG) emissions, then analyzing how the GHG emissions affect the climate system. The FEIS estimated and reported on four direct and indirect effects of climate change, driven by alternative scenarios of global GHG emissions, including changes in CO_2 concentrations changes in global mean surface temperature, changes in regional precipitation, and changes in sea level. The change in CO_2 concentration is a direct effect of the changes in GHG emissions and influences each of these factors. The FEIS analysis used a climate model to estimate the changes in CO_2 concentrations, global mean surface temperature, and changes in sea level for each alternative CAFE standard and used increases in global mean surface temperature combined with an approach and coefficients from the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report to estimate changes in global precipitation. For additional discussion of the FEIS climate analysis, *see* FEIS § 3.4. Tables IX.G-11 and IX.G-12 present the results from the Model for Assessment of Greenhouse Gas-induced Climate Change (MAGICC) for the final CAFE standards and compares the results to the Baseline. The analysis uses the A1B marker scenario from the IPCC as a reference case, equivalent to the A1B-AIM scenario in MAGICC.[456] Table IX.G-11 and IX.G-12 provide the results for the 2011-2015 CAFE standards (Section 3.4 of the FEIS) and Tables IX.G-13 and IX.G-14 provide the results for the MY 2011-2020 CAFE standards (Section 4.4 of the FEIS).

Table IX.G-11

Emissions and Emission Reductions (compared to No Action/Baseline) Due to the MY 2011-2015 CAFE Standards from 2010-2100 (MMTCO2)

	Emissions	Emission Reductions Compared to No Action/Baseline
No Action	195,501	0
Final CAFE Standards	184,038	11,463

Table IX.G-12

2011-2015 CAFE Standards Impact on CO_2 Concentration, Global Mean Surface Temperature Increase, and Sea-level Rise in 2100 Using MAGICC

	CO_2 Concentration (ppm)			Global Mean Surface Temperature Increase (°C)			Sea-level Rise (cm)		
	2030	**2060**	**2100**	**2030**	**2060**	**2100**	**2030**	**2060**	**2100**
No Action (A1B-AIM) a/	455.5	573.7	717.2	0.874	1.944	2.959	7.99	19.30	37.10
Final Standards	455.4	573.2	716.2	0.873	1.942	2.955	7.99	19.28	37.06
Reduction from No Action/Baseline									
Final Standards	0.1	0.5	1	0.001	0.002	0.004	0	0.02	0.04

a/ The A1B-AIM scenario is the SRES marker scenario used by the IPCC WG1 to represent the SRES A1B (medium) storyline.

[456] The IPCC A1B scenario is one of many Special Report on Emission Scenarios (SRES) scenarios. SRES scenarios are long-term emissions scenarios representing different assumptions about key drivers of GHG emissions. They are described in more detain in Section 3.4 of the FEIS.

Table IX.G-13

Cumulative Emissions and Emission Reductions (compared to No Action/Baseline) Due to the MY 2011-2015 CAFE Standards and Potential MY 2011-2020 CAFE Standards from 2010-2100 (MMTCO2)

	Emissions	Emission Reductions Compared to No Action/Baseline
No Action	195,501	0
Final CAFE Standards	162,913	32,589

Table IX.G-14

MY 2011-2015 CAFE Standards and Potential MY 2016-2020 CAFE Standard Alternatives Cumulative Impact on CO_2 Concentration, Global Mean Surface Temperature Increase, and Sea-level Rise in 2100 Using MAGICC

	CO_2 Concentration (ppm)			Global Mean Surface Temperature Increase (°C)			Sea-level Rise (cm)		
	2030	**2060**	**2100**	**2030**	**2060**	**2100**	**2030**	**2060**	**2100**
No Action (A1B-AIM) a/	455.5	573.7	717.2	0.874	1.944	2.959	7.99	19.30	37.10
Final Standards	455.3	572.4	714.2	0.873	1.939	2.947	7.99	19.26	36.99
Reduction from No Action/Baseline									
Final Standards	0.2	1.3	3.0	0.001	0.006	0.012	0	0.04	0.11

a/ The A1B-AIM scenario is the SRES marker scenario used by the IPCC WG1 to represent the SRES A1B (medium) storyline.

X. Other fuel economy standards required by EISA

In the NPRM, NHTSA explained that it is not promulgating standards for commercial medium- and heavy-duty on-highway vehicles or work trucks as part of this rule, because Congress was clear in EISA that several steps were necessary before such a rulemaking could begin. Section 103 of EISA added the following definitions to 49 U.S.C. § 32901(a) for these vehicles:

- "Commercial medium- and heavy-duty on-highway vehicle" means an on-highway vehicle with a gross vehicle weight rating of 10,000 pounds or more; and
- "Work truck" means a vehicle that—
  - (A) is rated at between 8,500 and 10,000 pounds gross vehicle weight; and
  - (B) is not a medium-duty passenger vehicle (as defined in 40 CFR § 86.1803-01, as in effect on the date of EISA's enactment).

EISA added a new provision to 49 U.S.C. § 32902 requiring DOT, in consultation with DOE and EPA, to examine the fuel efficiency of these vehicles and determine the appropriate test procedures and methodologies for measuring the fuel efficiency of these vehicles, as well as the appropriate metric for measuring and expressing their fuel efficiency performance and the range of factors that affect their fuel efficiency. This study would need to be performed within 1 year of the publication of the NAS study required by section 108 of EISA.[457]

Then, within two years of the completion of the study, DOT, in consultation with DOE and EPA, would need to undertake rulemaking to

> determine…how to implement a commercial medium- and heavy-duty on-highway vehicle and work truck fuel efficiency improvement program designed to achieve the maximum feasible improvement, and shall adopt and implement appropriate test methods, measurement metrics, fuel economy standards, and compliance and enforcement protocols that are appropriate, cost-effective, and technologically feasible for commercial medium- and heavy-duty on-highway vehicles and work trucks.[458]

EISA also requires a four-year lead time for fuel economy standards promulgated under this section, and would allow separate standards to be prescribed for different classes of vehicles.[459]

NHTSA received relatively few comments on this issue, perhaps not surprising since it is essentially concerned with a future rulemaking. Two commenters disagreed with NHTSA's characterization of Section 102 of EISA "mandating" or "requiring" that NHTSA develop CAFE standards for commercial medium- and heavy-duty on-highway vehicles and work trucks. Both Cummins, Inc. and EMA commented that NHTSA should change terminology used in footnotes 38 and 41 of the NPRM suggesting that CAFE standards were "mandated" for these vehicles. Both commenters argued that Congress did not necessarily have CAFE-type standards in mind for these vehicles in

[457] 49 U.S.C. § 32902(k)(1).
[458] 49 U.S.C. § 32902(k)(2).
[459] 49 U.S.C. § 32902(k)(2) and (3).

Section 102, as evidenced by the fact that Congress required a NAS study to be followed by another study by DOT in consultation with EPA and DOE. The commenters stated that Section 102 simply requires that NHTSA eventually implement a "fuel efficiency improvement program" with "fuel economy standards," but not necessarily CAFE standards. As Cummins argued, because the "truck sector has no broadly accepted metric for measuring fuel efficiency," "there could be major unintended consequences" if NHTSA implemented "a CAFE-like system that regulates by a miles per gallon metric," because such a system "could improve fuel economy but cause overall worse fuel efficiency by promoting multiple smaller trucks to do the same work that one does today." Cummins and EMA stated that NHTSA should therefore remove all terminology in the final rule suggesting that NHTSA would apply the "CAFE system" to commercial medium- and heavy-duty on-highway vehicles and work trucks.

Agency response: NHTSA disagrees with Cummins and EMA that CAFE standards for commercial medium- and heavy-duty on-highway vehicles and work trucks were not mandated by Section 102 of EISA. Congress was clear in Section 102 that, following completion of the required NAS and agency studies, NHTSA must engage in rulemaking to subject these vehicles to average fuel economy standards under EPCA and EISA, as the commenters recognized. Whether or not the precise contours of those standards are the same as the attribute-based average fuel economy standards established for passenger cars and light trucks, they will still be average fuel economy standards for fleets of particular vehicles. NHTSA sees no reason not to call these "corporate average fuel economy" or "CAFE" standards, and does not believe that such term connotes any pre-judgment on the part of the agency with respect to the outcomes of the required studies or eventual regulations.

NHTSA also received comments from NACAA and the Wisconsin DNR stating that CAFE standards should be applied to all passenger cars and light trucks up to 10,000 pounds GVWR. Wisconsin DNR argued that extending the standards to these vehicles would "capture the full range of non-commercial passenger vehicles."

Agency response: NHTSA explained in the NPRM that all four-wheeled motor vehicles with a gross vehicle weight rating of 10,000 pounds or less will be subject to the CAFE standards beginning in MY 2011, with the exception of commercial medium- and heavy-duty on-highway vehicles and work trucks, as discussed above. This follows up on NHTSA's statements in the 2006 final rule setting CAFE standards for MY 2008-2011 light trucks, where the agency said that it would begin regulating medium-duty passenger vehicles (MDPVs) under the light truck CAFE standards in MY 2011. MDPVs have been included in the MY 2011-2015 standards, although they make up a very small percentage (less than 1 percent) of light trucks in those model years.

XI. Vehicle classification

Vehicle classification, for purposes of the CAFE program, refers to whether NHTSA considers a vehicle to be a passenger automobile or light truck, and thus subject to either the passenger automobile or the light truck standards. NHTSA created regulatory definitions for passenger automobiles and light trucks, found at 49 CFR Part 523, to guide the agency and manufacturers in determining which vehicles are which.

As NHTSA explained in the NPRM, the statutory language is clear that some vehicles must be passenger automobiles (cars) and some must be non-passenger automobiles (light trucks). Passenger automobiles were defined in EPCA as "any automobile (other than an automobile capable of off-highway operation) which the Secretary [*i.e.*, NHTSA] decides by rule is manufactured primarily for use in the transportation of not more than 10 individuals." EPCA § 501(2), 89 Stat. 901.

Thus, under EPCA, there are two general groups of automobiles that qualify as non-passenger automobiles or light trucks: (1) those defined by NHTSA in its regulations as other than passenger automobiles due to their having not been manufactured "primarily" for transporting up to ten individuals; and (2) those expressly excluded from the passenger category by statute due to their capability for off-highway operation, regardless of whether they were manufactured primarily for passenger transportation. NHTSA's classification rule directly tracks those two broad groups of non-passenger automobiles in subsections (a) and (b), respectively, of 49 CFR § 523.5.

In the NPRM, NHTSA took a fresh look at the regulatory definitions in light of its desire to ensure clarity in how vehicles are classified, the passage of EISA, and the Ninth Circuit's decision in *CBD*. NHTSA explained the origin of the current definitions of passenger automobiles and light trucks by tracing them back through the history of the CAFE program, and did not propose to change the definitions themselves at that time, because the agency tentatively concluded that doing so would not lead to increased fuel savings. The NPRM did, however, propose to tighten the coverage of its regulatory definition of "light truck" to ensure that, starting in MY 2011, 2WD versions of SUVs are no longer classified as off-highway capable light trucks under 49 CFR § 523.5(b), simply because the SUV also comes in a 4WD version. This tightening of NHTSA's definitions will, as explained below, have significant impacts on fuel savings and preventing increased emission of carbon dioxide.

A. Summary of Comments

NHTSA received a number of comments on the vehicle classification issue from a range of organizations. Many commenters (including the Alliance, GM, Ford, and Toyota) supported the clarification in the NPRM concerning how 2WD vehicles should be classified. These commenters sought clarification that the change in how these 2WD vehicles are classified would become effective in MY 2011. Others (Nissan, NADA, and AIAM) questioned NHTSA's position on that issue, arguing that 2WD vehicles should be classified in the same way as 4WD versions of the same model. Some (Alliance, Ford, Toyota, and the Sierra Club) noted that moving large numbers of 2WD vehicles from the light truck category to the passenger category may have a significant impact on the stringency curves, and that the NPRM curves did not reflect this impact.

Several commenters (Public Citizen, Honda, UCS, CBD, and Sierra Club) argued that the rule's classification definitions needed to be revised. The commenters relied on several arguments: first, that the current definitions did not comport with the Ninth Circuit's opinion in CBD (which directed NHTSA either to "revise its regulatory definitions of passenger automobile and light trucks or provide a valid reason for not doing so") and do not reflect the fact that many light trucks are used as passenger vehicles; second, that they were not ratified by Congress in EISA; third, they do not ensure that some vehicles that these commenters believe should be classified as passenger cars are in fact classified as such; and fourth, that they allow manufacturers to "game" the definitions by making minor changes to vehicles to obtain a light truck classification and thus, a lower fuel economy targets. One commenter (GM) urged NHTSA to define "base form" (a term used in a 1981 interpretation concerning the classification of 2WD vehicles) and "model type," contending that these new definitions would help clarify how certain vehicles should be classified. NHTSA responds to these comments below.

B. Response to Comments

1. This rule substantially tightens NHTSA's vehicle classification definitions

(a) Under § 523.5(b), only vehicles that actually have 4WD will be classified as 4WD vehicles

As proposed in the NPRM, NHTSA has tightened the coverage of its regulatory definition of "light truck" to ensure that 2 wheel drive (2WD) versions of an SUV are not classified as light trucks under 49 CFR § 523.5(b) simply because the SUV also comes in a 4WD version. In order to be properly classifiable as a light truck under Part 523, a 2WD SUV must either be over 6,000 lbs GVWR and meet 4 out of 5 ground clearance characteristics to make it off-highway capable under § 523.5(b), or meet one of the functional characteristics under § 523.5(a) (*e.g.*, greater cargo carrying capacity than passenger carrying capacity). In other words, a 2WD vehicle of 6,000 lbs GVWR or less, even if it has a sufficient number of clearance characteristics, cannot be considered off-highway capable. This is based on the plain meaning of § 523.5(b) (which refers to a vehicle that "has" 4WD) and the statute (49 U.S.C. § 32901(a)(18)(b) speaks of a vehicle that "is a 4-wheel drive automobile"). No change in the regulatory definition is needed. The clarification accomplishes NHTSA's purpose. This clarification, which the vehicle manufacturers largely supported, resulted in the re-classification of an average of 1,400,000 2WD SUVs from light trucks to passenger cars in each of the five model years covered by the standards. The result of this re-classification is an average increase of 0.8 mpg in the combined passenger car and light truck standards over MYs 2011-2015, producing a corresponding additional 4.5 billion gallons of fuel savings and 54 million metric tons of avoided carbon dioxide emissions during the useful life of vehicles sold during these model years.

As noted above, several commenters agreed with NHTSA's clarification on the 2WD vehicles but asked for assurance that it would be applied only to MY 2011 and later production. The Alliance commented that it agreed that NHTSA's vehicle classification "regulations are consistent with congressional intent as expressed by EPCA and EISA," and that it did "not object to NHTSA's interpretations and its proposed regulatory revisions to 49 CFR Part 523, provided that these are effective with the 2011 model year." The Alliance argued that this was appropriate given that this rulemaking begins with MY 2011, and helps avoid "the need to reexamine and re-issue standards for 2009 and 2010 model years," which the Alliance stated had been "developed based on a data set with 4x2 utilities included in the truck fleet." Ford agreed, arguing that reclassifying 2WD SUVs for MYs 2008-2010 would "make it more difficult for many manufacturers to meet the light truck standards (as well as the car standards) and would amount to an improper increase in the stringency of the MY 2008-2010 standards." NHTSA hereby clarifies that its intention is that its clarification on the treatment of 2WD vehicles under § 523.5(b) become effective with regard to MY 2011 vehicles. Applying that treatment earlier would require the agency to change the standards for those model years, which the agency is statutorily prevented from doing later than 18 months before the start of the model year to which the amended standard applies, if the standards would be more stringent.[460]

Some commenters noted that this clarification, although thoroughly discussed in the NPRM, was not reflected in the stringency curves of the proposed standard. NHTSA believes that its announced intention to apply this clarification in the final rule was adequate notice to all concerned that the stringency levels of the final rule would reflect the concomitant movement of many 2WD vehicles from the light truck to the passenger car fleet. Commenters who are manufacturers had every opportunity to analyze how the change might affect their fleets and comment accordingly. In the period since issuance of the NPRM, NHTSA has had the opportunity to evaluate new manufacturer product plans in order to analyze the full impact of the clarification on the standard. As noted above, this change has resulted in an increase in the standards and fuel savings for MYs 2011-2015. The final curves for passenger cars and light trucks reflect this change.

Nissan disagreed with NHTSA's proposal to classify certain 2WD SUVs as passenger cars, offering the following basic arguments: (1) that NHTSA has always interpreted and set standards with 2WD SUVs as light trucks, even in the MY 2008-2011 CAFE rule (as evidenced, for example, by the CAFE reporting requirements that specify that a manufacturer must indicate whether a light truck has 4WD—Nissan argued that that presumed that some light trucks did not); (2) that NHTSA's 1981 interpretation states that vehicle classification is determined by the base vehicle; (3) that classifying 2WD SUVs as light trucks because they also come in 4WD is consistent with EPA emissions test procedures which describe equipment as "optional" if a manufacturer

[460] 49 U.S.C. § 32902 (g)(2).

expects less than one-third of the models sold to be equipped with it;[461] and (4) that NHTSA must provide notice and comment before changing the standards.

With regard to Nissan's comment that NHTSA has always interpreted and set standards with 2WD SUVs as light trucks, even in the MY 2008-2011 CAFE rule, NHTSA has never stated that 2WD SUVs are necessarily light trucks simply because they also come in 4WD, and in fact has stated to the contrary. As early as 1980, in the final rule promulgating light truck CAFE standards for MYs 1983-1985, NHTSA responded to a comment from GM requesting a change to the regulatory definitions to ensure that 2WD SUVs may be classified as light trucks even if their GVWR fell below 6,000 pounds. NHTSA stated that, "Under the agency's current regulations in 49 CFR Part 523, such a change in the vehicle's GVWR would result in their being classified as passenger automobiles." Although NHTSA's technical analysis for the 1980 final rule "treat[ed] 4x2 utility vehicles … as light trucks, consistent with the classification of current vehicles," NHTSA cautioned expressly that "this treatment should not be interpreted as a statement by the agency that all future designs of 4x2 utility vehicles … will continue to be classified as light trucks."[462] NHTSA also stated as much in a 1981 letter of interpretation, discussed in greater detail below. Thus, in response to Nissan's comment, while NHTSA has previously set standards with 2WD SUVs as light trucks, the agency has long held that 2WD SUVs are not inherently light trucks, and that the definitions could be tightened in the future. The fact that the reporting requirements include "4WD (yes/no)" does not, as Nissan suggests, indicate that 2WD SUVs may be light trucks under § 523.5(b) if their GVWR is less than 6,000 pounds.

[461] Thus, according to Nissan, if less than one-third of the "variants" of an SUV sold are 2WD, those 2WD variants are properly classified along with the 4WD "base" vehicle.
[462] 45 FR 81593, 81599-60 (Dec. 11, 1980).

Nissan's comments focus on how it believes NHTSA has construed and applied its definitions in the past. But Nissan does not make an argument that NHTSA's reading of its own rules, as proposed in the NPRM, is not a reasonable reading of those rules. In fact, NHTSA believes that it is reasonable to read a rule (§ 523.5(b)(1)(i)) that refers to a vehicle that "has 4-wheel drive" as encompassing only vehicles that have 4WD. The same is true with regard to the statute (49 U.S.C. § 32901(a)(18)(B)), which speaks of a vehicle that "is a 4-wheel drive automobile." NHTSA merely intends to read the rule and statute according to their plain meaning.

NHTSA also disagrees that the Nov. 1981 letter of interpretation indicates that vehicle classification is always determined by the base vehicle. In that letter, NHTSA used the term "base vehicle" for classifying vehicles under § 523.5(a), not § 523.5(b). NHTSA has never used the term "base vehicle" to describe a vehicle as off-highway capable and thus properly classifiable under § 523.5(b). A vehicle either is or is not off-highway capable—the fact that the vehicle may also come in 4WD does not make the 2WD version off-highway capable.

With regard to Nissan's comment about EPA emissions test procedures describing equipment as "optional" if a manufacturer expects less than one-third of the models sold to be equipped with it, NHTSA has examined EPA's regulations and remains unconvinced that 2WD would be the kind of "optional" equipment covered. EPA regulations describe "optional" equipment as an "item" that could add weight or influence emissions in the test. If anything was "optional" equipment, then, it would appear to be the presence of 4WD, which both adds weight to a vehicle and causes it to emit more pollution, compared to 2WD.[463] NHTSA would of course defer to EPA's interpretation of its own regulations, but does not find Nissan's argument convincing for purposes of this rulemaking.

And finally, with regard to Nissan's comment that the agency was reclassifying 2WD SUVs without providing notice and comment, NHTSA disagrees—these changes have been made with full notice, as provided in the NPRM, and an opportunity for comment, and are appropriate and timely revisions to NHTSA's application of Part 523. In the NPRM, NHTSA specifically sought comment on the proposed changes to the vehicle classification system and whether further changes were appropriate.

AIAM also disagreed with NHTSA's proposal to classify certain 2WD SUVs as passenger cars. AIAM stated that larger 2WD SUVs had originally been classifiable as light trucks per the statutory off-highway definition, but that over time "smaller, more fuel efficient versions of SUVs were offered in the U.S. market." AIAM thus suggested that NHTSA should classify "all SUVs in the same category and provide lead-time for manufacturers before the new criteria take effect," as NHTSA had done for minivans and the "three row" requirement in its 2006 rule on light truck standards. In response, the agency notes that a vehicle's fuel economy capability has no bearing on its proper classification as a passenger car or as a light truck. NHTSA believes that the lead time between when the final rule standards are promulgated and when the revised definitions take effect (MY 2011) should be sufficient for manufacturers, particularly given the increasing consumer preference for higher fuel economy vehicles and NHTSA's announced intention to move in this direction in the NPRM.

[463] *See, e.g.*, 40 CFR § 86.1832-01.

In summary, NHTSA believes its clarification of how, starting with MY 2011, it will apply § 523.5(b) to 2WD vehicles of 6,000 lbs or less GVWR constitutes a reasonable and significant tightening of its definitions related to vehicle classification. As a result, in MYs 2011 through 2015, an average of 1.4 million vehicles formerly classified as light trucks will be classified as passenger automobiles, which will produce an average increase of 0.8 mpg in the combined passenger car and light truck standards in those years. The resultant expected fuel savings (4.5 billion gallons) and avoided carbon dioxide emissions (54 million metric tons) are significant.

(b) The final rule amends § 523.5(a)(4) to prevent gaming that might jeopardize fuel savings created by NHTSA's clarified position on 2WD vehicles

In explaining in the NPRM (73 FR 24459) that 2WD SUVs would no longer be classifiable as light trucks simply because a version is also available in 4WD, NHTSA noted that, alternatively, a 2WD automobile may properly be classified as a light truck under § 523.5(a)(4) if it provides "greater cargo-carrying than passenger-carrying volume." In that context, NHTSA mentioned a 1981 letter of interpretation to GM.[464] The 1981 letter stated that "two-wheel drive utility vehicles which are truck derivatives and which, in base form, have greater cargo-carrying volume than passenger-carrying volume should be classified as light trucks for fuel economy purposes." NHTSA stated in the NPRM that "base form" means "the version of the vehicle sold as 'standard,' without optional equipment installed, and does not include a version that would meet the cargo volume criterion only if 'delete options' were exercised to remove standard

[464] *See* http://www.nhtsa.dot.gov/cars/rules/interps/gm/81/nht81-3.36.html (last accessed September 23, 2008) for the full text of the letter of interpretation to GM.

equipment." NHTSA gave the example of a base vehicle that comes equipped with a standard second-row seat, which the agency stated could not be classified as a light truck simply on the basis that the purchaser has an option to delete that second-row seat.[465]

In its comments, GM urged NHTSA to incorporate the definition of "base form" into Part 523. However, it is possible that a literal application of the 1981 letter's definition of "base form" could result in gaming of the classification system. For example, with regard to a particular vehicle, a manufacturer could describe as optional a second-row seat that is in fact an item that the manufacturer expects to install in nearly every vehicle of that model. In fact, even with regard to a vehicle that has long come equipped with a second-row seat as standard equipment, the manufacturer could suddenly describe that seat as optional. Even if most, or even all, vehicles of that model continued to be sold with second-row seats, the manufacturer's mere description of the seat as optional could, if the manufacturer's description of the vehicle's "base form" were the only consideration, allow the manufacturer to argue that the vehicle is a light truck because its base form has greater cargo-carrying than passenger-carrying volume.

The vehicles described by GM in the 1981 correspondence have little relation to the 2WD SUVs of today. To the best of the agency's knowledge, most 2WD SUVs are routinely offered with a standard full bench or pair of captain's chairs in the second row. Additionally, far fewer 2WD SUVs manufactured today are based on a truck chassis. To permit a manufacturer to continue to sell 2WD SUVs with second-row seats and consider them light trucks merely because the manufacturer has decided to list those seats as an option rather than as a standard feature of the base vehicle would be to stand the November 1981 interpretation on its head. That interpretation was intended to prevent

[465] 73 FR 24459, fn. 207 (May 2, 2008).

gaming of the “greater cargo-carrying volume” category of light trucks by limiting it to vehicles where carrying cargo was clearly the primary function for which the vehicle was designed. We cannot permit that interpretation to be used to produce the precisely opposite result, *i.e.*, to categorize 2WD vehicles that are primarily designed to be sold with a second-row seat for passengers as light trucks merely because the manufacturer suddenly labels the second-row seat as an option.

Therefore, in response to comments and consistent with Congress’ intent in EISA, starting with MYs 2011-2015, 2WD SUVs (including crossovers that are 2WD) may only be properly classified as light trucks under § 523.5(a)(4) if they are, like cargo vans, designed and sold primarily to serve a cargo-carrying function. The final rule amends that section to say: “Provide, as sold to the first retail purchaser, greater cargo-carrying than passenger-carrying volume, such as in a cargo van; if a vehicle is sold with a second-row seat, its cargo-carrying volume is determined with that seat installed, regardless of whether the manufacturer has described that seat as optional .” In light of this clarifying rule text, there is no need at this time to provide a definition for “base form.” The manufacturer must categorize its vehicles based upon the vehicle attributes when it is sold. If a cargo van is manufactured as such with no rear seating and is sold in that configuration then it can be considered a light truck under § 523.5(a)(4). If the same vehicle is sold with rear seating, it cannot be a truck under § 523.5(a)(4). GM’s HHR provides an example of this concept. The HHR is available and sold in a “panel” version with no rear seating and a passenger version with rear seating. The panel version if actually sold that way can be a light truck under § 523.5(a)(4); the passenger version, when sold with rear seating, cannot be a truck under § 523.5(a)(4) even if the manufacturer were to label that seating as optional.

Thus, through interpretation and changes to the rule text, NHTSA has significantly tightened the definitions governing which vehicles may be classified as light trucks. 2WD SUVs of 6,000 lbs or less GVWR may no longer be properly classified as light trucks under § 523.5(b) simply because they also come in 4WD. Additionally, 2WD SUVs may not be properly classified as light trucks simply because a manufacturer asserts that their base form has no back seat and thus would "provide greater cargo-carrying than passenger-carrying volume" according to § 523.5(a)(4).

2. Especially as tightened by this rule, NHTSA's classification definitions are more difficult to game than commenters suggest

As described above, this final rule effectuates significant changes in NHTSA's definitions and their interpretation that will substantially reduce any opportunities to game those definitions. NHTSA disagrees with the commenters' argument that the standards allow manufacturers to "game" the definitions by making minor changes to vehicles to obtain a light truck classification and thus, a lower fuel economy target.

Several commenters, including Sierra Club *et al*., UCS, and Honda commented that manufacturers are "gaming" the existing definitions by making changes to passenger cars in order to classify them as light trucks and obtain the benefit of lower fuel economy targets. UCS suggested that the "loophole" is a function of both the statutory requirement to set separate standards for passenger cars and light trucks, which "accommodat[es] an industry interest in having non-passenger vehicles held to less stringent fuel economy standards than passenger vehicles of the same attribute," and of

NHTSA's "equating SUVs, minivans, crossovers and even some station wagons with non-passenger vehicles." UCS argued that "The association of these categories has allowed automakers to tweak passenger vehicle characteristics in order to have them classified as light trucks that are held to lower fuel economy standards." The Sierra Club stated that the current definitions are being abused, with manufacturers classifying as light trucks "obvious examples [of] many sedans and station wagons, such as the Chrysler PT Cruiser, Dodge Magnum, and the Subaru Outback sedan," as well as "SUVs and minivans are advertised, sold, and used as passenger vehicles." Sierra Club argued that the attribute-based system, under which manufacturers are subject to standards based on their fleet mix, encourages further gaming, as evidenced by the "surge in 'crossover' vehicles that are more car-like and intended as passenger vehicles but are still classified as non-passenger vehicles and can therefore meet a lower fuel economy than cars." Honda stated that NHTSA should change the light truck definitions because "the current system is much too easy to game, which creates competitive impacts and diverts limited engineering resources to figuring out how to game the latest rules instead of improving fuel economy," and "in the long run, …will also encourage shifting sales towards vehicles classified as light trucks and cause increases in real world fuel consumption."

In response to the above comments, NHTSA notes that separate standards for passenger cars and light trucks are a statutory requirement under EISA. NHTSA believes, as explained elsewhere in this notice, that that requirement extends to setting the target curves for the passenger car fleet based only on the passenger cars, and the target curves for the light truck fleet based only on the light trucks. NHTSA does not believe that it has the authority to combine the fleets for the purposes of setting the standards.

Moreover, with regard to "crossovers" and commenters' examples of "many sedans and station wagons," being classified as light trucks, the agency notes that as a result of the tightened implementation of our vehicle definitions, many crossovers are in fact now properly classified as passenger cars. To the extent that crossovers are not classified as passenger cars, it is, we believe, only because they either (1) have 4WD and meet 4 out of 5 ground clearance characteristics; (2) are over 6,000 lbs GVWR and meet 4 out of 5 ground clearance characteristics; or (3) have three rows of seats and the capability to expand cargo-carrying volume through folding or removing seats.

Of the specific examples of the PT Cruiser, the Dodge Magnum, and the Subaru Outback sedan, NHTSA believes that manufacturers currently classify these vehicles as light trucks either because they come in four-wheel drive and have the required ground clearance, or because their rear seats may be easily removed to create a flat, floor level surface that increases cargo-carrying capacity. After MY 2011, vehicles may only be classified as light trucks on the basis of permitting expanded use of the vehicle for cargo-carrying purposes if they have three rows of standard designated seating positions that fold flat or are removable. As currently designed, the PT Cruiser and the Magnum do not meet this requirement, so NHTSA would likely classify these vehicles as passenger cars as well. If the Outback sedan does in fact have 4WD (or AWD) and meet the required ground clearance characteristics, NHTSA is required by EPCA and EISA to consider it a light truck, regardless of its body shape.

Finally, NHTSA believes that minor changes are not sufficient, and that fairly major changes would be necessary in order to reclassify a passenger car as a light truck. To make a 2WD SUV a light truck, for example, manufacturers would need either to add a third row of seats to it (and otherwise meet the requirements for expanded cargo space) convert it to 4WD, or raise its GVWR over 6,000 lbs and ensure that it met 4 out of the 5 ground clearance characteristics. These changes are not minor, and likely can be made only every few years at the time of one of the periodic vehicle redesigns. Additionally, the minor benefit to be gained in terms of a lower target must be balanced against consumer demand. In a time of high gas prices and increasing consumer interest in high fuel economy vehicles, it seems unlikely to NHTSA that manufacturers would take the risk of turning passenger cars into light trucks solely to obtain the slightly lower light truck target standard.

3. Additional changes in NHTSA's classification definitions would not result in greater fuel savings and lower CO_2 emissions

We have explained above the recategorization of 2WD vehicles that will result from NHTSA's tightening of its classification definitions. NHTSA considered whether recategorization of additional vehicles through further changes to its classification definitions would result in additional fuel economy improvements and therefore lower emissions of carbon dioxide. One of the concerns underlying the Ninth Circuit's decision in *CBD* was the potential impact of vehicle categorization on the ultimate fuel economy for light trucks. The commenters, too, were concerned about this in general. NHTSA has considered this issue carefully. In 2006, when NHTSA issued its MY 2008-2011 light truck fuel economy rule, and in 2007, when the Ninth Circuit issued its initial opinion in CBD concerning that 2006 light truck rule, EISA had not been enacted. Under EPCA as it then existed, the passenger car standard was a flat 27.5 mpg average requirement. Re-classifying light trucks (which had a standard far below 27.5 mpg) as passenger cars, in the flat pre-EISA world, intuitively would have resulted in their having to meet a higher standard, or in the manufacturers' having to build more small, lightweight vehicles in order to balance out former light trucks newly subject to the higher passenger standard, and could have resulted in more fuel savings. This assumption may no longer be correct, because such a recategorization could now result in lower standards for passenger automobiles.

In EISA, Congress made both the passenger car and light truck standards attribute-based, which means that the fuel economy target curves for each standard are a function of the fleet subject to that standard. In developing the curves that determine fuel economy targets for each vehicle footprint, NHTSA fits the curve based in part on the sizes (footprint) and fuel economy levels (given the estimated effects of adding fuel-saving technologies) of the vehicles in each regulatory class. Consider, for example, a small SUV typically classified as a light truck, and assume that the small SUV gets relatively good fuel economy for a truck. Moving the small SUV out of the truck fleet may reduce the overall average fuel economy level required of light trucks, because the vehicles remaining in that regulatory class will be the larger ones that have relatively lower fuel economy.   Averaging their capabilities will result in a lower target than if the small SUV in question remained in the light truck fleet. Moving the SUV into the passenger car fleet may either boost or lower the average fuel economy level required of passenger cars, depending on how the size and potential fuel economy of the given SUV compares to those of the vehicles that were already classified as passenger cars.

NHTSA's analysis indicates that the direction and magnitude of the net effects of vehicle re-classification depend on the composition of the fleet and the specific nature of the change in classification. As shown in Figure XI-1, assigning 2WD SUVs and those vehicles that do not meet the third row requirement to the passenger car fleet would add to the passenger car fleet a set of vehicles (labeled "PC Formerly Classified as LT") with fuel economy levels that are generally (though not universally) in the same range as those of passenger cars of similar footprint. However, further reassigning to the passenger car fleet minivans and vehicles that *do* meet the third row requirement, as commenters appear to suggest, would add to the passenger car fleet a set of vehicles (labeled "LT Reassigned to PC under Alternative Definition") with fuel economy levels that are generally (though not universally) lower than those of passenger cars of similar footprint. Figure XI-2 shows how the composition of the light truck fleet is affected by such shifts. Reassigning either the smaller or larger group of vehicles to the passenger car fleet removes from the light truck fleet vehicles that are generally (though not universally) smaller and more efficient than the vehicles that remain in the light truck fleet.

In contrast, a number of commenters, including CBD, Sierra Club *et al*., and UCS, did not address NHTSA's discussion and commented that NHTSA should revise the definitions of passenger car and light truck in accordance with the Ninth Circuit's opinion, generally for the purpose of increasing fuel savings. Honda also commented that NHTSA should revise its definitions to be consistent with that opinion. None of those commenters specified precisely which vehicles should be reclassified as passenger cars instead of light trucks.

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Figure XI-1. Effect on the Passenger Car Fleet

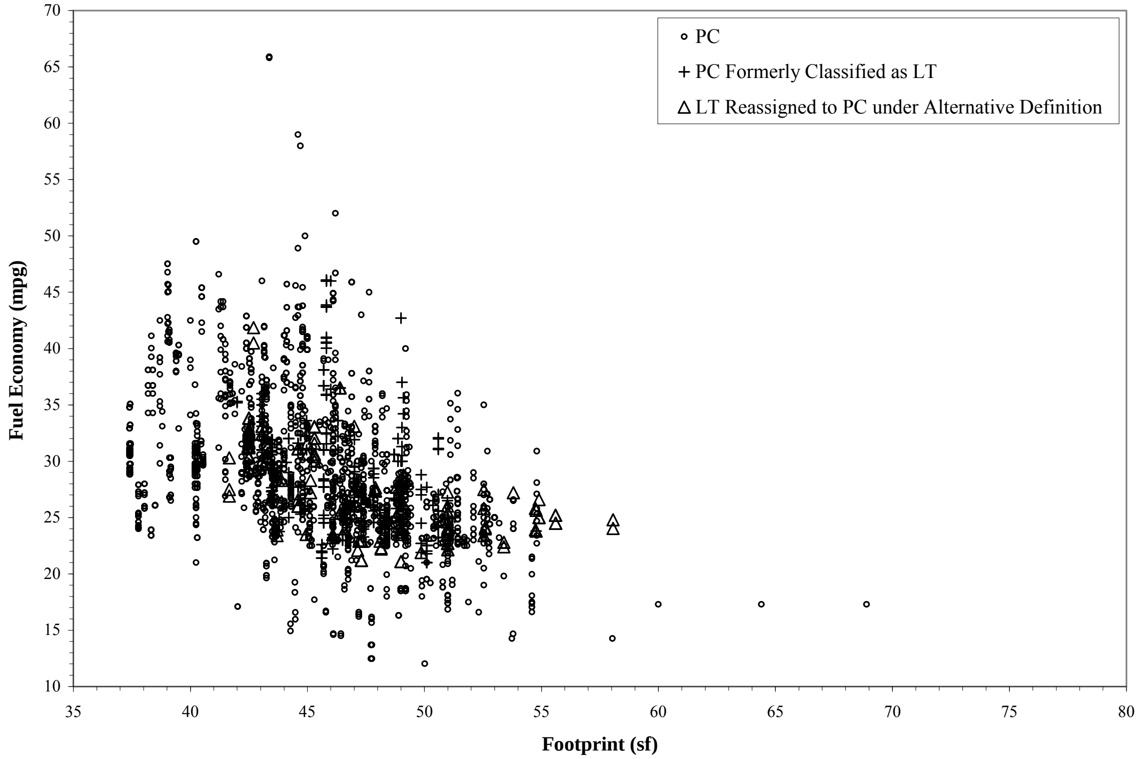
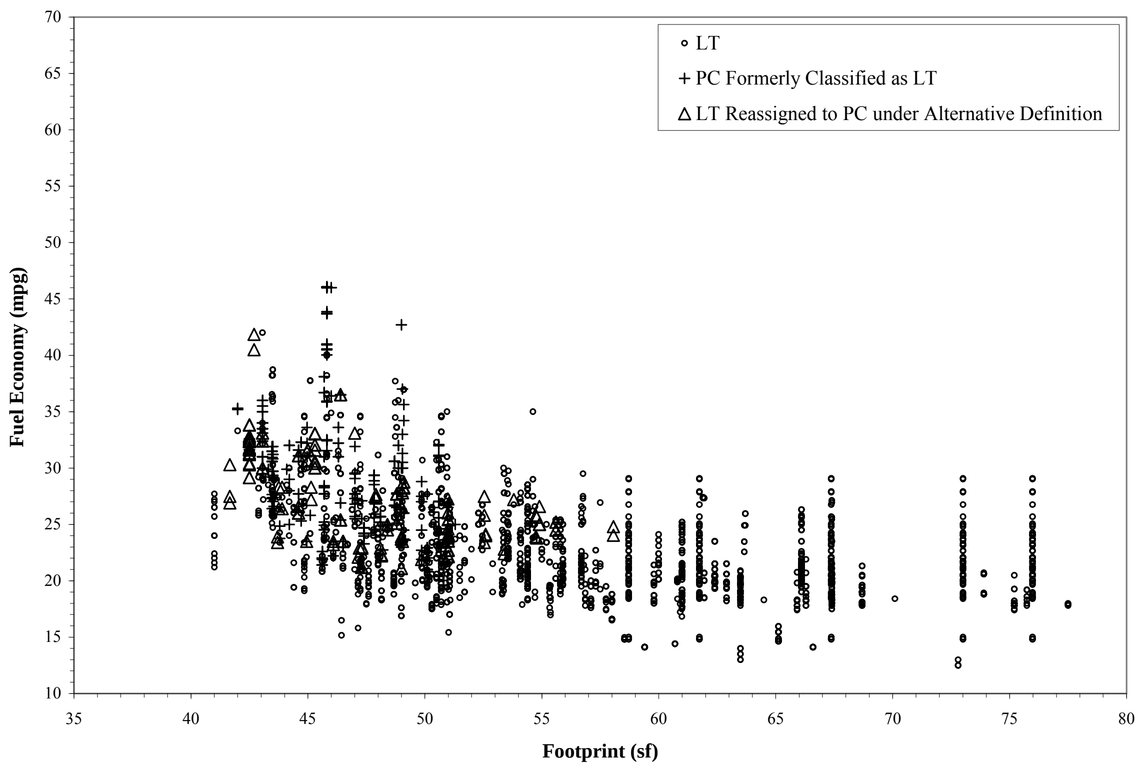


Figure XI-2. Effect on Light Truck Fleet



The following table shows how, for MY 2011–MY 2015, reclassifying 2WD SUVs by virtue of NHTSA's tightened classification decisions changed average required CAFE levels, and how additionally reclassifying minivans and vehicles that do not meet the third row requirement would have changed average required CAFE levels. The overall averages reflect changes in the size of each fleet under each approach to vehicle classification, again bearing in mind that "Alternative Definition" in the tables refers to moving all light trucks that meet the 3-rows criterion of § 523.5(a)(5)(ii) into the passenger car fleet.

Table XI-1. Average CAFE (mpg) Required During MY 2011-MY 2015 under Alternative Light Truck Definitions

Fleet	Former Definition	Final Definition	Alternative Definition
Passenger Car	30.3-34.5	30.2-37.1	29.7-34.0
Light Truck	24.5-27.4	24.1-27.1	24.0-26.9
Average	27.0-30.3	27.3-31.8	27.2-30.7

Similarly, the next table shows how these changes in vehicle classification affected the amount of fuel saved over the useful lives of vehicles in the MY 2011-MY 2015 fleet.

Table XI-2. Lifetime Fuel Savings (billion gallons) of the MY 2011-MY 2015 Fleet under Alternative Light Truck Definitions

Fleet	Former Definition	Final Definition	Alternative Definition
Passenger Car	5.6	12.2	9.4
Light Truck	13.5	11.5	11.6
Total	19.1	23.6	21.0

As discussed above, in the context of the MY 2011-2015 passenger car and light truck standards, moving 1,400,000 2WD SUVs from the light truck to the passenger car fleet results in an average increase of 0.8 mpg in the combined passenger car and light truck standards over MY 2011–MY 2015. Correspondingly, doing so increases the amount of fuel saved and carbon emission avoided by 4.5 billion gallons and 54 million metric tons, respectively. It is possible, as some industry commenters suggested, that manufacturers will respond to the tightening of the definition by ceasing to build 2WD versions of SUVs, which could reduce fuel savings. However, NHTSA expects that manufacturer decisions will be driven in much greater measure by consumer demand than by NHTSA's regulatory definitions. In this era of high gasoline prices and increasing consumer interest in high fuel economy vehicles, NHTSA believes that there will still be demand for 2WD SUVs, whether they are classified for CAFE purposes as passenger cars or as light trucks.

Nevertheless, going further and reclassifying other light trucks as passenger cars, as some commenters would have NHTSA do, would change the form and stringency of the curves for the maximum feasible standards. Substantially, it would reduce overall average required CAFE levels by an average of 0.4 mpg during MYs 2011-2015, reducing fuel savings by 2.6 billion gallons over the useful life of vehicles sold in these model years, and increasing carbon dioxide emissions by 28 million metric tons. Accordingly, EPCA and EISA's overarching purpose of energy conservation would not be better fulfilled by further changing the vehicle classifications.

4. The vehicle classification definitions embodied in this final rule are consistent with NHTSA's statutory authority and respond to the Ninth Circuit's opinion

Some commenters (Public Citizen, Sierra Club, CBD) argued broadly that the standards do not reflect the fact that many light trucks are used as passenger vehicles, and that, therefore, more of them should be classified as passenger cars. NHTSA discussed at length in the NPRM that the fact that vehicles are used for personal transportation does not make them passenger cars for purposes of CAFE. The commenters' argument overlooks the statutory definition of passenger automobile. Passenger automobiles were defined in EPCA as "any automobile (other than an automobile capable of off-highway operation) which the Secretary [*i.e.*, NHTSA] decides by rule is manufactured primarily for use in the transportation of not more than 10 individuals." EPCA § 501(2), 89 Stat. 901. The statute does not employ the word "used." If Congress had wanted all vehicles used to transport passengers to be classified as passenger automobiles, it would have said "used primarily" in EPCA, instead of "manufactured primarily." The definition of "passenger automobile" itself excludes two types of passenger-carrying vehicles: (1) vehicles capable of off-highway operation regardless of whether they transport any number of passengers, and (2) vehicles manufactured primarily to transport more than 10 passengers. This indicates that Congress envisioned from the start of the program that some vehicles would be used for passenger transportation but, for fuel economy purposes, not be classified as passenger automobiles. Congress also authorized NHTSA to define, by rule, those vehicles "manufactured primarily" for carrying 10 or fewer passengers, indicating that Congress also envisioned that other passenger-carrying vehicles would be excluded from the definition if manufactured primarily for another purpose.

NHTSA refers readers to the discussion in the NPRM at 73 Fed. Reg. 24458-24461 (May 2, 2008) for additional information on this issue. See further the discussion of EPCA's legislative history in the proposal and final rule establishing NHTSA's vehicle definition regulation. 41 Fed. Reg. 55368, 55369-55371, December 20, 1976, and 42

Fed. Reg. 38362, 38365-38367, July 28, 1977. That discussion, and not the incorrect and anomalous description of it in a preliminary notice published by the agency in late 2003 (68 Fed. Reg. 74908, 74926, December 29, 2003), represents the agency's historical position.

NHTSA also explained in the NPRM that in EISA Congress specifically addressed the vehicle classification issue. It redefined "automobile," added a definition of "commercial medium-and heavy-duty on-highway vehicle," defined "non-passenger automobile" and defined "work truck." Significantly, it did not change other definitions and its new definition of "non-passenger automobile," which is most relevant in this context, in no way contradicted how NHTSA has long construed that term. In enacting EISA, Congress demonstrated its full awareness of how NHTSA classifies vehicles for fuel economy purposes and chose not to alter those classifications. That strongly suggests Congressional approval of the agency's 30-year approach to vehicle classification.

Moreover, Congress has given clear direction that overall objectives must be obtained regardless of vehicle classification. EISA adds a significant requirement to EPCA – the combined car and light truck fleet must achieve at least 35 mpg in the 2020 model year. Thus, regardless of whether the entire fleet is classified as cars or light trucks, or any proportion of each, the result must still be a fleet performance of at least 35 mpg in 2020. This suggests that Congress did not want to spend additional time on the subject of whether vehicles are cars or light trucks. Instead, Congress focused on mandating fuel economy performance, regardless of classifications.

A number of commenters, including Sierra Club, UCS, and Honda, disagreed with the idea that Congress had expressed approval of NHTSA's classification system through its changes in EISA. The commenters argued instead that Congress's failure to address NHTSA's definitions for passenger car and light truck could just as well represent Congress's agreement with the Ninth Circuit's opinion in *CBD,* which found NHTSA's failure to revise its definitions or adequately explain its decision not to revise them to be arbitrary and capricious. UCS referred to Representative Edward Markey's (D-MA) extended comments on the Senate amendments to H.R. 6, which he submitted to the Congressional Record upon EISA's passage, and in which he stated that

> Section 106 is intended to clarify that Title I does not impact fuel economy standards or the standard-setting process for vehicles manufactured before model year 2011. This section is not intended to codify, or otherwise support or reject, any standards applying before model year 2011, and is not intended to reverse, supersede, overrule, or in any way limit the November 15, 2007 decision of the U.S. Court of Appeals for the Ninth Circuit in Center for Biological Diversity v. National Highway Traffic Safety Administration (No. 06-71891).[466]

Sierra Club and UCS argued that Rep. Markey's extended remarks indicate that Congress did not intend to nullify the decision of the Ninth Circuit. Honda also argued that "If [Congress] did not agree with the court order, they would have addressed it in EISA."

NHTSA has carefully considered the discussion of this issue in the extension of remarks by Rep. Markey. No Senate, House, or conference reports were created during the legislative process that culminated in EISA. The floor statements during Congressional consideration of EISA are also sparse. In any event, however, floor statements, regardless of who made them, are entitled to less weight than conference reports (even if they existed here) because they may not represent statements on the final

[466] *See, e.g.,* Representative Markey's insertions at 153 CONG. REC. H14253 (editor's note) and H14444 (daily ed. Dec. 6, 2007) (statement of Cong. Markey).

terms of a bill agreed to by both houses.[467] Various members, including Representative Markey, also inserted material into the *Congressional Record* after floor debate. Materials inserted by members after congressional action are not indicative of congressional intent.[468]

Regardless of the weight that might be accorded to Rep. Markey's remarks, Congress did not amend the definition of "passenger automobile" or direct the agency to amend the definition of that term in the agency's classification regulation, and Rep. Markey's remarks do not contradict, much less address, these points.

Moreover, even if Congress' intent was not to disturb the Ninth Circuit's decision with regard to vehicle classification, NHTSA's action is responsive to the Court's concerns and consistent with the Court's decision. The court said, "Thus, we remand to NHTSA to revise its regulatory definitions of passenger automobile and light truck or provide a valid reason for not doing so." 538 F.3d at 1209. In reaching its conclusion, the court stated that NHTSA had failed to follow a NAS recommendation that NHTSA "tighten" its definition of light truck, "a step EPA has already taken for emissions standards purposes." *Id*. The court did not indicate specifically how it thought NHTSA should change its definitions or what would constitute a valid reason for not doing so.

As explained at length above, NHTSA has, since the court's decision, made significant changes in how it applies its light truck definition and, in this final rule, in one aspect of the definition itself. In order to be classified as off-highway capable, a vehicle

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[467] *See, e.g.*, *In re Burns*, 887 F.2d 1541 (11th Cir. 1989). *See also In re Kelly*, 841 F.2d 908, 913 n. 3 (9th Cir. 1988) ("Stray comments by individual legislators, not otherwise supported by statutory language or committee reports, cannot be attributed to the fully body that voted on the bill. The opposite inference is far more likely.")

[468] *See, e.g., Sigmon Coal Co., Inc. v. Apfel*, 226 F.3d 291, 304-05 (4th Cir 2000) (quoting *INS v. Cardoza-Fonseca*, 480 U.S. 421, 432 n. 12 (1987)), *aff'd sub. nom., Barnhart v. Sigmon Coal Co., Inc.*, 534 U.S. 438 (2002), and *Shannon v. United States*, 512 U.S. 573, 583 (1994).

weighing 6,000 lbs GVWR or less must actually have 4WD. And, only vehicles actually manufactured and sold without second-row seats will be considered as having greater cargo-carrying volume than passenger-carrying volume. The first change has resulted in moving, on average, 1.4 million vehicles from the light truck category to the passenger category in the years covered by this rule. This change will produce an additional 4.5 billion gallons of fuel savings and 54 million metric tons of avoided carbon dioxide emissions. The second change will help prevent any gaming of the tightened definition based on a manufacturer's arbitrary declaration of what constitutes a vehicle's "base form." These changes constitute a very significant tightening of NHTSA's vehicle classification standards, which is what the court indicated was necessary. Moreover, the agency has also explained above in great detail why further changes to its definitions would not improve, and would in fact weaken, the fuel economy standards and accompanying fuel savings.

With regard to the argument that EPA's definitions are "tighter" than NHTSA's, NHTSA notes that this is not an apt comparison for several reasons. First, the NAS Report and the Ninth Circuit are referring to EPA's Tier 2 criteria pollutant emissions requirements for mobile sources.[469] These requirements are different from the CAFE requirements. The effect of having more light trucks on the roads (and thus wanting to limit their classification as light trucks) is greater for criteria pollutant emissions purposes than for CAFE purposes.

Second, EPA continues to use the same definitions as NHTSA does for CAFE purposes.[470] Even though EPA has changed its definitions for Tier 2 purposes, the effect

[469] NAS Report at 88; *CBD*, 538 F.3d at 1209.
[470] See 40 CFR Part 600.002-93.

of those changes was to move only four vehicle models—the Chrysler PT Cruiser, the Chevrolet HHR, the Honda Element, and the Dodge Magnum—whose combined production is currently less than 250,000 per year (less than 20 percent of the number of vehicles reclassified as a result of our tightening the implementation of our vehicle definitions). As discussed above, none of these vehicles currently come in 4WD or meet the 3-row fold-flat requirement, so as currently designed, starting in MY 2012, NHTSA would likely classify these vehicles as passenger cars as well.

And third, after MY 2009, EPA will have no distinction between passenger cars and light trucks for Tier 2 purposes—all vehicles will be subject to the same standard. In summary, EPA's action has little relevance to vehicle classification for CAFE purposes. This is proved by the fact that EPA ultimately intends to do away with the distinction between passenger car requirements and light truck requirements in Tier 2, an option that EPCA would not permit NHTSA to implement for CAFE.

Accordingly, NHTSA believes that the vehicle classification standards and clarification of those standards embodied in this final rule are consistent with Congress's directives in EPCA and EISA, and respond to the Ninth Circuit's decision with regard to vehicle classification.

XII. Flexibility mechanisms and enforcement

This section addresses comments received on the enforcement aspects of the flexibility mechanisms provided by EPCA and EISA for manufacturers in complying with the CAFE standards. These mechanisms include payment of civil penalties or fines; trade, transfer, and application of credits earned for over-compliance; and the manufacturing incentive for dual-fueled automobiles. Section VII.C.5 above addresses comments received with respect to how these flexibility mechanisms interact with the standard-setting process. Additionally, although this section does not repeat NHTSA's overview in the NPRM of the CAFE enforcement program, because no comments were received on it, NHTSA refers interested readers to the discussion in that document at 73 Fed. Reg. 24461 (May 2, 2008).

A. NHTSA's request for comment regarding whether the agency should consider raising the civil penalty for CAFE non-compliance

In the NPRM, NHTSA explained that the civil penalty for failing to comply with a CAFE standard, as adjusted for inflation by law,[471] is $5.50 for each tenth of a mpg that a manufacturer's average fuel economy falls short of the standard for a given model year multiplied by the total volume of those vehicles in the affected fleet (*i.e.*, import or domestic passenger car, or light truck), manufactured for that model year. NHTSA has collected $741.2 million in penalties to date.

NHTSA also explained that EPCA authorizes increasing the civil penalty up to $10, exclusive of inflationary adjustments, if NHTSA decides that the increase in the penalty—

(i) Will result in, or substantially further, substantial energy conservation for automobiles in model years in which the increased penalty may be imposed; and

(ii) Will not have a substantial deleterious impact on the economy of the United States, a State, or a region of a State.[472]

NHTSA explained that it did not intend to change the penalty in this rulemaking, but sought comment on whether it should initiate a proceeding to consider raising the

[471] Federal Civil Penalties Inflation Adjustment Act of 1990, 28 U.S.C. 2461 note, as amended by the Debt Collection Improvement Act of 1996, Pub.L. 104-134, 110 Stat. 1320, § 31001(s).
[472] 49 U.S.C. § 32912(c).

civil penalty, since it recognized that paying penalties could be a less expensive way for manufacturers to comply with CAFE standards than by applying technology or by buying credits from other manufacturers.

GM, Ferrari, Porsche, Volkswagen, Mercedes, and NADA commented that NHTSA should not raise fines and should not initiate rulemaking to consider doing so, because doing so would not substantially improve energy conservation. All manufacturers who commented on this issue took exception with what they considered to be NHTSA's characterization in the NPRM that manufacturers were choosing to pay penalties as a strategic decision instead of adding fuel saving technology to their vehicles. Ferrari, Porsche, Volkswagen, and Mercedes generally argued that because of the nature of their products, increasing fines would not improve their vehicles' fuel economy performance, due to the demands of the market for luxury performance vehicles. Volkswagen and Mercedes both stated that they had already employed many if not all of the technologies considered by NHTSA in the NPRM, and that higher penalties thus would be no incentive for them to apply *more* technology. Porsche and Mercedes argued that raising penalties would only serve to punish "niche manufacturers" offering a limited line of vehicles.

Mercedes also argued that NHTSA had suggested in the NPRM that an increase in civil penalties would be ameliorated by the new regulation permitting credit trading, because Mercedes anticipated that the credit trading market would not likely be very robust.

NADA commented that it is "premature" to initiate proceedings to raise the civil penalties, because "While historically a few manufacturers have found paying civil penalties to be substantially less expensive than installing fuel saving technologies, no evidence exists to suggest that vehicle manufacturers that have never paid a fine will choose to do so rather than attempt to comply with the 2011-2015 standards." NADA argued that NHTSA should only initiate rulemaking to increase penalties when it "can show that vehicle manufacturers are electing to pay fines as an alternative to investing in fuel saving technologies."

In contrast, UCS and ACEEE commented that NHTSA should raise fines in order to compel manufacturers to add more fuel economy-improving technologies to their vehicles.

UCS commented that because the NPRM indicated that "a significant number of manufacturers will opt for civil penalties over compliance with fuel economy requirements," thus, "Increasing the civil penalty would ensure the benefits are actually realized." UCS stated that the penalty has been $5 since EPCA was enacted in 1975, and argued that "inflation has devalued that penalty" over time, such that "A fine of equivalent value today would need to be more than $20 per 0.1 mpg."[473] UCS argued that NHTSA should "use existing authority to increase the CAFE noncompliance civil penalty from $5 to $10 per 0.1 mpg," in order to increase its effectiveness in light of the "escalating economic and environmental importance of energy conservation."

ACEEE also commented that NHTSA should consider raising the penalty. Although ACEEE recognized that historically "the incentive to meet CAFE has been for some manufacturers far greater than the avoided cost of CAFE fines, because those companies, or their shareholders, attach great importance to complying with all applicable laws," it argued that "DaimlerChrysler's payment of substantial fines for MY

[473] UCS cited http://data.bls.gov/cgi-bin/cpicalc.pl, stating "Comparison between 1975 and 2008."

2006 may signal increased willingness on the part of manufacturers to fall short of CAFE standards, even if this means incurring fines." Thus, since even NHTSA recognized that paying penalties may be less expensive than applying technologies to meet CAFE standards, ACEEE concluded that NHTSA should consider raising the penalty.

Agency response: NHTSA will take these comments into consideration in deciding whether to initiate rulemaking to raise the civil penalty for CAFE non-compliance. However, NHTSA wishes to respond to three points raised by commenters at this time. First, as discussed in the NPRM, the CAFE penalty was raised to $5.50 by application of an act of Congress, effective in model year 1998, to account for inflation, and prior to that was $5 since 1975 as stated by UCS. Second, in contrast to Mercedes' comments, NHTSA never suggested in the NPRM that it would consider raising penalties *because of* the additional compliance flexibility allowed by the credit transfer and trading programs. NHTSA may only raise penalties if doing so would "result in, or substantially further, substantial energy conservation," as established by statute. With regard to the manufacturers who argued that their fleet mix forces them to pay penalties, NHTSA would like to clarify that under the attribute-based Reformed CAFE system, each manufacturer has its own required fuel economy level based on its particular mix of vehicles. NHTSA will continue to review the statutory criteria (*i.e.*, whether increased penalties would substantially further energy conservation and the likely economic effects of higher penalties) in deciding whether to initiate rulemaking to raise the civil penalty for CAFE non-compliance.

B. CAFE credits

As discussed in the NPRM, the ability to earn and apply credits has existed since EPCA's original enactment,[474] but the potential for trading credits, *i.e.*, selling credits to other manufacturers or buying credits from them, was first raised in the 2002 NAS Report. NAS found that

> Changing the current CAFE system to one featuring tradable fuel economy credits and a "cap" on the price of these credits appears to be particularly attractive. It would provide incentives for all manufacturers, including those that exceed the fuel economy targets, to continually increase fuel economy, while allowing manufacturers flexibility to meet consumer preferences.[475]

However, as also discussed in the NPRM, Congress did not grant NHTSA authority to implement credit trading and transfer programs[476] until the passage of EISA in December 2007. Section 104 of EISA not only gave NHTSA authority to implement credit trading and transfer programs, but also extended the carry-forward period for credits from 3 to 5 years.

In the NPRM, NHTSA proposed a new Part 536 setting up these two credit programs, and sought comment generally on (1) whether the agency had correctly interpreted Congress' intent; (2) whether there were any ways to improve the proposed credit trading and transferring systems consistent with EISA and Congress' intent that the agency might have overlooked; and (3) whether any of the aspects of the programs proposed by the agency were either inconsistent with EISA and Congress' intent or the rest of the CAFE regulations, or were otherwise unworkable.

NHTSA received a number of comments on the proposed Part 536, which the agency has divided by issue below.

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[474] The credit provision (currently codified at 49 U.S.C. § 32903) was originally section 508 of EPCA's Public Law version.

[475] NAS Report, Finding 11, at 113.

[476] *"Trading" refers to movement of credits between the earning manufacturer and another entity. "Transfer" refers to application of a manufacturer's credits to one of its fleets other than the fleet in which the credits were earned.

Comments regarding credits generally

Who may be credit holders?

NHTSA stated in the NPRM that although only manufacturers may earn credits and apply them toward compliance, NHTSA would allow credits to be purchased or traded by both manufacturers and non-manufacturers in order to facilitate greater flexibility in the credit market.

NHTSA received comments regarding this proposed decision from AIAM, NADA, and the Wisconsin DNR, all of which were in favor of the decision, and generally stated that the additional flexibility in the credit market would facilitate and improve the market for credits. NADA cautioned that it did not believe the market would be particularly robust due to competitive concerns, but did suggest that the market would be enhanced by allowing non-manufacturers to purchase and sell credits.

Agency response: Comments favored the decision to allow non-manufacturers to be credit holders, and because NHTSA continues to believe that this broad definition of "credit holders" best serves the purposes of the credit trading program, this definition will be maintained in the final rule.

When a manufacturer has a shortfall, should NHTSA automatically apply oldest credits first or transfer credits to make up that shortfall?

In the proposed § 536.5, NHTSA proposed to manage some aspects of credit use by manufacturers automatically. For example, NHTSA would debit credits automatically from a manufacturer if the manufacturer fell below the standard in a compliance category, beginning with the oldest credits held by the manufacturer in that compliance category, transferring the oldest available credits in other categories if necessary, and notifying the manufacturer of its need to purchase additional credits, develop a carry-back plan, or pay fines if there were still insufficient credits to achieve compliance.[477] NHTSA was silent in the preamble with respect to its rationale for this proposal.

The Alliance, AIAM, Toyota, and Ford commented on NHTSA's proposal to use a manufacturer's oldest credits first and to transfer credits automatically if the manufacturer did not have sufficient credits in the original compliance category to make up the shortfall. The commenters generally argued that NHTSA was unduly restricting manufacturers' flexibility to manage credits at their own discretion, and that such a proposal was inconsistent with EISA.

The Alliance argued that the "automatic transfer is inconsistent with the history of NHTSA's administration of the CAFE program and EISA," stating that "Congress intended for the manufacturer to manage its own credits" as "acknowledged in the NPRM." The Alliance suggested that NHTSA's explanation in the NPRM that manufacturers should instruct NHTSA which credits to transfer when it wanted to transfer credits indicated that the agency recognized manufacturers' right to control credit transfers. The Alliance argued that "A manufacturer facing a shortfall in a given fleet should retain the flexibility to manage that shortfall as it sees fit, including filing a carryback plan, acquiring traded credits or by a combination of various actions."

AIAM agreed that NHTSA's approach of debiting oldest credits first "should be followed in most cases," but commented that in cases where "a manufacturer prefers to use available credits from some other compliance category or time period first, NHTSA should, upon request by the manufacturer, provide the manufacturer that flexibility." AIAM suggested that manufacturers might "wish to preserve credits in a particular

[477] Proposed § 536.5(d), at 73 FR 24485 (May 2, 2008).

category and year to enhance trading opportunities or to comply with inter-category credit transfer limitations." AIAM also stated that "nothing in [EISA]…mandates that manufacturers must use available credits in any particular order."

Toyota also commented that EISA did not specify a particular order in which credits should be applied, and argued that NHTSA should maximize flexibility in manufacturers' use of credits and allow manufacturers to make their own decisions unless they made decisions inconsistent with the law or unless there was "some clear reason" to restrict flexibility.

Ford argued that NHTSA's proposal to transfer credits automatically to make up manufacturer shortfalls was "inconsistent with EISA," because the statutory language with regard to the credit transfer program was permissive, stating that the Secretary of Transportation shall establish a regulation to "allow" manufacturers to transfer credits and apply them to different compliance categories in order to achieve compliance. Ford suggested that the automatic transfer of credits by NHTSA would interfere with manufacturers' flexibility to decide how to manage a shortfall. For example, Ford argued, a manufacturer may prefer to submit a carry-back plan rather than to transfer surplus credit to another category, and EISA did not give NHTSA the discretion to interfere in the manufacturer's decision in that regard.

Agency response: NHTSA did not intend to allocate credits without allowing the manufacturer an opportunity to comment. NHTSA agrees with the commenters that manufacturers must ultimately be responsible for how their shortfalls are addressed, and has revised the regulatory text accordingly.

EPCA originally stated, with regard to conventional carry-forward/carry-back credits, that application of credits was to occur automatically ("shall apply") if a manufacturer was short of the average fuel economy required and had credits available. The application of those credits offset any penalty to be paid by the manufacturer. 49 U.S.C. § 32903(d). EISA did not change that provision. However, EISA did introduce the two new credit programs for transfers and trades.

In the past, NHTSA developed carry-forward plans for manufacturers automatically if carry-forward credits existed, and submitted the plan to the manufacturer so that it could comment on the proposed allocation plan. Only if no carry-forward credits were available would NHTSA ask the manufacturer to submit a carry-back plan or to pay a fine.

Upon further review the agency has decided that Congress clearly intended to give the manufacturer an opportunity to comment before any application of credits occurs. *See* 49 U.S.C. § 32903(d). Accordingly, we have revised the text so that instead of NHTSA allocating credits automatically, a manufacturer with credits available will be required to submit a credit allocation plan to offset its confirmed shortfall. NHTSA will require manufacturers to submit a plan whenever NHTSA is informed by EPA that a manufacturer has not met the CAFE standards in a particular compliance category. An enforcement action will be initiated each time the agency receives notification from EPA that a standard has not been met. An enforcement letter will be sent to the responsible manufacturer identifying available credits and requesting that a credit allocation plan be submitted or penalty be paid. NHTSA will review and accept plans as received and allocate credits accordingly.

Should credits be denominated in mpg or in gallons for purposes of transfers and trades?

49 U.S.C. § 32903(c) indicates that Congress intended credits to be denominated in tenths of a mpg, but 49 U.S.C. § 32903(f) states that total oil savings must be preserved when trading credits. Because there is no similar caution that total oil savings must be preserved when *transferring* credits, NHTSA proposed in the NPRM to denominate credits in mpg rather than in gallons, the agency also sought comment on whether transferred credits should be denominated in gallons to ensure that no transfers resulted in any loss of fuel savings. When using the terms "denominating credits in gallons," the agency meant that credits be adjusted to preserve total oil savings as specified for credit trades in §32903 (f). Section §32903 (c) defines credits as the number of tenths of a mile per gallon the average fuel economy of a fleet exceeds the standard times the number of vehicles in that manufacturer's fleet. Therefore, credits should always be denominated in miles per gallon.. In the comments below, those who argue that credits should be denominated in mpg are opposing any adjustment to credit transfers to prevent losses in fuel savings.

The Alliance, AIAM, NADA, and Toyota commented that NHTSA should denominate credits in mpg. The commenters generally argued that because § 32903(c) indicates that credits are to be denominated in tenths of mpg, and because Congress did not specify in EISA that oil savings must be preserved in credit transfers, the agency should not attempt to read anything into the statute that is not plainly there. AIAM also stated that, "Using different units for transferred credits and other credits, as mentioned by the agency, would create unnecessary confusion and could create accounting problems." Toyota argued that "Since Congress specified the application of an adjustment factor for traded credits but did not specify such a requirement for transferred credits, the clear intent of Congress is that it intended transferred credits to be calculated in the same manner as carryforward/carryback credits."

Honda and EDF commented that NHTSA should denominate credits in gallons rather than in mpg. Honda stated that "trading MPG will erode the total fuel/GHG reductions, which is not appropriate," and argued that EISA did not prohibit trading credits in gallons instead of mpg, because it simply addresses the maximum *increase* that manufacturers may obtain from transferred credits, not the maximum decrease.

EDF commented that denominating credits in gallons instead of mpg "would be a more straightforward and simple way for the Agency to ensure that total oil savings are preserved in trading, banking and borrowing of CAFE credits," and would also "maximize the environmental integrity of the program." EDF stated that NHTSA had correctly identified the risk that "increasing fuel economy by one mpg at a higher fuel economy level results in less oil savings (and therefore less reductions in GHGs) than increasing fuel economy by one mpg at a lower fuel economy level." EDF argued that in order to promote the need of the nation to conserve energy, "Expressing CAFE credits in gallons of fuel saved, rather than in mpg, would be a natural, and less confusing, way to present the oil saving benefits from exceeding the standard (or the 'oil-saving-deficit' as a result of non-compliance)."

Agency response: Based on the discussion above, we believe that credits must be denominated in mpg per §32903(c)(1). The question is whether all credits, traded and transferred, should be adjusted to preserve fuel oil savings. With the exception of

§32903(c) and § 32903(f), there does not appear to be other expression of congressional intent in the text of the statute suggesting that NHTSA would have authority to adjust transferred credits to preserve oil savings. Thus, NHTSA will adjust credits to maintain fuel savings when credits are traded and used but will not adjust transferred credits that were not acquired by trade. If credits are traded to a non-manufacturer, the credits will not be subject to the adjustment factor until they are actually used by a manufacturer for compliance.

Comments regarding carry-forward/carry-back credits:

When should EISA's extension of the carry-forward period from 3 to 5 years take effect?

When Congress changed the carry-forward period from 3 to 5 years in EISA, it did not clearly specify to which credits that change was to apply. EISA's effective date was December 20, 2007, and NHTSA has historically defined the model year as beginning on October 1 of the previous calendar year (thus, the agency would define MY 2008 as beginning on October 1, 2007).[478] In the NPRM, NHTSA concluded that because EISA was enacted in the middle of MY 2008, the best interpretation of when the extension of the carry-forward period should take effect was to apply it only to vehicles manufactured in or after MY 2009. Interpreting the change as applying to all subsequent MY 2008 vehicles would have required the agency to find some way to prorate the change in credit lifespan, which the agency concluded would present considerable administrative difficulty, especially given that credits are denominated by year of origin

[478] *See* Letter of Interpretation to William Shapiro of Volvo Cars, Jan. 13, 2000, *available at* http://isearch.nhtsa.gov/files/18644KWII.ogms.html (last accessed Sept. 18, 2008), and Letter of Interpretation to William F. Canever of Ford Motor Company, Oct. 22, 1990, *available at* http://isearch.nhtsa.gov/files/2741y.html (last accessed Sept. 18, 2008).

and not month and year of origin. Thus, the agency added regulatory text stating that credits earned in MY 2008 or before had a 3-year carry-forward lifespan, and credits earned in MY 2009 or later had a 5-year carry-forward lifespan.

AIAM, Toyota, Chrysler, and NADA commented on this issue, and all argued that Congress intended the 5-year carry-forward provision to be effective concurrent with EISA's effective date. AIAM stated that it believed that any credits earned and not expired as of the effective date of EISA, including MY 2005-2007 credits, must be available for use in any of the five following model years. AIAM argued that if Congress had intended the 5-year carry-forward period to begin in MY 2009, it would have included such a limitation, as it included the provision disallowing transfers of credits earned before MY 2011. AIAM thus concluded that to maximize flexibility in use of credits, "enhancements to the credit system mandated by Congress must be made effective immediately, except where Congress has specified otherwise."

Toyota also commented that because Congress included an express start date for credit transfers, it must have intended that the 5-year carry-forward provision be effective on EISA's effective date. Toyota argued that Congress did address which credits could be used for 5-year carry-forward plans by stating in 49 U.S.C. § 32903(a) that when a manufacturer earns credits under this section, those "credits may be applied to—

(1) Any of the 3 consecutive model years immediately before the model year for which the credits are earned; and

(2) *to the extent not used by paragraph (1) of this subsection*, any of the 5 consecutive model years immediately after the model year for which the credits are earned. (Toyota's emphasis)

Toyota argued that Congress thus "clearly identifies the credits that are available for the 5-year carry-forward provision as being those that are not applied to the 3-year carry-back provision," and that Congress put no other limitation on when the 5-year carry-forward credits may be used. Toyota concluded that because the intent of Congress is clear in the statutory language, the agency has no room for interpretation under *Chevron*.

NADA also commented that "Credit system changes set out in EISA should take effect immediately, except as otherwise specified." NADA argued that even though the transfer provisions "may not take effect until MY 2011, any existing and future earned credits should immediately be available for the new five year carry-forward period and for trading."

Chrysler also commented that because Congress had chosen to put specific effective dates in some credit provisions but not in the carry-forward provision, the 5-year carry-forward provision must be applicable to MY 2008 credits. Chrysler argued that NHTSA's arguments regarding the difficulty of prorating MY 2008 credits were unavailing, because NHTSA could simply apply the 5-year carry-forward provision to all credits earned in MY 2008 and after. Chrysler further argued that NHTSA has "not felt it necessary to pro-rate credits (or penalties) when transfers of ownership take place, instead assigning the full year's credits (or penalties) to a single manufacturer, as agreed to among the parties involved." Chrysler also stated that "when carry-forward/carry-back credits were extended from 1 to 3 years as a result of the Automobile Fuel Efficiency Act of 1980 … NHTSA did not see any need to pro-rate credits. Instead, the agency's final rule [ ] had an immediate effective date." Chrysler suggested that if the agency is determined to prorate the MY 2008 credits, "it can simply divide the number of days after enactment but before October 1, 2009 (which is 285 days) by 365 and then multiply the credits earned in MY 2008 by the resultant (0.781)."

Agency response: NHTSA has decided to revise the implementation of the 5 year carry-forward allowance by changing the effective date from MY 2009 to MY 2008. As discussed, because EISA was enacted in the middle of MY 2008, NHTSA concluded in the NPRM that the best interpretation of this change in lifespan was to apply it only to vehicles manufactured in or after MY 2009, because the alternative of finding some way to prorate the change in lifespan presented considerable administrative difficulties.

However, 49 U.S.C. § 32903(b)(2) specifies that credits are available to a manufacturer at the end of the model year in which earned. Due to the fact that the MY 2008 credits were not finalized when EISA became effective, the agency agrees that it is reasonable to begin the 5-year carry-forward provision in MY 2008. The agency does not believe that this provision should be applied to all unexpired credits (MYs 2005-2007) as suggested by AIAM, but only to those credits that are actually earned in MY 2008 or after.

Can carry-forward/carry-back credits not acquired by trade or transfer be used to meet the minimum domestic passenger car standard?

Through EISA, Congress clearly intended to limit the use of traded or transferred credits by manufacturers in order to achieve compliance with the minimum domestic passenger car standards specified in Section 102(b)(4). *See* Section 104 (a)(4), codified (in relevant part) at 49 U.S.C. § 32903(f)(2) and (g)(4), respectively. In NHTSA's proposed regulatory text, the agency included these prohibitions, and also stated as follows:

> If a manufacturer's average fuel economy level for domestically manufactured passenger cars is lower than both the attribute-based standard and the minimum standard, then the difference between the attribute-based standard and the minimum standard may be relieved by the use of credits, but the difference between the minimum standard and the manufacturer's actual fuel economy level may not be relieved by credits and will be subject to penalties.[479]

NHTSA did not explain its reasoning in the NPRM for this provision, which prompted comments from a number of companies, including the Alliance, Chrysler, Ford, GM, and Toyota.

The commenters stated that the proposed § 536.9(d) improperly prevents manufacturers from employing carry-back and carry-forward credits to meet the minimum domestic passenger car standard. The commenters argued that Congress only explicitly prohibited the use of *traded* and *transferred* credits to meet the minimum domestic passenger car standard, but did not explicitly prohibit the use of originating manufacturer carry-forward/-back credits, and that therefore NHTSA should not assume that Congress intended more than it expressly stated. The commenters further stated that NHTSA was unduly and unnecessarily restricting manufacturers' flexibility in using credits to meet the standards, when the purpose of the carry-forward/carry-back allowances was to maximize flexibility.

Chrysler further argued that although "NHTSA may have assumed that the use of the word *minimum* [in EISA § 102(b)(4)] might imply that the actual level of the standard each year may be attained to ensure compliance," this would be inconsistent with NHTSA's own regulations that allow the use of credits to meet average fuel economy standards for cars and light trucks that NHTSA refers to as "minimum" levels.[480] Chrysler suggested that the minimum domestic passenger car standard was simply a "new

[479] 73 FR 24487 (May 2, 2008); proposed section 49 CFR § 536.9(d).
[480] Chrysler cited 49 CFR § 531.2 and § 533.2.

category" of standards, and that "allowing the use of carry-forward/carry-back credits does not spoil the statutory scheme nor does it result in reduced fleet fuel economy, since credits for exceeding the minimum standard must ultimately be earned."

Ford also further argued that because the compliance provision of EPCA, 49 U.S.C. § 32911(b), includes all fuel economy standards under § 32902, and states that "Compliance is determined after considering credits available to the manufacturer under section 32903 of this title," that credits may be used to meet the minimum domestic passenger car standard just as they may be used to meet the passenger car and light truck standards.

Agency response: NHTSA agrees with the commenters that Congress did not clearly establish in EISA that carry-forward and carry-back credits may not be used to comply with the minimum domestic passenger car standard, unlike traded and transferred credits which clearly may *not* be used, per § 32903(f)(2) and (g)(4). As Ford argued in its comments, 49 U.S.C. § 32903(a), which provides for the carry-forward and carry-back periods, expressly states that credits may be earned for exceeding "an applicable average fuel economy standard under subsections (a) through (d) of section 32902." Congress included the minimum domestic passenger car standard requirement in § 32902(b)(4), which indicates that Congress both intended for manufacturers to be able to earn credits for exceeding it, and to be able to use carry-forward and carry-back credits to achieve compliance with it.

A manufacturer's actual CAFE value may be above or below both or only one of its corresponding attribute-based or minimum standards. Also, a manufacturer's attribute-based standard may be above or below its corresponding minimum standard.

For each situation it must be clear how credits can be earned and allocated. 49 U.S.C. § 32903(a) states that credits are earned when a manufacturer "exceeds an applicable average fuel economy standard under subsections (a) through (d) of section 32902," which includes the minimum domestic passenger car standard under 32902(b)(4). To determine a credit excess or shortfall, a manufacturer's actual CAFE value is compared against either the attribute-based standard value or the minimum standard value, whichever is larger. Also, if a manufacturer's actual CAFE value is less than the minimum standard, only conventional carry-forward and carry-back credits earned by the originating manufacturer can be used to offset the shortfall between the actual CAFE value and the minimum standard.

Whether pre-MY 2011 passenger car credits may be carried forward for 5 years

AIAM requested that "NHTSA confirm that pre-2011 passenger auto credits, which are compiled separately for domestic and import fleets of a manufacturer, may be carried forward into 2011 and later years (subject to the 5 year limitation)."

Agency response: As NHTSA explained above, the agency has decided to apply the 5-year carry-forward provision to all credits earned in MY 2008 and after. Thus, credits earned in MYs 2008, 2009, and 2010 would be available to manufacturers through MY 2013, 2014, and 2015, respectively. However, credits earned before MY 2008 remain subject to the 3-year carry-forward lifespan, which means that a credit earned in MY 2007 would expire at the end of the MY 2010 model year, and not be available for MY 2011 or later.

Whether there is a cut-off date for consideration and use of carry-back credits

AIAM also requested that NHTSA confirm that the proposed § 536.7(e) "is not intended to establish an arbitrary cut-off date for consideration of carry-back credits." The proposed § 536.7(e) states that carry-back credits "from any source" may not be used for compliance more than three years after the non-compliance. AIAM argued that because "Precise final CAFE values are not established by the end of a model year," and because "Final determination of CAFE may be delayed for a significant period of time, due to the need for EPA to verify the data and to report to NHTSA," that therefore "Manufacturers should be permitted to develop a compliance approach based on credits, even if the final accounting takes place more than 3 years after the noncompliance." AIAM concluded that "A manufacturer should not be prohibited from carrying back credits for the three model year period based on administrative delays in establishing final CAFE calculations."

Agency response: NHTSA did not intend for the proposed § 536.7(e) to suggest that the agency meant to change the 3-year carry-back provision. As specified in § 536.7(a), credits earned in any model year may be used in carry-back plans approved by NHTSA, pursuant to 49 U.S.C. § 32903(b), for up to three model years prior to the years in which the credits were earned. As further specified in § 536.7(c), NHTSA will determine ultimate compliance with the approved carry back plan upon receipt of the final verified CAFE model year figures received from EPA. NHTSA recognizes that because manufacturers have 90 days after the end of the model year to submit final CAFE fleet numbers to EPA, and because it may take up to several months after that before EPA can validate the final data and report back to the manufacturer and NHTSA, that it is possible that the literal 3-year period may be exceeded. NHTSA will revise the regulatory text to clarify that there is no expiration or cut-off date associated with this process or with available carry-back credits.

Comments regarding credit trading issues

When should the credit trading program begin?

In the NPRM, NHTSA proposed to begin the credit trading program with credits earned in MY 2011 or later. AIAM commented that because EISA established a 2011 effective date for credit *transfers*, but added no specific effective date for credit *trades*, Congress must have intended "to not limit the trading system." Thus, AIAM supported an immediate effective date for trading of all credits in existence as of December 20, 2007.

Agency response: NHTSA disagrees with AIAM that it must allow all credits in existence as of December 20, 2007 to be immediately tradable. Although Congress mandated in EISA that NHTSA establish a credit transfer program, it gave the agency discretion to establish a credit trading program. Part of the agency's discretion in establishing a credit trading program lies in deciding when it should begin. While NHTSA supports flexibility in manufacturer use of credits, particularly given the stringency of the MY 2011-2015 standards, NHTSA believes that it is logical for credit trading to begin in MY 2011, at the same time as the new standards take effect, and be limited to credits earned in or after MY 2011. Allowing credit trading to include credits earned prior to MY 2011 could provide a windfall of credits for manufacturers currently exceeding, for example, the 27.5 mpg passenger car standard, which NHTSA believes would be inconsistent with Congress' intent in allowing the agency to develop a credit trading program. Additionally, for ease of implementation and management of the credit trading and transferring programs, the agency continues to believe that both programs should commence for credits earned after 2010, as Congress has stipulated for transferred credits.

How should NHTSA calculate the adjustment factor for trades to preserve total oil savings?

Congress stated in EISA that any credit trading program established must be set up "such that the total oil savings associated with manufacturers that exceed the prescribed standards are preserved when trading credits to manufacturers that fail to achieve the prescribed standards." EISA Sec. 104, to be codified at 49 U.S.C. § 32903(f)(1). NHTSA explained in the NPRM that EISA requires total oil savings to be preserved because one credit is not necessarily equal to another, as Congress realized. For example, the fuel savings lost if the average fuel economy of a manufacturer falls one-tenth of a mpg below the level of a relatively low standard are greater than the average fuel savings gained by raising the average fuel economy of a manufacturer one-tenth of a mpg above the level of a relatively high CAFE standard.

In order to ensure that total oil savings are preserved in credit trades, NHTSA proposed to subject traded credits to an adjustment factor. NHTSA explained that the effect of applying the adjustment factor would be to increase the value of credits that were earned for exceeding a relatively low CAFE standard and are intended to be applied to a compliance category with a relatively high CAFE standard, and to decrease the value of credits that were earned for exceeding a relatively high CAFE standard and are intended to be applied to a compliance category with a relatively low CAFE standard.

NHTSA proposed to multiply the value of each credit (with a nominal value of 0.1 mpg per vehicle) by an adjustment factor calculated by the following formula:

$$/A = \left(\frac{VMTe * \left(\left(\frac{1}{MPGe} \right) - \left(\frac{1}{MPGe - 0.1} \right) \right)}{VMTu * \left(\left(\frac{1}{MPGu} \right) - \left(\frac{1}{MPGu - 0.1} \right) \right)} \right)$$

Where A = adjustment factor applied to traded credits by multiplying mpg for a particular credit;

VMT_e = lifetime vehicle miles traveled for the compliance category in which the credit was earned (152,000 miles for domestic and imported passenger cars; 179,000 miles for light trucks);

VMT_u = lifetime vehicle miles traveled for the compliance category in which the credit is used for compliance (152,000 miles for domestic and imported passenger cars; 179,000 miles for light trucks);

MPG_e = fuel economy standard for the originating manufacturer, compliance category, and model year in which the credit was earned;

MPG_u = fuel economy standard for the manufacturer, compliance category, and model year in which the credit will be used.

NHTSA further explained it was proposing to use the fuel economy standard in the formula rather than the actual fuel economy or some average of the two, primarily because we believe it will be more predictable for credit holders and traders. However, we sought comment on those two alternatives, since they may be more precise in their ability to account for fuel savings.

Several commenters addressed NHTSA's proposal to use the fuel economy standard rather than the actual fuel economy in the adjustment factor formula. AIAM "agree[d] that [NHTSA's] approach is sensible and facilitates record keeping," and argued that "The proposed approach would encourage credit trading by valuing credits at a higher level, thereby providing an additional incentive for manufacturers to exceed the standards by substantial margins."

Cummins, Inc., commented instead that the adjustment factor formula should include "actual fuel economy" achieved by the manufacturer instead of "target fuel economy," because doing so "would ensure that total fuel savings are preserved." Cummins further commented that NHTSA should apply the adjustment factor to both trades and transfers, which would "ensure that we are meeting the EISA's objective of reducing the United States' dependence on oil.

Wisconsin DNR commented that using either actual fuel economy or an average of actual and formula-based fuel economy in calculating the adjustment factor would be preferable to NHTSA's proposed approach of using the fuel economy standard. Wisconsin DNR argued that "The proposed approach inflates the actual fuel economy achieved and reduces the net benefit in terms of fuel savings and pollution reductions."

ACEEE, in contrast, commented that the adjustment factor formula "does not ensure oil savings," and that the use of any formula is inappropriate, because "The increase in fuel economy in one compliance category needed to offset the additional fuel consumption associated with a shortfall in fuel economy in another compliance category can be expressed precisely, in closed form, and this should be required by the rule." ACEEE argued that the formula's use of a "linear approximation to a non-linear function" makes it inherently imprecise, and that that imprecision may result in errors that are "far from negligible." ACEEE presented the following example:

> If . . . one manufacturer exceeds a 22 mpg standard by 2 mpg and wishes to trade credits to a manufacturer falling short of a 34 mpg target (in a compliance category with the same lifetime vehicle miles traveled), the proposed adjustment factor would allow the second manufacturer to use those credits to comply at 29.2 mpg. The result would be that the extra fuel consumed by the second manufacturer's vehicles exceeds the fuel saved by the first manufacturer's vehicles by 21 percent.

ACEEE argued that this result was unacceptable and "inconsistent with the requirements of EISA."

Honda and Toyota both commented on the "lifetime vehicle miles traveled" estimates used as constants in the adjustment factor formula. Honda expressed concern "about the use of different lifetime mileage for cars versus light trucks," due to the rise in fuel prices changing driving behavior, and stated that "the separate lifetime mileage for cars and light trucks based upon historical data may be inappropriate when applied to current and future markets."

Toyota commented that "NHTSA may need to adjust those mileage accumulation rates to reflect alignment with the types of vehicles that NHTSA expects to be classified as cars and trucks in the future," suggesting that, as an example, "moving some portion of 2WD SUVs to the car compliance category would tend to raise the average car lifetime mileage accumulation and lower the average truck lifetime mileage accumulation." Toyota argued that "To the extent possible, NHTSA should ensure that the VMT rates in the adjustment equation reflect the vehicles in each category."

Agency response: The agency has re-evaluated the adjustment factor proposed in the NPRM based upon the comments received. Various formulas for the adjustment factor could be derived in an attempt to ensure total fuel oil savings are preserved, which are dependent on assumptions made relating to fuel prices, rebound affects and vehicle miles traveled (VMT). The relationship between fuel (gallons) saved or lost as fuel economy (mpg) increases or decreases is non-linear. The effect of applying an adjustment factor would be to increase the value of credits that were earned for exceeding a relatively low CAFE standard and to decrease the value of credits that were earned for exceeding a relatively high CAFE standard. Furthermore, the fuel savings lost if the average fuel economy of a manufacturer falls one-tenth of a mpg below the level of a given standard are greater than the fuel savings gained by raising the average fuel economy of a manufacturer one-tenth of a mpg above the level of the same or higher CAFE standard.

The NPRM formula set the adjustment factor at the ratio of the inverse of the earner's (seller) and the user's (buyer) CAFE target standard values, modified for the total vehicle miles traveled (VMT) by compliance category. For example, if one manufacturer with an attribute-weighted target standard of 21 mpg, and another manufacturer with an attribute-weighted target standard of 25 mpg, and the VMT was constant, then the adjustment factor was approximately 1.19 (the ratio of the inverse of the two target standard values, 25/21 = 1.19). This adjustment factor is accurate as long as the actual fuel economy values of the earner and user are close to their respective CAFE target standard values. However, ACEEE commented correctly that if the actual fuel economy values for the seller and/or buyer are several mpg different from their respective target standard values, using only the CAFE standard in the adjustment factor formula could produce an adjustment factor that provides the buyer with more fuel savings than the seller actually saved.

NHTSA believes that this issue can be resolved with a revised adjustment factor formula that sets the adjustment factor at the ratio of the average fuel savings per mpg achieved by the originating manufacturer and average fuel savings needed per mpg required by the user. This approach ensures that fuel oil savings are preserved by applying an adjustment to each credit based upon each credit's "fuel oil value." As an example, in a trade situation there is a seller (earner) who has excess credits to sell and a buyer (user) who has a credit deficit. Consider a seller and a buyer with the following situations, as described in the table below:

	Seller (earner)	**Buyer (user)**
Actual fuel economy………	31.0 mpg	16.0 mpg
Target fuel economy………	30.0 mpg	20.0 mpg
Fleet production volume…..	700,000 vehicles	10,000 vehicles
Car fleet total lifetime miles traveled……………………	150,992 miles	150,992 miles
Amt fuel used at target FE over life of all vehicles in fleet………………………....	(150,992 miles) x (700,000 vehicles) x (1/30 mpg) = 3,523,146,667 gallons	(150,992 miles) x (10,000 vehicles) x (1/20mpg) = 75,496,000 gallons
Amt fuel used at actual FE over life of all vehicles in fleet………………………....	(150,992 miles) x (700,000 vehicles) x (1/31mpg) = 3,409,496,774 gallons	(150,992 miles) x (10,000 vehicles) x (1/16.0mpg) = 94,370,000 gallons
Total fuel saved for seller; total excess fuel used for buyer……………………….	3,523,146,667 – 3,409,496,774 = 113,649,893 gallons	94,370,000 – 75,496,000 = 18,874,000 gallons
Credits earned (for seller)/needed (for buyer)….	(31.0 – 30.0) x 10 x 700,000 = 7,000,000 credits	(20.0 - 16.0) x 10 x 10,000 = 400,000 credits
Rate (gallons/credit)……….	113,649,893 / 7,000,000 = 16.2357 gal/credit	18,874,000 / 400,000 = 47.1850 gal/credit

Assume that the buyer wants to purchase only enough seller credits to offset half of its 400,000 credit shortfall. The buyer needs to purchase 9,437,000 (18,874,000/2) gallons worth of credits from the seller. If each seller credit is worth 16.2357 gallons as calculated above then the number of seller credits that must be purchased by the buyer is

(9,437,000 gal)/(16.2357gal/credit) = 581,250 credits

Thus, the buyer must purchase 581,250 credits of the seller's 7,000,000 available credits.

To depict this relationship as an adjustment factor A = (buyer gal/credit) / (seller gal/credit)

A = 47.1850/16.2357 = 2.9062 (rounded to four decimal places)

The buyer has to multiply the credit shortfall it wants to offset by the adjustment factor to determine the number of seller credits that must be obtained from the seller as follows:

(200,000 credit shortfall) x (A) = 581,240 seller credits required

(rounded to the nearest integer)

The following adjustment factor equation is derived from the above example:

$$A = \left(\frac{VMTu \quad * \ MPGae \quad * \ MPGse}{VMTe \quad * \ MPGau \quad * \ MPGsu} \right)$$

Where:

A	=	Adjustment Factor applied to traded credits to ensure fuel oil savings is preserved (rounded to four decimal places);
VMTe	=	Lifetime vehicle miles traveled for the compliance category in which the credit was earned: 150,992 miles for domestically manufactured and imported passenger cars, 172,552 miles for light trucks;
VMTu	=	Lifetime vehicle miles traveled for the compliance category in

which the credit is used for compliance: 150,992 miles for domestically manufactured and imported passenger cars, 175,552 miles for light trucks;

<u>MPGse</u> = Fuel economy target standard for the originating manufacturer, compliance category, and model year in which the credit was earned;

<u>MPGae</u> = Actual fuel economy value for the originating manufacturer, compliance category, and model year in which the credit was earned.

<u>MPGsu</u> = Fuel economy target standard for the user, compliance category, and model year in which the credit is used for compliance;

<u>MPGau</u> = Actual fuel economy value for the user manufacturer, compliance category, and model year in which the credit is used for compliance.

The revised adjustment factor thus includes both actual fuel economy value and the fuel economy targets to which the buyer and seller are subject, and helps to ensure that total fuel savings are preserved in trades.

Additionally, as noted above, Honda and Toyota commented that the agency should evaluate and possibly revise the values of the passenger car and light truck total vehicle miles traveled (VMT) values used in the adjustment factor equation.

Agency response: The agency agrees with the commenters that the VMT values should be revised. VMT is an important value used in the adjustment equation because it defines a vehicle's total lifetime miles traveled. The agency has moved over a million 2WD sport utility vehicles into the passenger car fleet every year from MYs 2011 through 2015. Also, the agency has moved to a higher fuel price forecast, which by way of the rebound effect lowers the VMT each year in every vehicle compliance category. For modeling purposes, four classes of VMT are used: passenger car, pickup, van and SUV. Table X-1 below shows the survival rates for passenger cars and light trucks (one survival rate applies to all three truck classes) and the average annual miles driven for each vehicle class.

In general, light trucks are driven more miles per year and survive more years than passenger cars. Among the light truck vehicle classes, SUVs are driven the most miles, while vans are driven the least. Changes in the analysis from the NPRM to the final rule include moving over seven million SUVs over the 2011-2015 model years that were classified as light trucks in the NPRM to the passenger car classification in the final rule. This means that the car VMT described in the NPRM must be adjusted to include these reclassified vehicles. The light truck fleet VMT must also be adjusted because the light truck fleet now has less SUVs. Over the five model years affected by this rule, the passenger car fleet now contains 47.04 million vehicles. There are 39.86 million vehicles that were classified as passenger cars in the NPRM (84.7 percent), plus 7.18 million SUVs (15.3 percent) that are reclassified as passenger cars in the final rule. The truck fleet over the five model years contains 35.77 million vehicles – 41.4 percent are pickups, 43.9 percent are SUVs, and 14.7 percent are vans. This reflects a reduction in SUVs in the truck fleet from the NPRM to the final rule.

In each fleet, the adjusted VMT in each year is the sum of the vehicle classes weighted by survival rate and market share. Adjusted car VMT equals the car VMT times the car survival rate times the car market share (84.7 percent), plus the SUV VMT times the SUV survival rate times the proportion of SUVs in the car fleet (15.3 percent).

$$\text{Adjusted Car VMT}_t = \text{Car VMT}_t * \text{Car Survival}_t * 0.847 + \text{SUV VMT}_t * \text{SUV Survival}_t * 0.153,$$
where t denotes model year

Adjusted truck VMT equals the pickup truck VMT times the pickup truck survival rate times the pickup truck market share (41.4 percent), plus the SUV VMT times the SUV survival rate times the proportion of SUVs in the truck fleet (43.9 percent), plus the van VMT times the van survival rate times the proportion of vans in the truck fleet (14.7 percent).

$$\text{Adjusted Truck VMT}_t = \text{Pickup VMT}_t * \text{Pickup Survival}_t * 0.414 + \text{SUV VMT}_t * \text{SUV Survival}_t * 0.439 + \text{Van VMT}_t * \text{Van Survival}_t * 0.147,$$
where t denotes model year

Total VMT is the sum over 36 years for the adjusted car and truck VMT. For passenger cars, the adjusted VMT is 150,922 miles. For light trucks, the adjusted VMT is 172,552 miles.

Table XII-1. Adjusted VMT for cars and trucks by vehicle age

Vehicle Age	% Surviving to Age: Cars	Light Trucks	Average Annual Miles Driven at Each Age: Car	SUV	Pickup	Van	Adjusted VMT by Age: Car	Light Truck
1	99.5%	99.5%	12,885	14,689	15,229	14,734	13,095	14,845
2	99.0%	97.4%	12,641	14,251	14,688	14,401	12,724	14,080
3	98.3%	96.0%	12,377	13,827	14,157	14,043	12,337	13,440
4	97.3%	94.2%	12,094	13,415	13,637	13,664	11,902	12,758
5	95.9%	91.9%	11,796	13,016	13,128	13,265	11,415	12,038
6	94.1%	89.1%	11,484	12,628	12,630	12,850	10,878	11,285
7	91.9%	85.9%	11,160	12,252	12,146	12,421	10,295	10,508
8	89.2%	82.3%	10,825	11,887	11,674	11,981	9,673	9,717
9	86.0%	78.3%	10,483	11,533	11,216	11,532	9,021	8,924
10	82.5%	74.0%	10,135	11,190	10,772	11,078	8,351	8,141
11	78.7%	69.6%	9,783	10,857	10,344	10,620	7,673	7,380
12	71.7%	65.0%	9,429	10,533	9,930	10,161	6,774	6,650
13	61.3%	60.4%	9,075	10,220	9,533	9,705	5,653	5,957
14	50.9%	55.2%	8,722	9,915	9,153	9,253	4,600	5,242
15	41.4%	50.1%	8,374	9,620	8,789	8,808	3,675	4,587
16	33.1%	45.2%	8,032	9,334	8,444	8,374	2,896	3,990
17	26.0%	40.6%	7,698	9,056	8,117	7,952	2,261	3,455
18	20.3%	36.3%	7,374	8,786	7,809	7,545	1,755	2,979
19	15.7%	32.4%	7,061	8,524	7,521	7,156	1,358	2,559
20	12.0%	28.7%	6,763	8,271	7,253	6,788	1,051	2,193
21	9.2%	25.4%	6,481	8,024	7,006	6,443	815	1,874
22	7.0%	22.4%	6,217	7,785	6,781	6,124	634	1,599
23	5.3%	19.8%	5,972	7,553	6,577	5,833	495	1,362
24	4.0%	17.4%	5,750	7,329	6,396	5,573	389	1,160
25	3.0%	15.2%	5,551	7,110	6,239	5,348	307	988
26	2.3%	13.3%	5,379	6,899	6,105	5,158	244	841
27	0.0%	11.7%	0	6,693	5,996	5,008	119	717
28	0.0%	10.2%	0	6,494	5,912	4,899	101	612
29	0.0%	8.9%	0	6,300	5,853	4,835	86	523
30	0.0%	7.7%	0	6,113	5,821	4,818	72	448
31	0.0%	6.7%	0	6,113	5,821	4,818	63	390
32	0.0%	5.9%	0	6,113	5,821	4,818	55	340
33	0.0%	5.1%	0	6,113	5,821	4,818	48	295
34	0.0%	4.4%	0	6,113	5,821	4,818	41	257
35	0.0%	3.9%	0	6,113	5,821	4,818	36	223
36	0.0%	3.3%	0	6,113	5,821	4,818	31	194
Lifetime	--	--	233,540	330,781	313,784	299,278	150,922	172,552

Comments regarding credit transfer issues

Whether NHTSA should prevent credits received by trade from being transferred in quantities beyond the transfer cap

In the NPRM, NHTSA proposed to allow manufacturers to transfer credits that they had obtained by trade from one compliance category to another, but not to allow credits obtained by trade and subsequently transferred to be used to exceed the statutory cap on increases in a manufacturer's fuel economy attributable to transferred credits under 49 U.S.C. § 32903(g)(3).

AIAM and Volkswagen commented that NHTSA should not limit the benefit of cross-compliance category trades via the cap on transfers. AIAM argued that a trade from, for example, Manufacturer A's passenger car fleet to Manufacturer B's light truck fleet should be considered a direct trade, rather than a trade followed by a transfer as NHTSA indicated in the NPRM. AIAM stated that "The agency's limitation is inconsistent with the express language of Congress in applying the maximum credit limit only to credit transfers." VW argued that unlimited trading should be allowed because the adjustment factor is in place to preserve total oil savings.

Agency response: NHTSA disagrees with the commenters that the example given by AIAM would be a direct trade rather than a trade followed by a transfer. Allowing traded credits to be used in the manner suggested by AIAM would circumvent the limit requirements set up by Congress for credit transfers. EISA provided NHTSA with the authority to develop a credit trading program along with the mandated credit transferring program. As part of the trading program, the agency decided not to specify limits on trades within the same compliance category. Further, the agency is clarifying the definition of "trade" in the regulatory text to make plain its intent that trades occur between manufacturers within the same compliance category only. Still, the agency believes that the limits that apply to transfers should apply to *all* transfers, including the transfer of credits earned by an originating manufacturer between its compliance categories and transfers of credits acquired by trade.

Further, NHTSA believes that VW is mistaken that the adjustment factor means that trading may be unlimited. The traded credit adjustment factor and the limits applied to transferred credits are two separate requirements. The adjustment factor is applied to ensure that credit values are standardized across different manufacturers, which ultimately preserves total oil savings. The credit transfer limits, in contrast, ensure that only a specified amount of a manufacturer's noncompliant fuel economy value can be offset by transferred credits. A traded credit that is subsequently transferred for compliance is adjusted to ensure total oil saving is preserved and is subject to the transfer limitations of Section 536.5(d)(3).

C. Extension and phasing out of flexible-fuel incentive program

NHTSA explained in the NPRM that EPCA encourages manufacturers to build alternative-fueled and dual-fueled vehicles by using a special, statutorily-specified calculation procedure for determining the fuel economy of these vehicles. The fuel economy calculation is based on the assumption that the vehicle operates on the alternative fuel a significant portion of the time. This approach gives such vehicles a much-higher fuel economy level compared to similar gasoline-fueled vehicles, and lets those vehicles be factored into a manufacturer's general fleet fuel economy calculation, but only to the extent that the overall fleet fuel economy rises 1.2 mpg per compliance category in a model year.

Congress extended the incentive in EISA for dual-fueled automobiles through MY 2019, but provided for its phase out between MYs 2015 and 2019.[481] The maximum fuel economy increase which may be attributed to the incentive is thus as follows:

Model Year	**mpg increase**
MYs 1993-2014………..	1.2
MY 2015……………….	1.0
MY 2016……………….	0.8
MY 2017……………….	0.6
MY 2018……………….	0.4
MY 2019……………….	0.2
After MY 2019………...	0

NHTSA further explained in the NPRM that 49 CFR Part 538 implements the statutory alternative-fueled and dual-fueled automobile manufacturing incentive, and that NHTSA was not proposing to amend Part 538 in this rulemaking to reflect the changes in EISA, but that the agency would undertake this task in a future rulemaking.

NHTSA received two comments on this issue. Cummins, Inc. stated that it "supports the continuation of the flex-fuel credit," because "The use of alternative fuels such as biodiesel can reduce the dependence on foreign oil and produce domestic economic benefits for local producers of these fuels."

The Alliance commented that despite NHTSA's statement in the NPRM that it would not be including changes to Part 538 in this rulemaking, it would "not be difficult to implement" changes in this rulemaking, and would not require supplemental notice and comment. The Alliance offered proposed text amending 49 CFR § 538.9, and argued that the proposal was simply a "ministerial implementation of 49 U.S.C. § 32906(a)," as

[481] 49 U.S.C. § 32906(a). NHTSA notes that the incentive for dedicated alternative-fuel automobiles, automobiles that run exclusively on an alternative fuel, at 49 U.S.C. § 32905(a), was not phased-out byEISA.

"Existing Section 538.9 of the Title 49 Code of Federal Regulations is clearly a ministerial application of EPCA."

Agency response: NHTSA agrees with the Alliance that amending 49 CFR § 538.9 would be simply a ministerial implementation of 49 U.S.C. § 32906(a), but reiterates that it will undertake this task in a near-future rulemaking. Meanwhile, to the extent that 49 U.S.C. § 32906(a) differs from 49 CFR § 538.9, the statute supersedes the regulation, and regulated parties may rely on the text of the statute. NHTSA appreciates the comment from Cummins, but notes that the decision to extend the manufacturing incentive was that of Congress and not of the agency.

XIII. Test procedure for measuring wheelbase and track width and calculating footprint

The reformed CAFE program requires manufacturers to use vehicle wheelbase and track width data to establish target standards for each of its compliance categories. Manufacturers are required to provide these data to the agency in the pre-model year reports as specified in 49 CFR Part 537, "Automotive Fuel Economy Reports." As part of its assigned CAFE responsibilities, NHTSA's Office of Vehicle Safety Compliance (OVSC) is establishing a program to validate the wheelbase and track width data for selected vehicle configurations (models). As mentioned in the NPRM, the OVSC has developed a draft test procedure for measuring production vehicle wheelbase and track width dimensions. This test procedure was made available on NHTSA's website.[482] It will be used by NHTSA and will not be a requirement that manufacturers must follow. Accordingly, NHTSA is not required to provide notice and an opportunity to comment on

[482] *Available at* http://www.nhtsa.gov/staticfiles/DOT/NHTSA/Vehicle%20Safety/Test%20Procedures/Associated%20Files/TP%20537-00%20Draft.pdf (last accessed Oct. 1, 2008).

its procedure. Nevertheless, the agency sought comments in the NPRM on the draft test procedure. In response, the Alliance submitted a list of comments that are categorized into three subject areas, including test procedure execution, measured value tolerances, and administrative or editorial issues. All of the comments were considered. An updated revision to the draft procedure will be posted on the NHTSA web site concurrent with the final rule for further review and comment. NHTSA will eventually publish its final test procedure on its website, as it does for all test procedures. Following is a brief discussion of the key issues in each of these three areas.

A. Test procedure execution

The Alliance commented that the base tires and test weight should be confirmed prior to executing the test. Vehicle track width is determined utilizing the vehicle base tire. The test procedure already included identification of the base tire information. However, in response to the Alliance's comment, the procedure was revised to clarify that if the base tire information is not provided in the manufacturer's pre-model year reports, the information will be requested directly from the manufacturer prior to testing. As for confirming the vehicle weight, it is NHTSA's intent to conduct testing at the vehicle curb weight. The test procedure has been revised to specify this loading condition. Additionally, NHTSA does not currently have a definition for "base tire." Recent discussions with manufacturers have indicated to the agency that there is some confusion with regard to what the term means. Since different tire sizes may affect vehicle track width, and thus affect footprint, a precise definition for "base tire" is necessary to prevent gaming. A definition has been added to 49 CFR § 523.2.

The Alliance further stated that the actual measurement point for the track width is under the tire at the geometric center of the tire tread patch when in contact with the ground (tire to ground interface). NHTSA's draft procedure, which called for measuring the track width at the front of the front tires and at the rear of the rear tires at ground level, provided a means for measuring the approximate front and rear track widths. The differences between the two measurement techniques are unknown but would be impacted by camber and toe angles. NHTSA is evaluating other approaches that may be more accurate for measuring the vehicle track width. The Alliance suggested a possible technique of rolling the vehicle over an impressionable material and measuring the perpendicular distance between the corresponding axle tire patch tread centers, which will be further investigated. If NHTSA decides to use a different approach the test procedure will be revised accordingly and make the revised test procedure available on NHTSA's website.

The Alliance also commented on the procedure used to verify that the front tires are pointed in the forward direction during testing. NHTSA agrees that placement of tires, including steering angle and suspension adjustments can have an impact on measured results. During testing the front tires will be placed in a "straight ahead position" parallel to the longitudinal axis of the vehicle, although the agency does not believe that it is necessary to specify particular tolerances. The test procedure has been modified to include an additional step of rolling the vehicle in a straight line forward and backwards once positioned on the test surface to ensure any steering and suspension loading and imbalances caused from steering the vehicle onto the test surface are removed.

B. Measured value tolerances

The Alliance questioned what tolerances the agency will allow between manufacturer-provided wheelbase, track width and footprint data, and the corresponding agency-measured and -calculated wheelbase, track width and footprint data. The Alliance argued that just being off by 1/8-inch for the wheelbase and 1/8-inch for the track width can result in a 0.2 square foot difference in footprint.

NHTSA understands that both test instrumentation accuracy and the inherent measurement variations between design dimensions and physical measurements must be considered when determining an acceptable tolerance between manufacturer-reported data and NHTSA-measured data. In the short term, the agency plans to collect physical data by measuring wheelbase and track width dimensions of production vehicles in the field. Also, the agency is in the process of asking each manufacturer for data relating to known tolerances between design and production measurements. The agency plans to collect and analyze these data along with the field data to understand better the tolerances that can be expected. NHTSA plans to revise its test procedure accordingly to address the issue raised.

The Alliance also expressed concern with the accuracy of the hand level and tape measure proposed to be used in the draft test procedure, and argued that more accurate means exist and should be employed in order to eliminate any sources that would cause discrepancies between design data and field measurements. The agency agrees with the Alliance that more accurate instrumentation exists for measuring wheelbase and track width dimensions. Further research is ongoing to identify instrumentation that can be easily adapted to this kind of application. The agency is open to any suggestions that the

Alliance has for identifying inexpensive and portable tools and instrumentation that can be used with a high level of accuracy and repeatability for making field measurements. When instrumentation changes are made the NHTSA test procedure will reflect them accordingly.

The Alliance also commented that wheelbase and track width measurement procedures round the measurements to a finer level than is repeatable. The Alliance appeared to be referencing the statements in the test procedure which allow for recording the track width and wheelbase measurements to the nearest 1/8-inch and then rounding to the nearest 1/10-inch. Measuring the wheelbase and track width in inches and rounding to the nearest 1/10-inch is required by the definition of footprint as specified in 49 CFR Part 523. The test procedure will be revised to remove references to recording the measurements to the nearest 1/8" and will incorporate making the measurement to a more precise value that correlates to the measuring instrument the agency ultimately decides to use. However, the test procedure will retain requirements for rounding wheelbase and track width measurements to the nearest 1/10-inch.

C. Administrative and editorial issues

The Alliance suggested that the test procedure reference SAE J1100 (W101). "L101 Wheelbase" and "W101-1, 2 Tread Width Front & Rear Tires" are the applicable SAE items equivalent to the agency's definitions of wheelbase and track width in Part 523. The Alliance argued that the use of these dimensions is a standard practice for the industry and should be incorporated in NHTSA's test procedure.

In response to the Alliance's comment, the agency notes that the definitions for wheelbase in SAE J1100 and 49 CFR Part 523 are the same. Both SAE J1100 and 49

CFR § 523.2 define "wheelbase" as the longitudinal distance between front and rear wheel centerlines. However, differences exist in SAE J1100 and the Part 523 definitions for track width. SAE J1100 defines "track width" as the lateral distance between the centerlines of the tires at ground, whereas Part 523 specifies the lateral distance between the centerlines of the *base tires* at ground, *including the camber angle*. Base tire size and camber angle impact the track width dimension. Vehicle manufacturers must report wheelbase and track width dimensions per the Part 523 definitions in MY 2008 and later pre-model year CAFE reports required by 49 CFR Part 537. However, plan view and profile view figures depicting the vehicle wheelbase and track width measurements, similar to what is provided in SAE J1100, will be added to the NHTSA test procedure for clarification.

The Alliance also commented that manufacturers already attest in the pre-MY report that they follow 49 CFR Part 537 for things like analytically-derived fuel economy, and argued that this official certification should extend to the wheelbase, track width and footprint data provided. The Alliance appears to suggest that the agency should accept the data submitted by the vehicle manufacturers without implementing any type of validation enforcement program. The primary mission of NHTSA's enforcement is to ensure and verify that manufacturers conform to appropriate Federal regulations and comply with required Federal motor vehicle safety standards. Verification of the key data used to calculate the manufacturer's fuel economy standards required by 49 CFR Part 533 is essential to meeting this mission.

The Alliance also questioned the use of the term "Apparent Noncompliance" in the test procedure and requested clarification regarding what would constitute a failure.

In response, the field data collected will be used to validate wheelbase and track width data submitted by each manufacturer required by 49 CFR Part 537. Collected data may identify possible discrepancies between manufacturer-submitted data and production vehicle measurements. Footprint calculations derived from the wheelbase and track width measurements are critical for determining compliance with CAFE standards. Any noted discrepancies will have to be discussed with the respective vehicle manufacturer and resolved prior to the manufacturer submittal of final data to the Environmental Protection Agency. If the vehicle manufacturer's data are found to be in error, it could be classified as a non-conformance to the CAFE pre-model year reporting requirements of 49 CFR Part 537. This would not qualify as a non-compliance to a safety standard. The test procedure text will be updated to reflect this distinction. However, a non-conformance to the CAFE footprint requirements could result in a re-determination of applicable fuel economy target standards for each respective vehicle model.

Finally, the Alliance argued that the procedure should measure dimensions using metric units of measure and a conversion to English should follow at the end only to generate English equivalents for secondary reporting. The Alliance stated that "The manufacturers that comprise the Alliance of Automobile Manufacturers, are citizens of the world and it makes our great country look arrogant when we continue to author Technical Procedures based on English units." It is the agency's common practice in development of test procedures to follow the unit of measure format used in the corresponding regulation or standard. The agency has worked for several years to issue revised and new regulations and standards employing the metric system of measures. However, to date, not all of the agency regulations and standards have been converted.

49 CFR Part 523 specifies wheelbase and track width dimensions to be measured in inches and rounded to the nearest tenth of an inch. Thus, for now, the test procedure will continue to use the English units of measure.

XIV. Sensitivity and Monte Carlo Analysis

NHTSA is establishing fuel economy standards that maximize net societal benefits, based on the Volpe model. That is, where the estimated benefits to society exceed the estimated cost of the rule by the highest amount. This analysis is based, among other things, on many underlying estimates, all of which entail uncertainty. Future fuel prices, the cost and effectiveness of available technologies, the damage cost of carbon dioxide emissions, the economic externalities of petroleum consumption, and other factors cannot be predicted with certainty.

Recognizing these uncertainties, NHTSA has used the Volpe model to conduct both sensitivity analyses, by changing one factor at a time, and a probabilistic uncertainty analysis (a Monte Carlo analysis that allows simultaneous variation in these factors) to examine how key measures (*e.g.*, mpg levels of the standard, total costs and total benefits) vary in response to changes in these factors.

However, NHTSA has not conducted a probabilistic uncertainty analysis to evaluate how optimized stringency levels respond to such changes in these factors. The Volpe model currently does not have the capability to integrate Monte Carlo simulation with stringency optimization.

The agency has performed several sensitivity analyses to examine important assumptions. The analyses include:

1) The value of reducing CO_2 emissions. We examined $2 per metric ton as a domestic value, $33 per metric ton as a global value and $80 per metric ton as a global value, with the main analysis using a value of $2 per metric ton as a domestic value. These values can be translated into dollars per gallon by multiplying by 0.0089 metric tons per gallon[483], as shown below:

   $2 per ton CO_2 = $2*0.0089 = $0.0178 per gallon

   $33.00 per ton CO_2 = $33*0.0089 = $0.2937 per gallon

   $80.00 per ton CO_2 = $80*0.0089 = $0.712 per gallon

2) The value of monopsony costs. For domestic values of CO_2, the main analysis uses $0.266 per gallon for monopsony costs. At the low end of the range for domestic values, the sensitivity analysis uses a value of $0.210. For global values of CO_2, a $0 value of monopsony cost is appropriate. As discussed previously in Section V, this is consistent with the fact that monopsony payments are a transfer rather than a real economic benefit when viewed from the same global perspective, and thus have a net value of zero.

3) The price of gasoline. The main analysis uses the AEO 2008 High Price case forecast for the price of gasoline (see Table VIII-3). In this sensitivity analysis we also examine the AEO 2008 Reference Case forecast of the price of gasoline.

4) Military security. For one of the scenarios, we assumed a $0.05 reduction in military security costs for each gallon of fuel saved. The derivation of this estimate is discussed in detail in Section V.

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483 The molecular weight of Carbon (C) is 12, the molecular weight of Oxygen (O) is 16, thus the molecular weight of CO_2 is 44. One ton of C = 44/12 tons CO_2 = 3.67 tons CO_2. 1 gallon of gas weighs 2,819 grams, of that 2,433 grams are carbon. $1.00 CO_2 = $3.67 C and
$3.67/ton * ton/1000kg * kg/1000g * 2433g/gallon = (3.67 * 2433) / 1000 * 1000 = $0.0089/gallon

Sensitivity analyses were performed on only the optimized (7%) alternative. In the PRIA, we examined the sensitivity of the price of gasoline (low, reference, and high case), values of reducing CO_2 emissions (\$0 to \$14 per ton), combined externalities (\$0.120 and \$0.504 per gallon), and the rebound effect (10 to 20 percent). Only the price of gasoline had a significant impact on the results.

The results of the sensitivity analyses indicate that the much wider values of CO_2 examined have relatively little impact on the mpg levels of the standard, increasing industry-wide required CAFE levels by 0.2 mpg increase in MY 2014 for both passenger cars and light trucks, by 0.3 mpg for MY 2015 passenger cars, and by 1.1 mpg for MY 2015 light trucks. This occurs because the effect of the higher global values for reducing CO_2 emissions is partly offset by the accompanying reduction of the benefit from savings in monopsony costs from its domestic value of \$0.266 per gallon to its global value of \$0.000. However, the extent to which eliminating the monopsony benefit offsets the higher values of reducing CO_2 emissions is limited by the fact that these values continue to grow at the assumed 2.4 percent rate over the period spanned by the analysis, while the monopsony benefit remains fixed.

The lower fuel prices forecast in the AEO 2008 Reference Case have a significant impact on the levels of the standards, reducing required CAFE levels for both cars and light trucks by about 2.0 mpg in MY 2015. Assuming a savings in military security costs of \$0.05 per gallon has no significant impact on the level of the standards.

OMB Circular A-4 requires formal probabilistic uncertainty analysis of complex rules where there are large, multiple uncertainties whose analysis raises technical challenges or where effects cascade and where the impacts of the rule exceed \$1 billion.

The agency identified and quantified the major uncertainties in the preliminary regulatory impact analysis and estimated the probability distribution of how those uncertainties affect the benefits, costs, and net benefits of the alternatives considered in a Monte Carlo analysis. The results of that analysis, summarized for the combined passenger car and light truck fleet across both the 7 percent (typically the lower range) and 3 percent (typically upper range) discount rates[484] are as follows:

Fuel Savings: The analysis indicates that MY 2011 vehicles (both passenger cars and light trucks) will experience between 732 million and 1,114 million gallons of fuel savings over their useful lifespan. MY 2012 vehicles will experience between 2,406 million and 3,528 million gallons of fuel savings over their useful lifespan. MY 2013 vehicles will experience between 4,640 million and 6,391 million gallons of fuel savings over their useful lifespan. MY 2014 vehicles will experience between 5,618 and 7,843 million gallons of fuel savings over their useful lifespan. MY 2015 vehicles will experience between 7,139 and 9,807 million gallons of fuel savings over their useful lifespan. Over the combined lifespan of the five model years, between 20.5 billion and 28.7 billion gallons of fuel will be saved.

Total Costs: The analysis indicates that vehicle manufacturers will invest between $760 million and $2,235 million to improve the fuel economy of MY 2011 passenger cars and light trucks. MY 2012 owners will pay between $2,915 million and $6,262 million more. MY 2013 owners will pay between $6,570 million and $11,414 million more. MY 2014 owners will pay between $7,852 million and $13,230 million more. MY 2015 owners will pay between $10,298 million and $17,189 million more.

[484] In a few cases the upper range results were obtained from the 7% rate and the lower range results were obtained from the 3% rate. While this may seem counterintuitive, it results from the random selection process that is inherent in the Monte Carlo technique.

Owners of all five model years vehicles combined will pay between $28.4 billion and $50.3 billion in higher vehicle prices to purchase vehicles with improved fuel efficiency.

Societal Benefits: The analysis indicates that changes to MY 2011 passenger cars and light trucks to meet the proposed CAFE standards will produce overall societal benefits valued between $1,003 million and $2,229 million. MY 2012 vehicles will produce benefits valued between $3,191 million and $7,551 million. MY 2013 vehicles will produce benefits valued between $5,754 million and $13,971 million. MY 2014 vehicles will produce benefits valued between $6,832 million and $17,172 million. MY 2015 vehicles will produce benefits valued between $8,453 million and $21,607 million. Over the combined lifespan of the five model years, societal benefits valued between $25.2 billion and $62.5 billion will be produced.

Net Benefits: The uncertainty analysis indicates that the net impact of the higher CAFE requirements for MY 2011 passenger cars and light trucks will range from a net loss of $913 million to a net benefit of $1,224 million. There is at least an 80 percent certainty (the lower of the passenger car and light truck certainty levels) that changes made to MY 2011 vehicles to achieve the higher CAFE standards will produce a net benefit. The net impact of the higher CAFE requirements for MY 2012 will range from a net loss of $1,974 million to a net benefit of $3,750 million. There is at least an 88 percent certainty that changes made to MY 2012 vehicles to achieve the CAFE standards will produce a net benefit. The net impact of the higher CAFE requirements for MY 2013 will range from a net loss of $3,983 million to a net benefit of $7,868 million. There is at least a 72 percent certainty that changes made to MY 2013 vehicles to achieve the higher CAFE standards will produce a net benefit. The net impact of the higher

CAFE requirements for MY 2014 will range from a net loss of $4,489 million to an net benefit of $7,868 million. There is at least a 71 percent certainty that changes made to MY 2014 vehicles to achieve the CAFE standards will produce a net benefit. The net impact of the higher CAFE requirements for MY 2015 will range from a net loss of $6,233 million and a net benefit of $9,637 million. There is at least a 65 percent certainty that changes made to MY 2015 vehicles to achieve the CAFE standards will produce a net benefit. Over all five model years, the higher CAFE standards will produce net benefits ranging from a net loss of $17.6 billion to a net benefit of $28.4 billion. There is *at least* a 65 percent certainty that higher CAFE standards will produce a net societal benefit in *each* of the model years covered by this final rule. In most individual model years, this probability is noticeably higher.

XV. Regulatory notices and analyses

The following discussion of relevant regulatory notices and analyses considers both the final rule and the FEIS together.

A. Executive Order 12866 and DOT Regulatory Policies and Procedures

Executive Order 12866, "Regulatory Planning and Review" (58 FR 51735, Oct. 4, 1993), provides for making determinations whether a regulatory action is "significant" and therefore subject to OMB review and to the requirements of the Executive Order. The Order defines a "significant regulatory action" as one that is likely to result in a rule that may:

(1) Have an annual effect on the economy of $100 million or more or adversely affect in a material way the economy, a sector of the economy, productivity, competition,

jobs, the environment, public health or safety, or State, local or Tribal governments or communities;

(2) Create a serious inconsistency or otherwise interfere with an action taken or planned by another agency;

(3) Materially alter the budgetary impact of entitlements, grants, user fees, or loan programs or the rights and obligations of recipients thereof; or

(4) Raise novel legal or policy issues arising out of legal mandates, the President's priorities, or the principles set forth in the Executive Order.

This rulemaking is economically significant. Accordingly, OMB reviewed it under Executive Order 12866. The rule is significant within the meaning of the Department of Transportation's Regulatory Policies and Procedures.

The benefits and costs of this final rule are described above. Because the rule is economically significant under both the Department of Transportation's procedures and OMB guidelines, the agency has prepared a Final Regulatory Impact Analysis (FRIA) and placed it in the docket and on the agency's website. Further, pursuant to OMB Circular A-4, we have prepared a formal probabilistic uncertainty analysis for this proposal. The circular requires such an analysis for complex rules where there are large, multiple uncertainties whose analysis raises technical challenges or where effects cascade and where the impacts of the rule exceed $1 billion. This rule meets these criteria on all counts.

B. National Environmental Policy Act

Under NEPA, a Federal agency must prepare an Environmental Impact Statement (EIS) on proposed actions that could significantly impact the quality of the human environment. The requirement is designed to serve three major functions: (1) to provide the decisionmaker(s) with a detailed description of the potential environmental impacts of a proposed action prior to its adoption, (2) to rigorously explore and evaluate all reasonable alternatives, and (3) to inform the public of, and allow comment on, such efforts.

NHTSA complied with NEPA by preparing a draft EIS (DEIS), soliciting and analyzing public comments thereon, including both a public hearing and written comments, and preparing a final EIS (FEIS), which responds to public comments and incorporates the information relevant to the effects of each of the alternatives considered in the EIS. Specifically, in March 2008, NHTSA issued a Notice of Intent (NOI) to prepare an EIS for the MY 2011-2015 CAFE standards. 73 Fed. Reg. 16615; *see* 40 CFR § 1501.7. In April 2008, NHTSA issued a supplemental NOI. 73 Fed. Reg. 22913. On June 26, 2008, NHTSA submitted the DEIS to the Environmental Protection Agency (EPA). On July 2, 2008, NHTSA published a *Federal Register* Notice of Availability of its DEIS. *See* 73 FR 37922. NHTSA's Notice of Availability also made public the date and location of a public hearing, and invited the public to participate at the hearing on August 4, 2008, in Washington, DC. *See id.* On July 3, 2008, the EPA issued its Notice of Availability of the DEIS, triggering the 45-day public comment period. *See* 73 FR 38204. *See also* 40 CFR § 1506.10. In accordance with CEQ regulations, the public was invited to submit written comments on the DEIS until August 18, 2008. *See* 40 CFR § 1503, *et seq.*

NHTSA mailed approximately 200 copies of the DEIS to interested parties, including federal, state, and local officials and agencies; elected officials, environmental and public interest groups; Native American tribes; and other interested individuals, as listed in Chapter 9 of the DEIS. NHTSA held a public hearing on the DEIS at the National Transportation Safety Board Conference Center in Washington, DC, on August 4, 2008.

NHTSA received 66 written comments from interested stakeholders, including the EPA, the Centers for Disease Control (CDC), state and local agencies, elected officials, automobile trade associations, organizations, and individuals. In addition, NHTSA received one petition with 10,540 signatures. During the public comment hearing in Washington, DC, 44 individuals provided oral statements. The transcript from the public hearing and written comments submitted to NHTSA are part of the administrative record, and are available on the Federal Docket, which can be found on the Web at http://www.regulations.gov, Reference Docket No. NHTSA-2008-0060. Written comments and the public hearing transcript can also be viewed in their entirety in Appendix D of the FEIS.

NHTSA reviewed and analyzed all written and oral comments received during the public comment period in the preparation of the FEIS. NHTSA revised the FEIS in response to comments on the DEIS.[485] For a more detailed discussion of NHTSA's scoping and comment periods, please see Section 1.3 and Chapter 10 of the FEIS.

On October 10, 2008, NHTSA submitted the FEIS to the EPA. On October 17, 2008, the EPA published a Notice of Availability of the FEIS in the *Federal Register*. *See* 73 Fed. Reg. 61859.

[485] The agency also changed the FEIS as a result of updated information that became available after issuance of the DEIS.

This Final Rule constitutes the Record of Decision (ROD) for NHTSA's MY 2011-2015 CAFE standards, pursuant to the National Environmental Policy Act (NEPA) and Council on Environmental Quality's (CEQ) implementing regulations.[486] *See* 40 CFR § 1505.2. As required by CEQ regulations, this Final Rule sets forth the following: (1) the agency's decision; (2) alternatives considered by NHTSA in reaching its decision, including the environmentally preferable alternative; (3) the agency's preferences among alternatives based on relevant factors, including economic and technical considerations; (4) factors balanced by NHTSA in making its decision, including considerations of national policy; and (5) how these factors and considerations entered into its decision. This Final Rule also addresses mitigation as required by CEQ regulations and applicable laws.

The MY 2011 – 2015 CAFE standards adopted in this Final Rule have been informed by information and analyses contained in the *Final Environmental Impact Statement, Corporate Average Fuel Economy Standards, Passenger Cars and Light Trucks, Model Years 2011 – 2015*, Docket No. NHTSA-2008-0060-0605 (FEIS).[487] For purposes of this rulemaking, the agency referred to an extensive compilation of technical and policy documents available in the dockets for the NPRM and Final Rule and for the EIS. The EIS docket and the rulemaking docket are available on the Federal Docket, which can be found on the Web at http://www.regulations.gov, Reference Docket Nos.: NHTSA-2008-0060 (EIS) and NHTSA-2008-0089 (Rulemaking).

[486] NEPA is codified at 42 U.S.C. § 4321-4347. CEQ NEPA implementing regulations are codified at 40 Code of Federal Regulations (CFR) Parts 1500-1508.
[487] The Notice of Availability of the FEIS was published in the *Federal Register* by the EPA on October 17, 2008.

When preparing an EIS, NEPA requires an agency to compare the potential environmental impacts of its proposed action and a reasonable range of alternatives. EPCA, as amended by EISA, requires the Secretary of Transportation to establish average fuel economy standards for each model year at least 18 months before the beginning of that model year and to set them at "the maximum feasible average fuel economy level that the Secretary decides the manufacturers can achieve in that model year." NHTSA is delegated responsibility for implementing EPCA fuel economy requirements assigned to the Secretary of Transportation. 49 CFR §§ 1.50, 501.2(a)(8). When setting maximum feasible fuel economy standards, NHTSA is required to "consider technological feasibility, economic practicability, the effect of other motor vehicle standards of the Government on fuel economy, and the need of the United States to conserve energy." 49 U.S.C. § 32902(f). NHTSA interprets the statutory factors as including environmental issues and permitting the consideration of other relevant societal issues, such as safety. The EPCA fuel economy requirements form the purpose of and need for the MY 2011-2015 CAFE standards and, therefore, inform the range of alternatives for consideration in the NEPA analysis.

In developing its reasonable range of alternatives, NHTSA identified alternative stringencies that represent the full spectrum of potential environmental impacts and safety considerations. The DEIS and FEIS analyzed the impacts of the following six "action" alternatives: 25 Percent Below Optimized, Optimized, 25 Percent Above Optimized, 50 Percent Above Optimized, Total Costs Equal Total Benefits, and Technology Exhaustion. The DEIS and FEIS also analyzed the impacts that would be expected if NHTSA imposed no new requirements (the No Action Alternative). In accordance with CEQ regulations, the agency selected a Preferred Alternative in its DEIS and FEIS (Optimized Alternative).

In response to public comments, the FEIS analyzed how the proposed alternatives are affected by variations in the economic assumptions input into the computer model NHTSA uses to calculate the costs and benefits of various potential CAFE standards (the Volpe model). Specifically, the agency calculated and analyzed mpg standards and environmental impacts associated with each alternative under four model input scenarios: Reference Case, High Scenario, Mid-1 Scenario, and Mid-2 Scenario. *See* FEIS § 2.2.2. As such, the FEIS presented the decisionmaker with a broad, comprehensive spectrum of the alternatives, varied economic inputs, and potential environmental impacts.

The agency compared the potential environmental effects of alternative mpg levels analyzed by NHTSA. In addition, the FEIS analyzed direct, indirect, and cumulative impacts and analyzed impacts in proportion to their significance. A broad and comprehensive analysis of the alternatives, varied by economic inputs and sensitivities, and potential environmental impacts are also included in the FEIS for decisionmakers. For a discussion of the environmental impacts associated with each of the alternatives, including the Optimized Alternative using the Mid-2 Scenario, see Chapters 3 and 4 of the FEIS. *See also* see Appendix B to the FEIS and Section IX.G of this Final Rule.

The agency carefully considered and analyzed each of the individual economic assumptions to determine which assumptions most accurately represent future economic conditions. For a discussion of the analysis supporting the selection of the economic assumptions relied on by the agency in this final rule, see Section V. The economic assumptions used by the agency in this final rule are reflected in the Mid-2 Scenario set of assumptions analyzed in the FEIS. *See* FEIS § 2.2. NHTSA's decision to proceed with the Optimized Alternative using economic assumptions that are reflected in the Mid-2 Scenario, which were prompted in part by public comments, is squarely within the spectrum of alternatives set forth in the DEIS and the FEIS, and all relevant environmental impacts associated with the Optimized Alternative have been considered by NHTSA. *See* FEIS Chapter 3, Chapter 4 and Appendix B.

The environmental impacts associated with all the scenarios were placed before the decisionmaker and the public in the FEIS. *See* Appendix B and Chapters 3 and 4 of the FEIS. The environmental impacts associated with the alternatives using Mid-2 Scenario economic assumptions, including the Optimized Alternative, were placed before the decisionmaker and the public in Appendix B to the FEIS, and discussed in Chapters 3 and 4 of the FEIS. The decisionmaker, therefore, was aware of the environmental impacts associated with the economic assumptions used in this Final Rule, including the varying assumptions and inputs that commenters urged NHTSA to include in its analysis in the FEIS. For a discussion of the environmental impacts associated with the Mid-2 Scenario, see Appendix B to the FEIS. *See also* Chapters 3 and 4 of the FEIS.

After carefully reviewing and analyzing all of the information in the public record including technical support documents, the FEIS, public and agency comments submitted on the Draft Environmental Impact Statement (DEIS), and public and agency comments submitted on the NPRM, NHTSA's decision is to proceed with the Optimized Alternative. For a discussion of the agency's selection of the Optimized Alternative, see Section VII.E.2.b of this Final Rule. In the DEIS and the FEIS, the agency identified the

Optimized Alternative (maximizing societal net benefits) as NHTSA's Preferred Alternative.

The Technology Exhaustion Alternative is the overall Environmentally Preferable Alternative. Specifically, Technology Exhaustion is the Environmentally Preferable Alternative in terms of the following reductions: fuel use, CO_2 emissions, criteria air pollutant emissions, health impacts, and a majority of the mobile source air toxics (MSATs). However, according to NHTSA's analysis set forth in the FEIS (summarized here in Section IX.G), the MSATs acrolein and formaldehyde demonstrate larger increases under the Technology Exhaustion Alternative (as compared to the other alternatives). In regard to acrolein, the analysis for acrolein emissions is incomplete because upstream emissions factors are not available. For this MSAT, the agency, therefore, is unable to conclude which alternative is environmentally preferable. As explained in Chapter 5 of the FEIS, because upstream emissions demonstrate decreases under a fuel economy level increase due to fuel savings and reduced emissions from fuel refining and transportation, if upstream emissions of acrolein were included in the analysis, total acrolein emissions would potentially show smaller increases or might decrease. In regard to formaldehyde, the Optimized Alternative is the Environmentally Preferable Alternative, as it results in the smallest amount of emissions. Overall, however, Technology Exhaustion is the Environmentally Preferable Alternative. For additional discussion regarding the alternatives considered by the agency in reaching its decision, including the alternatives considered to be environmentally preferable, see Section VII.D of this Final Rule. For a discussion of the environmental impacts associated with the alternatives, see Chapter 3, Chapter 4 and Appendix B of the FEIS. *See also* Section IX.G of this Final Rule.

The Optimized Alternative results in a decrease in CO_2 emissions and associated climate change effects, a reduction in total criteria air pollutant emissions and toxic air pollutant emissions, and a decrease in energy consumption as compared to the No Action Alternative. In addition, the Optimized Alternative will reduce adverse health outcomes and health costs related to motor vehicle air pollution. As such, the Optimized Alternative will generally have beneficial environmental impacts and health effects.

According to NHTSA's environmental analysis, emissions of acetaldehyde, acrolein, and formaldehyde would increase under the Optimized Alternative. The increases, however, are approximately 1 percent or less over the No Action Alternative. In addition, the emission increases for acetaldehyde and formaldehyde only occur during 2015 and 2020. By 2025, the agency's analysis shows a decrease in emissions of these two MSATs. *See* Section IX.G of the Final Rule. *See also* Appendix B of the FEIS. As noted above, the analysis for acrolein emissions is incomplete because upstream emissions factors are not available. Moreover, Table IX.G-7 (Table B2-109 in the FEIS) shows that formaldehyde emissions are increasing over a declining baseline, such that the formaldehyde emissions increases may not create such adverse impacts as the magnitude of the difference from baseline might imply.

Beyond these considerations at the national level, there could also be localized increases in criteria and toxic air pollutant emissions in some nonattainment areas as a result of implementation of the CAFE standards. These localized increases would represent a slight decline in the rate of reductions being achieved by implementation of Clean Air Act standards. For further discussion, see Chapters 3, 4 and 5 of the FEIS. It is also possible that certain emission reductions generally attributable to the control strategies implemented under the Clean Air Act might be slowed somewhat. Any such lessening of the air quality improvements for these emissions is offset by the accelerating decreases brought about by the Optimized Alternative for the criteria pollutants and other MSATs emissions. As such, air quality is generally improved under the Optimized Alternative. Some metropolitan areas may experience larger increases in these emissions relative to emissions at the national level (where metropolitan increases are offset by decreases in other areas). More detailed examination of these trends is warranted as auto manufacturers implement programs to meet the new CAFE requirements. Since the NHTSA analysis in no way constricts auto manufacturers in how they meet the CAFE requirements, these increases may or may not materialize depending on the technologies employed. To the extent that any increases do occur, States and localities should employ existing mechanisms under the Clean Air Act and Title 23 of the U.S. Code to reduce them.

Under NEPA, an EIS is required to "'a reasonably complete discussion of possible mitigation measures.'" *Northern Alaska Environmental Center v. Kempthorne*, 457 F.3d 969, 979 (9th Cir. 2006) (citing *Robertson v. Methow Valley Citizens Council,* 490 U.S. 332, 352 (1989)). Essentially, "[t]he mitigation must "'be discussed in sufficient detail to ensure that environmental consequences have been fairly evaluated.'" *Id.* (citing *City of Carmel-By-The-Sea v. U.S. Dept. of Transp.,* 123 F.3d 1142, 1154 (9th Cir. 1997)). NEPA, however, "does not require an agency to formulate and adopt a complete mitigation plan." *Id.* (citing *Robertson,* 490 U.S. at 352 (noting that NEPA does not contain a substantive requirement that a complete mitigation plan be actually formulated and adopted)). *See also Valley Community Preservation Com'n v. Mineta*, 231 F. Supp. 2d 23, 41 (D.D.C. 2002) (noting that NEPA does not require that a complete mitigation plan be formulated and incorporated into an EIS). An agency is not required to mitigate adverse consequences of an environmental action; it is only required to analyze them. *See Robertson,* 490 U.S. at 333 (holding, *inter alia*, that "NEPA does not impose a substantive duty on agencies to mitigate adverse environmental effects or to include in each EIS a fully developed mitigation plan"). *See also Valley Community Preservation Com'n*, 231 F. Supp. 2d 23. Indeed, "'it would be inconsistent with NEPA's reliance on procedural mechanisms-as opposed to substantive, result-based standards-to demand the presence of a fully developed plan that will mitigate environmental harm before an agency can act.'" *Id.* (citing *Robertson*, 490 U.S. at 333).

Chapter 5 of the FEIS explains that Federal transportation funds administered by the Federal Highway Administration (FHWA) might be available to assist in funding projects to reduce any increases in MSATs. FHWA provides funding to states and localities specifically to improve air quality under the Congestion Mitigation and Air Quality Improvement (CMAQ) Program. FHWA and FTA also provide funding to States and localities under other programs that have multiple objectives including air quality improvement. As State and local agencies recognize the need to reduce emissions of CO, acetaldehyde, acrolein, or formaldehyde – or other emissions eligible under the CMAQ Program, including the criteria pollutants and MSATs analyzed for the FEIS – they have the ability to apply CMAQ funding to reduce impacts in most areas. Further, the EPA has the authority to continue to improve vehicle emissions standards.

NHTSA acknowledges that the absolute level of GHG emissions will continue to rise over current levels. This was explained in the FEIS. *See* Figure 3.4-4 and Table 3.4-1 of the FEIS. The increase in emissions from factors such as an increase in vehicle miles traveled (VMT) is beyond NHTSA's jurisdiction to control under EPCA, as amended by EISA. Essentially, NHTSA does not have the statutory authority to reduce the total amount of GHGs emitted by all vehicles driven, because NHTSA, under its statutory authority conferred by EPCA, cannot control how many miles citizens elect to drive. *See* FEIS §§ 10.1 – 10.2. In view of this statutory directive, it is not reasonable for NHTSA to explore mitigation strategies related to the quantity of vehicle miles traveled by the public.

Based on the agency's current understanding of global climate change, certain effects are likely to occur due to the increasing global GHG emissions entering the atmosphere. The Optimized Alternative will not prevent these effects. Instead, the Optimized Alternative may diminish the effects of climate change by contributing to global GHG reductions from currently anticipated trends. As such, the Optimized Alternative will generally have beneficial environmental impacts and health effects. Based on the foregoing, the agency concludes that the environmental analysis and public involvement process complies with both the letter and spirit of NEPA implementing regulations issued by CEQ, DOT Order 5610.1C, and NHTSA regulations.[488]

1. Clean Air Act (CAA)

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[488] NEPA is codified at 42 U.S.C. § 4321-4347. CEQ's NEPA implementing regulations are codified at 40 CFR Pts. 1500-1508, and NHTSA's NEPA implementing regulations are codified at 49 CFR Part 520.

The CAA (42 U.S.C. § 7401) is the primary Federal legislation that addresses air quality. Under the authority of the CAA and subsequent amendments, the EPA has established National Ambient Air Quality Standards (NAAQS) for six criteria pollutants, which are relatively commonplace pollutants that can accumulate in the atmosphere as a result of normal levels of human activity. The EPA is required to review the NAAQS every five years and to change the levels of the standards if warranted by new scientific information.

The air quality of a geographic region is usually assessed by comparing the levels of criteria air pollutants found in the atmosphere to the levels established by the NAAQS. Concentrations of criteria pollutants within the air mass of a region are measured in parts of a pollutant per million parts of air (ppm) or in micrograms of a pollutant per cubic meter (µg/m3) of air present in repeated air samples taken at designated monitoring locations. These ambient concentrations of each criteria pollutant are compared to the permissible levels specified by the NAAQS in order to assess whether the region's air quality is potentially unhealthful.

When the measured concentrations of a criteria pollutant within a geographic region are below those permitted by the NAAQS, the region is designated by the EPA as an attainment area for that pollutant, while regions where concentrations of criteria pollutants exceed Federal standards are called nonattainment areas (NAAs). Former NAAs that have attained the NAAQS are designated as maintenance areas. Each NAA is required to develop and implement a State Implementation Plan (SIP), which documents how the region will reach attainment levels within time periods specified in the CAA. In maintenance areas, the SIP documents how the State intends to maintain compliance with the NAAQS. When EPA changes a NAAQS, States must revise their SIPs to address how they will attain the new standard.

Section 176(c) of the CAA prohibits Federal agencies from taking actions in nonattainment or maintenance areas that do not “conform” to the State Implementation Plan (SIP). The purpose of this conformity requirement is to ensure that Federal activities do not interfere with meeting the emissions targets in the SIPs, do not cause or contribute to new violations of the NAAQS, and do not impede the ability to attain or maintain the NAAQS. The EPA has issued two sets of regulations to implement CAA Section 176(c):

- The Transportation Conformity Rules (40 CFR 51 Subpart T), which apply to transportation plans, programs, and projects funded under title 23 United States Code (U.S.C.) or the Federal Transit Act. Highway and transit infrastructure projects funded by FHWA or the Federal Transit Administration (FTA) usually are subject to transportation conformity.
- The General Conformity Rules (40 CFR 51 Subpart W) apply to all other Federal actions not covered under transportation conformity. The General Conformity Rules established emissions thresholds, or *de minimis* levels, for use in evaluating the conformity of a project. If the net emission increases due to the project are less than these thresholds, then the project is presumed to conform and no further conformity evaluation is required. If the emission increases exceed any of these thresholds, then a conformity determination is required. The conformity determination may entail air quality modeling studies, consultation with EPA and State air quality agencies, and commitments to revise the SIP or to implement measures to mitigate air quality impacts.

The CAFE standards and associated program activities are not funded under title 23 U.S.C. or the Federal Transit Act. Further, CAFE standards are established by NHTSA and are not an action undertaken by FHWA or FTA. Accordingly, the CAFE standards are not subject to transportation conformity.

The General Conformity Rules contain several exemptions applicable to "Federal actions," which the conformity regulations define as: "any activity engaged in by a department, agency, or instrumentality of the Federal Government, or any activity that a department, agency or instrumentality of the Federal Government supports in any way, provides financial assistance for, licenses, permits, or approves, other than activities [subject to transportation conformity]." 40 CFR § 51.852. "Rulemaking and policy development and issuance" are exempted at 40 CFR § 51.853(c)(2)(iii). Since NHTSA's CAFE standards involve a rulemaking process, its action is exempt from general conformity. Also, emissions for which a Federal agency does not have a "continuing program responsibility" are not considered "indirect emissions" subject to general conformity under 40 CFR § 51.852. "Emissions that a Federal agency has a continuing program responsibility for means emissions that are specifically caused by an agency carrying out its authorities, and does not include emissions that occur due to subsequent activities, unless such activities are required by the Federal agency." 40 CFR § 51.852. Emissions that occur as a result of the final CAFE standards are not caused by NHTSA carrying out its statutory authorities and clearly occur due to subsequent activities, including vehicle manufacturers' production of passenger car and light truck fleets and consumer purchases and driving behavior. Thus, changes in any emissions that result from NHTSA's final CAFE standards are not those for which the agency has a "continuing program responsibility" and NHTSA is confident that a general conformity determination is not required. NHTSA is evaluating the potential impacts of air emissions under NEPA.

2. National Historic Preservation Act (NHPA)

The NHPA (16 U.S.C. § 470) sets forth government policy and procedures regarding "historic properties"—that is, districts, sites, buildings, structures, and objects included in or eligible for the National Register of Historic Places (NRHP). *See also* 36 CFR Part 800. Section 106 of the NHPA requires federal agencies to "take into account" the effects of their actions on historic properties. The agency concludes that the NHPA is not applicable to NHTSA's Decision, because it does not directly involve historic properties. The agency has, however, conducted a qualitative review of the related direct, indirect, and cumulative impacts, positive or negative, of the alternatives, including NHTSA's Decision, on potentially affected resources, including historic and cultural resources. *See* Section 3.5.7 of the FEIS.

3. Executive Order 12898 (Environmental Justice)

Under Executive Order 12898, Federal agencies are required to identify and address any disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations. NHTSA complied with this order by identifying and addressing the potential effects of the alternatives, including NHTSA's Decision, on minority and low-income populations in Section 3.5.9. In Section 4.6 of the FEIS, the agency set forth a qualitative analysis of the cumulative effects of the alternatives, including NHTSA's

Decision, on these populations. Given the foregoing, the agency concludes that it complied with Executive Order 12898.

4. Fish and Wildlife Conservation Act (FWCA)

The FWCA (16 U.S.C. § 2900) provides financial and technical assistance to States for the development, revision, and implementation of conservation plans and programs for nongame fish and wildlife. In addition, the Act encourages all Federal agencies and departments to utilize their authority to conserve and to promote conservation of nongame fish and wildlife and their habitats. The agency concludes that the FWCA is not applicable to NHTSA's Decision, because it does not directly involve fish and wildlife.

5. Coastal Zone Management Act (CZMA)

The Coastal Zone Management Act (16 U.S.C. § 1450) provides for the preservation, protection, development, and (where possible) restoration and enhancement of the nation's coastal zone resources. Under the statute, States are provided with funds and technical assistance in developing coastal zone management programs. Each participating State must submit its program to the Secretary of Commerce for approval. Once the program has been approved, any activity of a Federal agency, either within or outside of the coastal zone, that affects any land or water use or natural resource of the coastal zone must be carried out in a manner that is consistent, to the maximum extent practicable, with the enforceable policies of the State's program.

The agency concludes that the CZMA is not applicable to NHTSA's Decision, because it does not involve an activity within, or outside of, the nation's coastal zones. The agency has, however, conducted a qualitative review of the related direct, indirect, and cumulative impacts, positive or negative, of the alternatives, including NHTSA's Decision, on potentially affected resources, including coastal zones. *See* Section 4.5.5 of the FEIS.

6. Endangered Species Act (ESA)

The ESA (16 U.S.C. § 1531) provides for the protection of species that are at risk of extinction throughout all or a significant portion of their range, and for the protection of ecosystems on which they depend. Under Section 7 of the ESA, all Federal agencies are required to undertake programs for the conservation of endangered and threatened species.

Federal agencies are responsible for determining whether their proposed action requires consultation with Fish and Wildlife Service or National Marine Fisheries Service under Section 7 of the ESA. To make this determination, an agency examines the direct and indirect effects of its proposed action to see if the action "may affect" a listed species. For indirect effects, the impact to the species must be later in time, must be caused by the proposed action, and must be reasonably certain to occur.

As stated in the FEIS, the action alternatives, including NHTSA's Decision, show a reduction in emissions of CO_2, NO_x, $PM_{2.5}$, SO_x, VOC, DPM, benzene, and 1,3-butadiene compared to the No Action Alternative. The FEIS also quantified the resulting decreases in sea-level rise, changes in precipitation, and temperature decreases for each of the alternatives from decreasing CO_2 emissions. NHTSA then qualitatively discussed the impacts to ecosystems, ocean acidification, natural resources, wildlife, and many other factors. Because it is beyond the ability of current modeling and the level of uncertainty is very high, it was not possible to quantitatively calculate the effects of the

CO_2 reduction on specific localized ecosystems. *See* United States Department of Interior, Fish and Wildlife Service, Memorandum, "*Expectations for Consultations on Actions that would Emit Greenhouse Gases*," dated May 14, 2008. NHTSA discussed the issue with the U.S. Fish and Wildlife Service to ensure proper compliance. Without sufficient data to establish the required causal connection (to the level of reasonable certainty) between the proposed rulemaking, GHG emissions, and the subsequent impacts to listed species or critical habitat, Section 7 consultation is not required.

For additional discussion regarding NHTSA's compliance with Section 7 of the ESA, please see Section 10.3.6.1, Section 3.5.2.2, and Section 4.7.2.1 of the FEIS.

7. Floodplain Management (Executive Order 11988 & DOT Order 5650.2)

These Orders require Federal agencies to avoid the long- and short-term adverse impacts associated with the occupancy and modification of floodplains, and to restore and preserve the natural and beneficial values served by floodplains. Executive Order 11988 also directs agencies to minimize the impact of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains through evaluating the potential effects of any actions the agency may take in a floodplain and ensuring that its program planning and budget requests reflect consideration of flood hazards and floodplain management. DOT Order 5650.2 sets forth DOT policies and procedures for implementing Executive Order 11988. The DOT Order requires that the agency determine if a proposed action is within the limits of a base floodplain, meaning it is encroaching on the floodplain, and whether this encroachment is significant. If significant, the agency is required to conduct further analysis of the proposed action and any practicable alternatives. If a practicable alternative avoids floodplain encroachment, then the agency is required to implement it.

In this rulemaking, the agency is not occupying, modifying and/or encroaching on floodplains. The agency, therefore, concludes that the Orders are not applicable to NHTSA's Decision. The agency has, however, conducted a review of the alternatives, including NHTSA's Decision, on potentially affected resources, including floodplains. *See* Chapters 3 and 4 of the FEIS.

8. Preservation of the Nation's Wetlands (Executive Order 11990 & DOT Order 5660.1a)

These Orders require Federal agencies to avoid, to the extent possible, undertaking or providing assistance for new construction located in wetlands unless the agency head finds that there is no practicable alternative to such construction and that the proposed action includes all practicable measures to minimize harms to wetlands that may result from such use. Executive Order 11990 also directs agencies to take action to minimize the destruction, loss or degradation of wetlands in "conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities." DOT Order 5660.1a sets forth DOT policy for interpreting Executive Order 11990 and requires that transportation projects "located in or having an impact on wetlands" should be conducted to assure protection of the Nation's wetlands. If a project does have a significant impact on wetlands, an EIS must be prepared.

The agency is not undertaking or providing assistance for new construction located in wetlands. The agency, therefore, concludes that these Orders do not apply to

NHTSA's Decision. The agency has, however, conducted a review of the alternatives, including NHTSA's Decision, on potentially affected resources, including wetlands. *See* Chapters 3 and 4 of the FEIS.

9. Migratory Bird Treaty Act (MBTA), Bald and Golden Eagle Protection Act (BGEPA), Executive Order 13186.

The MBTA provides for the protection of migratory birds that are native to the United States by making it illegal for anyone to pursue, hunt, take, attempt to take, kill, capture, collect, possess, buy, sell, trade, ship, import, or export any migratory bird covered under the statute. The statute prohibits both intentional and unintentional acts. Therefore, the statute is violated if an agency acts in a manner that harms a migratory bird, whether it was intended or not. *See, e.g., United States v. FMC Corp.*, 572 F.2d 902 (2nd Cir. 1978).

The BGEPA (16 U.S.C. § 668) prohibits any form of possession or taking of both bald and golden eagles. Under the BGEPA, violators are subject to criminal and civil sanctions as well as an enhanced penalty provision for subsequent offenses.

Executive Order 13186, "Responsibilities of Federal Agencies to Protect Migratory Birds," helps to further the purposes of the MBTA by requiring a Federal agency to develop a Memorandum of Understanding (MOU) with the Fish and Wildlife Service when it is taking an action that has (or is likely to have) a measurable negative impact on migratory bird populations.

The agency concludes that the MBTA, BGEPA, and Executive Order 13186 do not apply to NHTSA's Decision, because there is no disturbance and/or take involved in NHTSA's Decision.

10. Department of Transportation Act (Section 4(f))

Section 4(f) of the Department of Transportation Act of 1966 (49 U.S.C. § 303), as amended by Pub. Law § 109-59, is designed to preserve publicly owned parklands, waterfowl and wildlife refuges, and significant historic sites. Specifically, Section 4(f) of the Department of Transportation Act provides that DOT agencies cannot approve a transportation program or project that requires the use of any publicly owned land from a significant public park, recreation area, or wildlife and waterfowl refuge, or any land from a significant historic site, unless a determination is made that:

- There is no feasible and prudent alternative to the use of land, and
- The program or project includes all possible planning to minimize harm to the property resulting from use, or
- A transportation use of Section 4(f) property results in a *de minimis* impact.

The agency concludes that the Section 4(f) is not applicable to NHTSA's Decision because this rulemaking does not require the use of any publicly owned land. For a more detailed discussion, please see Section 3.5.6 of the FEIS.

C. Regulatory Flexibility Act

Pursuant to the Regulatory Flexibility Act (5 U.S.C. § 601 et seq., as amended by the Small Business Regulatory Enforcement Fairness Act (SBREFA) of 1996), whenever an agency is required to publish a notice of rulemaking for any proposed or final rule, it must prepare and make available for public comment a regulatory flexibility analysis that describes the effect of the rule on small entities (*i.e.*, small businesses, small organizations, and small governmental jurisdictions). The Small Business Administration's regulations at 13 CFR part 121 define a small business, in part, as a business entity "which operates primarily within the United States." 13 CFR 121.105(a). No regulatory flexibility analysis is required if the head of an agency certifies the rule will not have a significant economic impact on a substantial number of small entities.

I certify that the final rule will not have a significant economic impact on a substantial number of small entities. The following is NHTSA's statement providing the factual basis for the certification (5 U.S.C. § 605(b)).

The final rule directly affects seventeen large single stage motor vehicle manufacturers.[489] The final rule also affects four small domestic single stage motor vehicle manufacturers.[490] According to the Small Business Administration's small business size standards (*see* 13 CFR 121.201), a single stage automobile or light truck manufacturer (NAICS code 336111, Automobile Manufacturing; 336112, Light Truck and Utility Vehicle Manufacturing) must have 1,000 or fewer employees to qualify as a small business. All four of the vehicle manufacturers have less than 1,000 employees and make less than 1,000 vehicles per year. The rulemaking would not have a significant economic impact on the small vehicle manufacturers because under Part 525, passenger car manufacturer making less than 10,000 vehicles per year can petition NHTSA to have alternative standards set for those manufacturers. These manufacturers currently do not meet the 27.5 mpg standard and must already petition the agency for relief. If the standard is raised, it has no meaningful impact on these manufacturers, and they still must go through the same process and petition for relief. Given that there already is a

[489] BMW, Mercedes, Chrysler, Ferrari, Ford, Subaru, General Motors, Honda, Hyundai, Lotus, Maserati, Mitsubishi, Nissan, Porsche, Suzuki, Toyota, and Volkswagen

[490] The Regulatory Flexibility Act only requires analysis of small domestic manufacturers. There are four passenger car manufacturers we know of and no light truck manufacturers: Avanti, Panoz, Saleen, and Shelby.

mechanism for handling small businesses, which is the purpose of the Regulatory Flexibility Act, a regulatory flexibility analysis was not prepared.

NHTSA received comments on its discussion of the Regulatory Flexibility Act from Ferrari and NADA. Ferrari argued that the proposed standards did impact small manufacturers because they must pay fines in lieu of compliance and alternative standards are not available for manufacturers producing over 10,000 vehicles per year. Ferrari further argued that these fines would be particularly onerous if NHTSA raised the fine amount. In response, NHTSA notes that it has not yet initiated rulemaking to consider raising the penalties for CAFE non-compliance, and that the regulations are clear that manufacturers producing more than 10,000 vehicles per year are not small manufacturers, while manufacturers producing less may petition the agency. While the decision whether to grant the petition is within the agency's discretion, NHTSA has no interest in merely forcing manufacturers to pay fines. If an alternative standard is appropriate, NHTSA will set one.

NADA commented that NHTSA should have undertaken a full regulatory flexibility analysis in order to evaluate the impact of the standards on U.S. car and truck dealers, arguing that many of these are small businesses as defined by the Small Business Administration. NHTSA disagrees that these entities are directly impacted by the CAFE standards, as they are not a regulated entity under CAFE. As stated above, a regulatory flexibility analysis is not necessary for this rulemaking.

D. Executive Order 13132 (Federalism)

Executive Order 13132 requires NHTSA to develop an accountable process to ensure "meaningful and timely input by State and local officials in the development of regulatory policies that have federalism implications." The Order defines the term "Policies that have federalism implications" to include regulations that have "substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government." Under the Order, NHTSA may not issue a regulation that has federalism implications, that imposes substantial direct compliance costs, and that is not required by statute, unless the Federal government provides the funds necessary to pay the direct compliance costs incurred by State and local governments, or NHTSA consults with State and local officials early in the process of developing the proposed regulation. The agency has complied with the Order's requirements.[491]

As NHTSA set forth in the NPRM, the issue of preemption of State emissions standards under EPCA is not a new one; it has been the subject of an ongoing public dialogue regarding the preemptive impact of CAFE standards for three consecutive notice and comment rulemakings. This dialogue has involved a variety of parties (i.e., many of the States, the federal government, a wide variety of environmental groups, and the general public) and has taken place through a variety of means, including several rulemaking proceedings. NHTSA first addressed the issue relatively briefly in its rulemaking on CAFE standards for MY 2005-2007 light trucks[492] and then explored it at

[491] In addition, with respect to preemption, courts consider and place "some weight" on the views of the agency with authority to implement the federal fuel economy program. Geier v. American Honda Motor Co., 529 U.S. 861, 883 (2000) ("Congress has delegated to DOT authority to implement the statute; the subject matter is technical; and the relevant history and background are complex and extensive. The agency is likely to have a thorough understanding of its own regulation and its objectives and is 'uniquely qualified' to comprehend the likely impact of state requirements."); Medtronic, Inc. v. Lohr, 518 U.S. 470, 496 (1996) ("agency is uniquely qualified to determine whether a particular form of state law stands as an obstacle to the accomplishment and execution of the full purposes and objectives of Congress") (internal quotation marks omitted); see also id. at 506 (Breyer, J., concurring) (agency has "special understanding of * * * whether (or the extent to which) state requirements may interfere with federal objectives").

[492] 67 FR 77015, 77025; December 16, 2002, and 68 FR 16868, 16895; April 7, 2003.

great length, after receiving extensive public comment, in its final rule regarding MY 2008-2011 light trucks.[493] Throughout this dialogue, NHTSA has consistently taken the position that state regulations regulating CO_2 tailpipe emissions from automobiles are expressly and impliedly preempted.

Numerous commenters agreed with the agency's position in the NPRM on preemption, including General Motors Corporation, Cummins, the Alliance of Automobile Manufacturers, American Honda Motor Co., Inc., the Engine Manufacturers Association, Ford, the Association of International Automobile Manufacturers (AIAM), the New Mexico Automotive Dealers Association, Chrysler, the National Automobile Dealers Association, the Washington Legal Foundation, and David H. Sweeney.

Other commenters, including a number of states, disagreed with NHTSA preemption analysis. Some commenters, such as South Coast Air Quality Management District, National Association of Clean Air Agencies, and Public Citizen similarly cited recent court decisions as support for the proposition that NHTSA's position on preemption has been substantially changed judicially and that the discussion of preemption states should be excised from this rulemaking. Other comments submitted by several States' Attorneys General, the Union of Concerned Scientists, the Northeast States for Coordinated Air Use Management, the New Hampshire Department of Environmental Services, the Sierra Club, and the Center for Biological Diversity generally support the notion that recent court decisions all stand for the proposition that State standards regulating GHG tailpipe emissions are not preempted by EPCA, thus NHTSA's inclusion of its position on preemption is inappropriate.

[493] 70 FR 51414, 51457; August 30, 2005, and 71 FR 17566, 17654-17670; April 6, 2006.

Following notice, comment and analysis of the relevant factors and law, NHTSA's position in today's final rule is that expressed in the final rule for MY 2008-2011 light trucks in April 2006. See 71 FR 17566, 17654-670 (April 6, 2006), remanded on other grounds, Center for Biological Diversity v. NHTSA, 538 F.3d 1172 (9th Cir. 2008). (That discussion is reproduced in a slightly updated form in an appendix to this preamble.) In adopting that position, NHTSA has carefully analyzed developments and reexamined the detailed technological and scientific analyses and conclusions it presented in its 2006 final rule. The agency reaffirms those analyses and conclusions.

EPCA preempts state laws and regulations that are "related to fuel economy standards or average fuel economy standards for automobiles covered by an average fuel economy standard." 49 U.S.C. § 32919(a). As NHTSA concluded in the 2006 final rule, EPCA both expressly and impliedly preempts state laws regulating emissions of CO_2 from motor vehicles covered by federal fuel economy standards. NHTSA determined that a state requirement limiting CO_2 emissions from motor vehicles is related to average fuel economy standards under EPCA and thus expressly preempted. In reaching this conclusion, NHTSA followed established precedent on interpreting preemption provisions and on the broad scope of the central phrase "related to" in 49 U.S.C. § 32919(a). See, e.g., Morales v. Trans World Airlines, Inc., 504 U.S. 374, 383-384 (1992).

In the 2006 final rule, NHTSA explained that, "as a matter of basic chemistry, the burning of a gallon of gasoline produces about 20 pounds of [CO_2]." 71 FR at 17659. The agency determined that CO_2 "emissions are always and directly linked to fuel consumption because [CO_2] is the ultimate end product of burning gasoline." Id.[494] NHTSA explained that the amount of CO_2 emissions is "the controlling independent variable" in the calculation of fuel economy. Id. at 17661. Indeed, for purposes of CAFE standards compliance, automobile manufacturers use a formula developed by EPA, which "calculates fuel economy based on carbonaceous emissions from the vehicle." 71 FR at 17660. Thus, "compliance with federal fuel economy standards is based primarily on [CO_2] emission rates of covered vehicles." Id.

Further, NHTSA determined that "the only technologically feasible, practicable way for vehicle manufacturers to reduce [CO_2] emissions is to improve fuel economy." 71 FR at 17656. There are no emission control technologies that can be used to capture or destroy the tailpipe emissions of CO_2. Accordingly, the technologies for reducing those emissions are the technologies for reducing fuel consumption. It is by reducing the amount of fuel consumed per mile that the amount of CO_2 emitted per mile can be reduced.

As to state regulations, the agency noted the near identity of the California GHG regulation and CAFE standards: "[j]ust as in the case of compliance with federal fuel economy standards, [determining] compliance with [California's] regulation is largely a function of [measuring] tailpipe [CO_2] emissions." Id. at 17666. Thus, the California GHG regulations not merely met the criterion in EPCA's express preemption provision of

[494] Although combustion in a motor vehicle engine is imperfect, and thus also results in the emission of other substances, including carbon monoxide and hydrocarbons, those other emissions have declined in their significance as the Clean Air Act has required manufacturers to reduce such emissions, with the result "that fuel economy has become virtually synonymous with [CO_2] emission rates." 71 FR at 17659-17660. Unlike other motor vehicle emissions, CO_2 cannot be meaningfully reduced other than by reducing fuel usage.

being "related to" CAFE standards, they were practically synonymous with them, especially insofar as the California regulations regulate tailpipe emissions of CO_2.

NHTSA also explained that state regulation of CO_2 emissions would frustrate the objectives of Congress in establishing the CAFE program and conflict with the efforts of NHTSA to implement the program in a manner consistent with the commands of EPCA. 71 FR at 17667. Other congressional objectives underlying EPCA include avoiding serious adverse economic effects on manufacturers and maintaining a reasonable amount of consumer choice among a broad variety of vehicles. Id. To guide the agency toward the selection of standards meeting these competing objectives, Congress specified four factors that NHTSA must consider in determining which level is the maximum feasible level of average fuel economy and thus the level at which each standard must be set. Id. NHTSA therefore explained that given that the only practical way to reduce tailpipe emissions of CO_2 is to improve fuel economy, such a State standard would be meaningless since it would not reduce CO_2 emissions to an extent greater than the CAFE standards. Instead, a State would establish a standard that has the effect of requiring a higher level of average fuel economy. Setting standards that are more stringent than the fuel economy standards promulgated under EPCA would upset the efforts of NHTSA to balance and achieve Congress's competing goals. Setting a standard too high, above the level judged by NHTSA to be consistent with the statutory consideration after careful consideration of these issues in a rulemaking proceeding, would negate the agency's analysis and decisionmaking. Id.

Since NHTSA's 2006 final rule, there have been several developments cited by commenters on the issue of preemption. One development is the Supreme Court's 2007 decision in Massachusetts v. EPA, 549 U.S. 497, 127 S.Ct. 1438 (2007). In that case, the Court ruled that CO_2 is an "air pollutant" within the meaning of the Clean Air Act (CAA) and thus potentially subject to regulation under Section 202(a)(1) of that statute. Accordingly, it addressed EPA's obligations under Section 202(a)(1) of the CAA.

In NHTSA's view, the Supreme Court in Massachusetts did not address the issue of preemption under EPCA of state regulations regulating CO_2 tailpipe emissions from automobiles. In this respect, NHTSA agrees with Public Citizen's public comment that "[t]he [C]ourt [in Massachusetts] did not resolve the issue of whether carbon dioxide emissions regulations for motor vehicles were preempted under the current law." The Court did observe, with respect to potential EPA regulations, that EPA's obligations under the CAA and NHTSA's obligations under EPCA "may overlap, but there is no reason to think the two agencies cannot both administer their obligations and yet avoid inconsistency." 127 S. Ct. at 1462. This language did not mention the states or their regulations.

Another development is decisions arising in the lower federal courts. To date, two federal district courts have ruled on state regulations governing CO_2 from motor vehicles. See Green Mountain Chrysler v. Crombie, 508 F.Supp.2d 295 (D.Vt. 2007), on appeal, Case Nos. 07-4342(L), et al. (2d Cir.)[495] and in Central Valley Chrysler-Jeep v. Goldstene, 529 F.Supp.2d 1151 (E.D. Cal. 2007), reconsideration denied, 563 F. Supp.2d 1158, final judgment entered 2008 WL 4443103 (Sept. 26, 2008), on appeal, Case Nos. 08-17378, et al. (9th Cir.). In those decisions, the district courts ruled that the GHG motor

[495] The Environmental Defense Fund (EDF) incorporated by reference into its comments the brief submitted on behalf of the appellees in the Green Mountain Chrysler appeal in the Second Circuit. Echoing the district court in Green Mountain Chrysler, the EDF argues that preemption principles do not apply to the interplay of two federal laws, CAA and EPCA.

vehicle emission standards adopted by California and later adopted by Vermont are not preempted under EPCA. Appeals have been filed concerning the judgments in both cases, in the U.S. Courts of Appeal for the Second and Ninth Circuit, respectively. The Green Mountain Chrysler appeal is now fully briefed, and a briefing schedule for early 2009 was recently set in the Central Valley Chrysler-Jeep appeal.[496]

NHTSA respectfully does not agree with the decisions in either Green Mountain Chrysler or Central Valley Chrysler-Jeep. NHTSA is not bound by these district court decisions involving challenges to state GHG regulations. We note that while the Supreme Court has recognized that courts are to consider and place "some weight" on an agency's views regarding the underlying technical issues, matters long within the agency's expertise, and preemption, both of the courts in Green Mountain Chrysler and Central Valley Chrysler-Jeep ignored NHTSA's preemption analysis in the 2006 CAFE rulemaking.

The district court in Green Mountain Chrysler expressed the view that the challenge to Vermont's regulations could be resolved without direct application of EPCA's preemption provision. The court said that the dispute was not about preemption, but about reconciling two different federal statutes (EPCA and the CAA). In this regard, the district court stated that if EPA approved California's waiver petition (which had not occurred), then Vermont's GHG regulations become "other motor vehicle standards" whose effect NHTSA is required to take into consideration in setting CAFE standards. 49 U.S.C. § 32902(f). In the court's view, once a waiver is granted by EPA, compliance with California's standards is deemed to satisfy federal standards. In states that adopt

[496] Two other district court cases addressing EPCA preemption of state regulations are pending: Lincoln Dodge, Inc. v. Sullivan, Case No. 06-00070 (D.R.I.) and Zangara Dodge, Inc. v. Curry, Case No. 07- 01305 (D.N.M.).

California's standards, compliance with that standard would be deemed to satisfy federal standards as well. With this federal accommodation of state standards, Vermont's regulations would stand.

NHTSA does not agree with that view. The court's premise that preemption principles do not apply is not based on precedent and is not supported by applicable law. In fact, the district court in Central Valley Chrysler-Jeep recognized that "[t]he Green Mountain court never actually offers a legal foundation for the conclusion that a state regulation granted waiver under [CAA] section 209 [42 U.S.C. § 7543] is essentially a federal regulation such that any conflict between the state regulation and EPCA is a conflict between federal regulations." Central Valley Chrysler-Jeep, 529 F.Supp.2d at 1165.

NHTSA also does not agree with the district courts' express preemption analysis. EPCA preempts state laws and regulations that are "related to fuel economy standards or average fuel economy standards for automobiles covered by an average fuel economy standard." 49 U.S.C. § 32919(a) (emphasis added). The courts in Green Mountain Chrysler and Central Valley Chrysler-Jeep recognized the relationship between CO_2 emissions and fuel economy. Nonetheless, they erroneously concluded that the "related to" language in EPCA's preemption clause should be construed "very narrowly" and adopted a cramped interpretation of "related to" E.g., 529 F.Supp.2d at 1176.

The courts in Green Mountain Chrysler and Central Valley Chrysler-Jeep failed to recognize the broad interpretation to be accorded to "related to" in EPCA's preemption provision, based on precedents regarding the interpretation of that language in other statutes. A state law "relates to" a federal law if it "has a connection with or refers to" the subject of the federal law. Shaw v. Delta Airlines, Inc., 463 U.S. 85, 97 (1983) (ERISA case). The Court, citing similar federal statutory language, extended the application of the 'related to' standard to the Airline Deregulation Act in Morales v. Trans World Airlines, Inc., 504 U.S. 374, 383-84 (1992): "For purposes of the present case, the key phrase, obviously, is "relating to." The ordinary meaning of these words is a broad one-"to stand in some relation; to have bearing or concern; to pertain; refer; to bring into association with or connection with," . . . -and the words thus express a broad pre-emptive purpose. *Id*. at 383. The courts look "both to the objectives of the … statute as a guide to the scope of the state law that Congress understood would survive, [and] to the nature of the effect of the state law on [the Federal standards]." California Div. of Labor Standards Enforcement v. Dillingham Constr., N.A., Inc., 519 U.S. 316, 325 (1997), (quoting N.Y Conference of Blue Cross & Blue Shield Plans v. Travelers Ins. Co., 514 U.S. 645, 656 (1995)).

With this understanding of applicable law, one of Congress' objectives in EPCA was to create a national fuel economy standard, as expressed in 49 U.S.C. 32919(a). As we previously stated, the legislative history of that provision confirms that Congress intended to be broadly preemptive in the area of fuel economy regulation. The Senate bill [S. 1883, 94th Cong., 1st Sess., Section 509] would have preempted State laws only if they were "inconsistent" with federal fuel economy standards, labeling, or advertising, while the House bill [H.R. 7014, 94th Cong., 1st Sess., Section 507 as introduced, Section 509 as reported] would have preempted State laws only if they were not "identical to" a Federal requirement. The express preemption provision as enacted preempts all State laws that relate to fuel economy standards. No exception is made for

State laws on the ground that they are consistent with or identical to federal requirements. See 71 FR 17566, 17657 (April 6, 2006).

The district courts' view of the express preemption provision disregards that provision's actual language and legislative history to the point of replacing the "related to" criterion chosen by Congress with a wholly different criterion considered and rejected by Congress. The two district courts would limit the effect of the express preemption provision to preempting only those state laws that are identical to a CAFE standard. Under their approach, the two almost entirely identical state standards in the examples below would be treated entirely differently. The first would be preempted, but its near identical twin would not.

> Example (1). A state fuel economy standard that requires a manufacturer's fleet to achieve a specified number of miles per gallon. Compliance is determined by measuring each vehicle's CO_2 emissions per mile and converting that CO_2 figure into the mathematically equivalent amount of fuel consumed per mile, based on the carbon content of fuel,[497] and finally converting that figure in miles per gallon of fuel.
>
> Example (2). A state standard identical to the standard in (1), except for the following differences: (A) its requirement is converted from miles per gallon into the mathematically equivalent number of grams of CO_2 tailpipe emitted per mile, based on the carbon content of fuel; and (B) compliance is determined by measuring each vehicle's CO_2 emissions per mile, but no conversion to gallons per mile or miles per gallon is made. Such a state standard has essentially the same structure, compliance measuring procedures, and types and amounts of

[497] This is the method that EPA uses to determine compliance with NHTSA's CAFE standards.

benefits (in terms of fuel savings and CO_2 tailpipe emission reductions) as the standard in (1), and depends on the same technologies for compliance, but is not labeled as fuel economy standard (i.e., a State tailpipe CO_2 standard). It is a fuel economy standard in every respect, but name.

The rationale for this disparate treatment is not readily understandable. The treatment does not serve to prevent the creation of what is commonly called in academic circles a "regulatory gap." In the examples above, the first standard serves the same purpose as the second. This is because regulating the amount of fuel consumed per mile is same as regulating amount of CO_2 produced or emitted per mile. The amount of fuel consumed per mile determines how much CO_2 is produced per mile. Indeed, measuring the amount of CO_2 emitted per mile is the way EPA measures fuel economy under its CAFE test procedures. It does this because it is easier to precisely measure CO_2 emissions than to measure the amount of fuel consumed.

The district courts gave some reasons why, in their view, the state GHG emissions standards are not sufficiently related to fuel economy standards to be expressly preempted. These included because: (1) the GHG regulations cover all GHGs, unlike CAFE which only covers CO_2; (2) insofar as the GHG regulations do regulate CO_2, there are other ways for manufacturers to reduce CO_2 emissions (under current and expected technologies) besides raising their fuel economy levels; and, (3) the GHG regulations address upstream fuel production emissions, and CAFE does not. 508 F.Supp.2d at 353. However, the district court's distinction of state regulations is unavailing for factual reasons. For example, the district court in Green Mountain Chrysler attempted to distinguish the Vermont regulations by noting that they regulate all GHGs (and not just

CO_2). However, CO_2 constitutes approximately 95 percent of all GHGs. The court also ignored NHTSA's analysis that the only technologically feasible, practicable way for vehicle manufacturers to reduce CO_2 emissions is to improve fuel economy. 71 FR at 17656. In Central Valley Chrysler-Jeep, the court noted that "[t]he waiver provision of the Clean Air Act recognizes that California has exercised its police power to regulate pollution emissions from motor vehicles since before March 30, 1966, a date that predates both the Clean Air Act and EPCA. Thus, the court must presume that Congress did not intend that EPCA would supersede California's exercise of its historically established police powers." 529 F.Supp.2d at 1174-75. In these and other ways, the courts improperly construed the "related to" language of EPCA's preemption provision.

The courts in Green Mountain Chrysler and Central Valley Chrysler-Jeep also interpreted the factors NHTSA must "consider" under 49 USC 32902(f) to require that a state CO_2 emissions standard control the stringency of EPCA's fuel economy standards. For example, in Green Mountain Chrysler, the Court stated that "once EPA issues a waiver for a California emissions standard, it becomes a motor vehicle standard of the government, with the same stature as a federal regulation with regard to determining maximum feasible average fuel economy under EPCA." 508 F.Supp.2d at 347. The court in Central Valley Chrysler-Jeep went further, noting that while NHTSA is required to give consideration to "other standards," including those "promulgated by EPA," "[t]here is no corresponding duty by EPA to give consideration to EPCA's regulatory scheme. This asymmetrical allocation by Congress of the duty to consider other governmental regulations indicates that Congress intended that DOT, through NHTSA, is to have the burden to conform its CAFE program under EPCA to EPA's determination of what level of regulation is necessary to secure public health and welfare." Central Valley Chrysler-Jeep, 529 F.Supp.2d at 1168.

In support of its position, the Central Valley Chrysler-Jeep found persuasive the Green Mountain Chrysler court's view that California emissions regulations under CAA Section 209 have always been considered "other standards" on fuel economy. As originally enacted, EPCA contained a Section 502(d) that provided that any manufacturer could apply to DOT for modification of an average fuel economy standard for model years 1978 through 1980 if it could show the likely existence of a "Federal standards fuel economy reduction," defined to include EPA-approved California emissions standards that reduce fuel economy. "Thus, in 1975 when EPCA was passed, Congress unequivocally stated that federal standards included EPA-approved California emissions standards. § 502(d)(3)(D)(i)."[498] Central Valley Chrysler-Jeep, 529 F.Supp.2d at 1173 (quoting Green Mountain Chrysler, 508 F.Supp.2d at 345). When EPCA was recodified in 1994, "all reference to the modification process applicable for model years 1978 through 1980, including the categories of federal standards, was omitted as executed." Id. The court noted that the legislative intent of the 1994 recodification was not intended to make a substantive change to the law. Id. Thus, the court concluded that "[i]f the recodification worked no substantive change in the law, then the term 'other motor vehicle standards of the Government' continues to include both emission standards issued by EPA and emission standards for which EPA has issued a waiver under Section 209(b) of the CAA, as it did when enacted in 1975." Id.

[498] EPCA Section 502(d)(3)(D)(i) provided: "Each of the following is a category of Federal standards: . . . Emissions standards under section 202 of the Clean Air Act, and emissions standards applicable by reason of section 209(b) of such Act."

NHTSA believes that the district courts have misread EPCA to the point of turning it on its head. Under EPCA, NHTSA balances a number of factors that under 49 USC 32902(f) it "shall" consider. One EPCA factor is the effect of other Federal motor vehicle standards on fuel economy. However, the district courts' view is that this factor, which is but one of four factors that NHTSA is to "consider" in the balancing under 49 USC § 32902, is instead an "obligation" to "harmonize" CAFE standards with state emissions regulations under a CAA section 209 waiver. See, e.g., Central Valley Chrysler-Jeep, 529 F.Supp.2d at 1170. In other words, under the district courts' opinions, a state standard controls what NHTSA does and there is no balancing to be done by the agency. Consistent with the legislative history and NHTSA's long-standing interpretations, it is NHTSA's considered view, in interpreting EPCA, a statute which it administers in implementing the national fuel economy program, that EPCA's requirement that that it "consider" the 4 EPCA statutory factors set forth in 49 USC 32902(f) does not mean the agency is obligated under EPCA to harmonize CAFE standards with state CO_2 emissions standards.

This view suggests an apparent misunderstanding of the underlying concerns and purposes of the requirement to consider other standards. There is no hint in the history of EPCA of an intent to give other standards special, much less superior, status under EPCA. The limited concerns and purpose were to ensure that any adverse effects of other standards on fuel economy were taken into consideration in connection with the fuel economy standards. Those concerns are evident in a 1974 report, entitled "Potential for Motor Vehicle Fuel Economy Improvement," submitted to Congress by the Department of Transportation and Environmental Protection Agency.[499] That report noted that the weight added by safety standards would and one set of emissions standards might temporarily reduce the level of achievable fuel economy.[500] These concerns can also be found in the congressional reports on EPCA.[501]

NHTSA further believes that the district courts in Green Mountain Chrysler and Central Valley Chrysler-Jeep misconstrued the provision in EPCA as enacted in 1975 that allowed manufacturers to petition NHTSA to reduce CAFE standards that Congress had set for model years 1978, 1979 and 1980 if there was a "Federal standards fuel economy reduction." Pub. L. No. 94-163 § 502(d), 89 Stat. 904-05. This provision did not involve a factor to be balanced in determining fuel economy standards. It provided for a reduction in fuel economy standards for cars at a time when only conventional pollutants were regulated. It was specifically designed to address California's then-existing smog regulations, particularly with regard to the additional weight (which other things being equal reduces fuel economy) associated with catalytic converters. In so doing, Congress recognized the potential interplay for three model years between California's smog regulations and the possibility that it could reduce federal fuel economy standards for those model years. See H.R. No. 94-340, at 87. Thus, EPCA went on to include "Emissions standards under section 202 of the Clean Air Act, and emissions standards applicable by reason of section 209(b) of such Act" in its list of "categor[ies] of Federal standards." *Id.* § 502(d)(3)(D).

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[499] This report was prepared in compliance with Section 10 of the Energy Supply and Environmental Coordination Act of 1974, P.L. 93-319.

[500] See pages 6-8 and 91-93.

[501] See page 22 of Senate Report 94-179, pages 88 and 90 of House Report 94-340, and pages 155-7 of the Conference Report, Senate Report 94-516.

Because California standards to combat smog (which were not GHG regulations) “by reason of section 209(b)” could be considered to reduce federal fuel economy standards for three years, the district courts erroneously believed that state CO_2 regulations are somehow now “federal” standards under 49 USC 32902(f). On its face, this language applied only to three long past model years and only to reducing standards, not setting them. “For purposes of this subsection,” referred to section 502(d) of EPCA – not EPCA section 502(e) [now 49 U.S.C. 32902(f)] which sets forth the EPCA factor of “the effect of other Federal motor vehicle standards on fuel economy.” After MY 1980, section 502(d) became obsolete. When EPCA was codified in 1994, section 502(d) was dropped as executed and therefore surplusage. As the listing of Federal standards in section 502(d) never had any application outside that section and ceased to have significance when that section became obsolete, it had and has no bearing on the codified version of EPCA. It worked no substantive change for the codification simply to rescind a provision that had had and could have had no substantive significance for 14 years.

NHTSA believes that the district courts in Green Mountain Chrysler and Central Valley Chrysler-Jeep seek to give a CAA waiver for the California GHG regulation an effect far beyond the terms of the CAA provision authorizing such a waiver. The courts overlooked the fact that the CAA itself makes clear that waiver of preemption under that statute operates only to relieve "application of this section," the preemption provision of the Clean Air Act. 42 U.S.C. § 7543(b)(1) (emphasis added); see also 42 U.S.C. § 7543(b)(3) ("compliance with such State standards shall be treated as compliance with applicable Federal standards for purposes of this subchapter") (emphasis added). State GHG regulations, even if subject to an EPA waiver, would remain regulations “adopt[ed] or enforc[ed]" by "a State or political subdivision of a State" and therefore would be subject to preemption by EPCA. 49 U.S.C. § 32919(a).

NHTSA further does not agree with the district courts' implied preemption analysis.

The Green Mountain Chrysler court concluded that there is no conflict preemption presented by the Vermont GHG standards, and rejected the contention that Vermont's GHG regulations would conflict with Congress' intent that there be a single, nationwide fuel economy standard, and that those regulations upset NHTSA's careful balancing of the EPCA statutory factors in its rulemaking proceedings, particularly with regard to economic practicability and technological feasibility. In rejecting the manufacturers' arguments, the court held that the Vermont standards do not create an obstacle to achieving EPCA's goals because the Vermont standards are, in the court's own judgment, consistent with EPCA's standard setting criteria. In reaching that conclusion, the court did not consider the impact of the Vermont standards on the balancing done by NHTSA in setting CAFE standards. For its part, the court in Central Valley Chrysler-Jeep concluded that there was no conflict preemption because if California's standards were granted a waiver under CAA section 209 by EPA, they would satisfy CAA objectives and be consistent with EPCA. 529 F.Supp.2d at 1179. The court simply assumed consistency. If this assumption proved incorrect, to the extent of any incompatibility between the two regimes, "NHTSA is empowered to revise its standards" to take into account California's regulations. Id.

The district courts did not appear to recognize, as set forth in the 2006 final rule, that NHTSA is required to set fuel economy standards at the "maximum feasible" levels achievable by manufacturers in the applicable model years, taking into consideration four statutory factors: (1) technological feasibility; (2) economic practicability; (3) "the effect of other motor vehicle standards of the Government on fuel economy;" and, (4) the need of the United States to conserve energy. 49 U.S.C. § 32902(f).[502] State regulation of CO_2 emissions "would frustrate the objectives of Congress in establishing the CAFE program and conflict with the efforts of NHTSA to implement the program in a manner consistent with the commands of EPCA." 71 Fed. Reg. at 17667. Because EPCA requires the federal government to establish the maximum feasible CAFE standards, and because Congress directed the agency to consider specific criteria and to avoid serious adverse economic effects while maintaining consumer choice, the agency concluded that a state regulation imposing more stringent requirements than NHTSA's fuel economy standards "would upset the efforts of NHTSA to balance and achieve Congress's competing goals" and "would negate the agency's analysis and decisionmaking." *Id*. at 17667, 17669.

NHTSA reaffirms its implied preemption analysis as set forth above and more fully in the 2006 final rule. The views of the district courts do not take into account the view, as NHTSA expressed in the 2006 final rule, that EPCA impliedly preempts such a state regulation due to the conflict with the exclusive federal regulatory scheme.

Moreover, in reconciling the interaction between the statutory regimes in both EPCA and the CAA, it remains NHTSA's considered view that the agency will not consider currently state regulations, such as those adopted by California and Vermont (but subject to a waiver), to be "other motor vehicle standards of the Government" because they are preempted by EPCA, and because of the equivalence of the proposed

[502] Congress in adopting EISA in December 2007 did not change these EPCA statutory factors.

state GHG regulations and fuel economy standards, particularly insofar as they regulate tailpipe emissions of CO_2. See 71 FR at 17669. Moreover, it remains the agency's view that a state emissions standard may be preempted by EPCA - even if the state has been granted a waiver by EPA pursuant to the CAA.[503] As NHTSA explained in its 2006 final rule, "EPCA does not include any exception to its preemption provision that would cover GHG and CO_2 standards," and it NHTSA does not consider "State emissions standards that are expressly or impliedly preempted under EPCA, regardless of whether or not they have received such a [EPA] waiver." 71 FR at 17669 (emphasis added). This reading of EPCA's preemption provision allows that provision to function in a consistent way, without irrational limitation, to protect the national CAFE program from interference by any State standard effectively regulating fuel economy. It also simultaneously maximizes the ability of EPCA and the Clean Air Act to achieve their respective purposes.

Accordingly, for these and other reasons, we continue to respectfully disagree with the two district court rulings in Green Mountain Chrysler and Central Valley Chrysler-Jeep.

Another development that followed our 2006 CAFE rule was the enactment of EISA. In late 2007, Congress enacted EISA, amending EPCA by mandating substantial and sustained annual increases in the passenger car and light truck CAFE standards. As further amended by EISA, EPCA also mandates that standards be attribute-based and established and implemented separately for passenger cars and light trucks. As it did

[503] Indeed, the Supreme Court in Massachusetts v. EPA noted that "in some circumstances the exercise of [state] police powers to reduce in-state motor-vehicle emissions might well be pre-empted," although the Court did not reach that question. 127 S. Ct. at 1454.

before EISA, EPCA permits manufacturers to adjust their product mix on a national basis in order to achieve compliance while meeting consumer demand.

The enactment of EISA has increased the conflict between state regulations regulating CO_2 tailpipe emissions from automobiles and EPCA. A conflict between state and federal law arises when compliance with both federal and state regulations is a physical impossibility or when state law stands as an obstacle to the accomplishment and execution of the full purposes and objectives of Congress. Here, the conflict between state regulations regulating CO_2 tailpipe emissions and EPCA is greatly magnified in light of EISA, as state regulations: (1) have the same effect as fuel economy standards, (2) are not attribute-based as required by EISA, thus creating safety risks, especially given the substantial increases mandated by California, (3) do not establish separate standards for passenger cars and non-passenger cars as EISA and EPCA requires, and (4) do not balance factors required by EPCA. Such state regulations are contrary the judgment of NHTSA and the mandate of Congress.

Several commenters suggested that the enactment of EISA, specifically the so-called "savings clause" of Section 3 of EISA (42 U.S.C. § 17002 (2007)), acts to negate the preemption language in EPCA.[504] For example, the California Air Resources Board (CARB) stated its belief that the EISA savings provision "made it crystal clear that U.S. EPA, California, and the states adopting California's standards retain their authority to regulate motor vehicle GHG emissions pursuant to Clean Air Act Sections 202(a), 209(b), and 177, respectively." The South Coast Air Quality Management District stated

[504] SEC. 3. RELATIONSHIP TO OTHER LAW. Except to the extent expressly provided in this Act or an amendment made by this Act, nothing in this Act or an amendment made by this Act supersedes, limits the authority provided or responsibility conferred by, or authorizes any violation of any provision of law (including a regulation), including any energy or environmental law or regulation. (Emphasis added.)

that the "Agency's attempt to buttress its position by stating that 'the enactment of EISA … has increased the conflict between state regulations regulating GHG tailpipe emissions and EPCA' conflicts with the express savings provision in EISA." The EDF concurs, citing the appellee's brief submitted in the Green Mountain Chrysler appeal. Comments submitted by the Natural Resources Defense Counsel and the Sierra Club generally echo these views.

It is NHTSA's view that the EISA savings clause does not impact preemption of state efforts to regulate CO_2 emissions from vehicles as de facto fuel economy regulations under the preemption clause of EPCA. Express preemption of those state regulations does not arise from either anything in EISA or in any amendment made by EISA. It arises instead from a provision in EPCA as originally enacted.

Instead of viewing the savings clause, as might be reasonably assumed from its language, as simply preserving the status quo ante, some members of Congress expressed the view either during floor consideration of the bill that became EISA or in later inserted remarks that the intent of the savings clause was to allow states the ability to regulate CO_2 emissions, notwithstanding EPCA. In other words, they in effect transformed the savings clause into a rescission of the express preemption provision.

The legislative history of EISA is sparse, at best. The legislation was adopted hurriedly. No Senate, House, or Conference reports were created during the legislative process that culminated in EISA. A small number members inserted material into the Congressional Record after floor consideration of the legislation. There is no indication that the material inserted reflects the views of the Senate or House committees with jurisdiction over the legislation at large. For example, some members, such as

Congressman Markey [153 Cong. Rec. H14443-44 (December 6, 2007)] and Senator Feinstein [153 Cong. Rec. S15386 (December 13, 2007)], may have expressed the view that Congress' intent by including the savings clause was to, in effect, "immunize" state CO_2 regulations from preemption. However, statements and materials inserted by members are not indicative of congressional intent.[505]

In any event, there is also evidence that other members of Congress may have had a different view. For example, on December 13, 2007, Senators Levin, Feinstein, and Inouye inserted a colloquy into the Congressional Record which indicated a Congressional intent that "with respect to regulation of greenhouse gas emissions, any future regulations issued by the Environmental Protection Agency to regulate greenhouse gas emissions from vehicles be consistent with the Department of Transportation's new fuel economy regulations that will reach an industry fleet wide level by 35 miles per gallon by 2020." 153 Cong. Rec. S15385-86 (December 13, 2007). During this earlier colloquy, Senator Feinstein seemed to indicate an agreement with that view. Id. That same day, Senator Levin stated on the floor: "I voted earlier to invoke cloture and to move forward with the bill [i.e., EISA] after receiving assurances that my understanding

[505] "The intent of Congress as a whole is more apparent from the words of the statute itself than from a patchwork record of statements inserted by individual legislators and proposals that may never have been adopted by a committee, much less an entire legislative body-a truth which gives rise to 'the strong presumption that Congress expresses its intent through the language it chooses.'" Sigmon Coal Co., Inc. v. Apfel, 226 F.3d 291, 304-05 (4th Cir. 2000) (quoting INS v. Cardoza-Fonseca, 480 U.S. 421, 432 n. 12 (1987)), aff'd, Barnhart v. Sigmon Coal Co., Inc., 534 U.S. 438 (2002). See also In re Kelly, 841 F.2d 908, 912 n. 3 (9th Cir. 1988) ("Stray comments by individual legislators, not otherwise supported by statutory language or committee reports, cannot be attributed to the full body that voted on the bill. The opposite inference is far more likely.")

of congressional intent relative to the fuel economy provisions is correct." See 153 Cong. Rec. S15427 (December 13, 2007).[506]

NHTSA believes, on a review of the entire legislative record, that Congress, in amending EPCA, could have changed EPCA's preemption clause, 49 U.S.C. § 32919(a), when it adopted EISA. But Congress did not do so. Thus, the EISA savings clause does not remove the issue of state regulation of CO_2 emissions from vehicles from the application of preemption legal principles. Indeed, NHTSA believes it would be an absurd construction of EPCA to hold that the December 2007 EISA savings clause could negate the scope and intent of the 1975 EPCA preemption clause. The central purpose of EPCA's preemption clause, 49 U.S.C. § 32919(a), is to ensure national uniformity in fuel economy regulation. To read the EISA savings clause as urged by commenters pointing to these remarks would write out the EPCA preemption clause from the statute. Therefore, under applicable law, NHTSA does not believe it is appropriate to read the EISA savings clause in a way that defeats a central objective of EPCA.

As set forth in the NPRM, and in reaffirming its position in today final rule, NHTSA fully appreciates the great importance to the environment of addressing and reducing GHG emissions. Given that substantially reducing CO_2 tailpipe emissions from automobiles is unavoidably and overwhelmingly dependent upon substantially increasing fuel economy through installation of engine technologies; transmission technologies; accessory technologies; vehicle technologies; and hybrid technologies, increases in fuel

[506] According to Senator Levin: "With the colloquy accepted and placed in the CONGRESSIONAL RECORD, I voted to invoke cloture. Sometime after the vote on cloture, later in the day, a separate colloquy between Senator FEINSTEIN and Senator INOUYE was inserted in the CONGRESSIONAL RECORD. It was placed in the RECORD immediately following the Levin-Feinstein-Inouye colloquy, quoted above, although it was, in fact, presented for inclusion in the RECORD at a later point in the day, as noted by Senator INOUYE in the second sentence of the Inouye- Feinstein colloquy." 154 Cong. Rec. S1519-20 (March 4, 2008).

economy will produce commensurate reductions in CO_2 tailpipe emissions. And as noted above, through EISA, Congress has ensured that there will be substantial and sustained, long term improvements in fuel economy. Thus, no regulatory gap is created by giving EPCA's express preemption provision full effect.

Given the importance of the EPCA fuel economy program, and in light of the fact that some courts have ignored (or all but ignored) the 2006 final rule preamble, and after considering comments on NPRM, NHTSA is taking the further step of summarizing its position on preemption by EPCA in appendices to be added to the parts in the Code of Federal Regulations setting forth the passenger car and light truck CAFE standards. Some commenters stated that an appendix to regulatory text is not an appropriate method of incorporating NHTSA's interpretation of EPCA's preemptive effect on State GHG regulations. However, NHTSA continues to believe that its interpretation of the preemptive effect of EPCA on State GHG emissions standards is appropriately included as an appendix to the final regulatory text. Indeed, Federal Register Document Drafting Handbook provides the appropriate use of an appendix in an administrative rulemaking. The Handbook provides that an appendix is appropriate for "[s]upplemental, background, or explanatory information which illustrates or amplifies a rule that is complete in itself."[507] Accordingly, the section on preemption is explanatory information that provides the agency's interpretation of the effect of the statute's preemption language on a potential State regulation regarding CO_2 tailpipe emissions.

We have closely examined our authority and obligations under EPCA and that statute's express preemption provision. For those rulemaking actions undertaken at an

[507] See National Archives And Records Administration, Office Of The Federal Register, Federal Register Document Drafting Handbook 7-9 (October 1998 Revision).

agency's discretion, Section 3(a) of Executive Order 13132 instructs agencies to closely examine their statutory authority supporting any action that would limit the policymaking discretion of the States and assess the necessity for such action. This is not such a rulemaking action. NHTSA has no discretion not to issue the CAFE standards proposed in this document. EPCA mandates that the issuance of CAFE standards for passenger cars and light trucks for model years 2011-2015. Given that a State regulation for tailpipe emissions of CO_2 is the functional equivalent of a CAFE standard, there is no way that NHTSA can tailor the stringency or structure of a fuel economy standard so as to avoid preemption. Further, EPCA's express preemption provision, 49 U.S.C. § 32919(a), preempts state standards "related to" average fuel economy standards. Under the relatedness test, preemption is not dependent on the existence or nonexistence of any inconsistency or any difference between those State standards and the CAFE standards. Likewise, it is not dependent upon a state standard or a portion of a state standard's being identical to or equivalent to a CAFE standard in terms of stringency. "NHTSA's determination here is fully consistent, as noted above, with the legal positions that the United States has taken in court that state GHG regulations are subject to EPCA preemption regardless of any EPA waiver." *See supra* at 340; United States Amicus Br. at 18-19, Green Mountain Chrysler-Plymouth-Dodge-Jeep v. Crombie, No. 07-4342(L) (2d Cir. filed Apr. 16, 2008) (citing 49 USC 32919(a).

E. Executive Order 12988 (Civil Justice Reform)

Pursuant to Executive Order 12988, "Civil Justice Reform,"[508] NHTSA has considered whether this rulemaking would have any retroactive effect. This final rule does not have any retroactive effect.

F. Unfunded Mandates Reform Act

Section 202 of the Unfunded Mandates Reform Act of 1995 (UMRA) requires Federal agencies to prepare a written assessment of the costs, benefits, and other effects of a proposed or final rule that includes a Federal mandate likely to result in the expenditure by State, local, or tribal governments, in the aggregate, or by the private sector, of more than $100 million in any one year (adjusted for inflation with base year of 1995). Adjusting this amount by the implicit gross domestic product price deflator for 2006 results in $126 million (116.043/92.106 = 1.26). Before promulgating a rule for which a written statement is needed, section 205 of UMRA generally requires NHTSA to identify and consider a reasonable number of regulatory alternatives and adopt the least costly, most cost-effective, or least burdensome alternative that achieves the objectives of the rule. The provisions of section 205 do not apply when they are inconsistent with applicable law. Moreover, section 205 allows NHTSA to adopt an alternative other than the least costly, most cost-effective, or least burdensome alternative if the agency publishes with the final rule an explanation why that alternative was not adopted.

This final rule will not result in the expenditure by State, local, or tribal governments, in the aggregate, of more than $126 million annually, but it will result in the expenditure of that magnitude by vehicle manufacturers and/or their suppliers. In promulgating this final rule, NHTSA considered a variety of alternative average fuel economy standards lower and higher than those promulgated. NHTSA is statutorily

[508] 61 FR 4729 (Feb. 7, 1996).

required to set standards at the maximum feasible level achievable by manufacturers and has concluded that the final fuel economy standards are the maximum feasible standards for the passenger car fleet for MYs 2011-2015 and for the light truck fleet for MYs 2011-2015 in light of the statutory considerations.

G. Paperwork Reduction Act

Under the procedures established by the Paperwork Reduction Act of 1995, a person is not required to respond to a collection of information by a Federal agency unless the collection displays a valid OMB control number. The final rule amends the reporting requirements under 49 CFR part 537, Automotive Fuel Economy Reports. In addition to the vehicle model information collected under the approved data collection (OMB control number 2127-0019) in Part 537, passenger car manufacturers will also be required to provide data on vehicle footprint. Manufacturers and other persons wishing to trade fuel economy credits would be required to provide an instruction to NHTSA on the credits to be traded. For these changes, NHTSA is submitting to OMB a request for approval of the following collection of information.

In compliance with the PRA, this notice announces that the Information Collection Request (ICR) abstracted below has been forwarded to OMB for review and comment. The ICR describes the nature of the information collections and their expected burden. This is a request for an amendment of an existing collection.

Agency: National Highway Traffic Safety Administration (NHTSA).

Title: 49 CFR part 537, Automotive Fuel Economy (F.E.) Reports.

Type of Request: Amend existing collection.

OMB Clearance Number: 2127-0019.

Form Number: This collection of information will not use any standard forms.

Requested Expiration Date of Approval: Three years from the date of approval.

Summary of the Collection of Information

So that NHTSA can determine a manufacturer's required fuel economy level, NHTSA would require manufacturers to provide data on vehicle (including passenger car and light truck) footprint. This information collection would be included as part of the existing fuel economy reporting requirements. NHTSA would also require that manufacturers and other persons wishing to trade fuel economy credits provide an instruction to NHTSA on the credits to be traded.

Description of the Need for the Information and Use of the Information

NHTSA needs the footprint information to determine a manufacturer's required fuel economy level and its compliance with that level. NHTSA needs the credit trading instruction to ensure that its records of a manufacturer's available credits are accurate in order to determine whether a manufacturer has sufficient credits available to offset any non-compliance with the CAFE requirements in a given year.

Description of the Likely Respondents (Including Estimated Number, and Proposed Frequency of Response to the Collection of Information)

NHTSA estimates that 20 manufacturers would submit the required information. The frequency of reporting would not change from that currently authorized under collection number 2127-0019.

Estimate of the Total Annual Reporting and Recordkeeping Burden Resulting from the Collection of Information

For footprint, NHTSA estimates that each passenger car manufacturer would incur an additional 10 burden hours per year. This estimate is based on the fact that data collection would involve only computer tabulation. Thus, each passenger car manufacturer would incur an additional burden of 10 hours or a total on industry of an additional 200 hours a year (assuming there are 20 manufacturers). At an assumed rate of $21.23 an hour, the annual, estimated cost of collecting and preparing the additional passenger car footprint information is $4,246.

For credit trading, NHTSA estimates that each instruction would incur an additional burden hour per year. This estimate is based on the fact that the data required is already available and thus the only burden is the actual preparation of the instruction. NHTSA estimates that the maximum instructions it would receive each year is 20. While non-manufacturers may also participate in credit trading, NHTSA does not believe that every manufacturer would need to, or be able to, participate in credit trading every year. NHTSA does not, at this time, have a way of estimating how many non-manufacturers may with to participate in credit trading. Therefore NHTSA believes that the total number of manufacturers is a reasonable estimate, for a total annual additional burden of 20 hours a year. At an assumed rate of $21.23 an hour, the annual estimated cost of collecting and preparing the credit trading instruction is $425.

NHTSA estimates that the recordkeeping burden resulting from the collection of information would be 0 hours because the information would be retained on each manufacturer’s existing computer systems for each manufacturer’s internal administrative purposes. There would be no capital or start-up costs as a result of this collection.

Manufacturers can collect and tabulate the information by using existing equipment. Thus, there would be no additional costs to respondents or record keepers.

Comments are invited on:

- Whether the collection of information is necessary for the proper performance of the functions of the Department, including whether the information will have practical utility.
- Whether the Department's estimate for the burden of the information collection is accurate.
- Ways to minimize the burden of the collection of information on respondents, including the use of automated collection techniques or other forms of information technology.

A comment to OMB is most effective if OMB receives it within 30 days of publication. Send comments to the Office of Information and Regulatory Affairs, Office of Management and Budget, 725 17th Street, NW, Washington, DC 20503, Attn: NHTSA Desk Officer. PRA comments are due within 30 days following publication of this document in the **FEDERAL REGISTER**.

The agency recognizes that the amendment to the existing collection of information contained in today's final rule may be subject to revision in response to public comments and the OMB review. For Peter Feather, Division Chief, Fuel Economy Division, Office of International Policy, Fuel Economy, and Consumer Programs, National Highway Traffic Safety Administration, 1200 New Jersey Avenue, SE, Washington, DC 20590. You may also contact him by phone at (202) 366-0846 or by fax at (202) 493-2290.

H. Regulation Identifier Number (RIN)

The Department of Transportation assigns a regulation identifier number (RIN) to each regulatory action listed in the Unified Agenda of Federal Regulations. The Regulatory Information Service Center publishes the Unified Agenda in April and October of each year. You may use the RIN contained in the heading at the beginning of this document to find this action in the Unified Agenda.

J. Executive Order 13045

Executive Order 13045[509] applies to any rule that: (1) is determined to be economically significant as defined under E.O. 12866, and (2) concerns an environmental, health or safety risk that NHTSA has reason to believe may have a disproportionate effect on children. If the regulatory action meets both criteria, we must evaluate the environmental health or safety effects of the final rule on children, and explain why the final regulation is preferable to other potentially effective and reasonably feasible alternatives considered by us.

This final rule does not pose such a risk for children. The primary effects of this final rule are to conserve energy and to reduce tailpipe emissions of CO_2, the primary greenhouse gas, by setting fuel economy standards for motor vehicles.

K. National Technology Transfer and Advancement Act

Section 12(d) of the National Technology Transfer and Advancement Act (NTTAA) requires NHTSA to evaluate and use existing voluntary consensus standards in its regulatory activities unless doing so would be inconsistent with applicable law (*e.g.*, the statutory provisions regarding NHTSA's vehicle safety authority) or otherwise impractical.

[509] 62 FR 19885 (Apr. 23, 1997).

Voluntary consensus standards are technical standards developed or adopted by voluntary consensus standards bodies. Technical standards are defined by the NTTAA as "performance-based or design-specific technical specification and related management systems practices." They pertain to "products and processes, such as size, strength, or technical performance of a product, process or material."

Examples of organizations generally regarded as voluntary consensus standards bodies include the American Society for Testing and Materials (ASTM), the Society of Automotive Engineers (SAE), and the American National Standards Institute (ANSI). If NHTSA does not use available and potentially applicable voluntary consensus standards, we are required by the Act to provide Congress, through OMB, an explanation of the reasons for not using such standards.

The final rule categorize passenger cars according to vehicle footprint (average track width X wheelbase). For purposes of this calculation, NHTSA will base these measurements on those developed by the automotive industry. Determination of wheelbase would be consistent with L101-wheelbase, defined in SAE J1100 MAY95, Motor vehicle dimensions. NHTSA's final rule uses a modified version of the SAE definitions for track width (W101-tread-front and W102-tread-rear as defined in SAE J1100 MAY95). The definition of track width reduces a manufacturer's ability to adjust a vehicle's track width through minor alterations.

L. Executive Order 13211

Executive Order 13211[510] applies to any rule that: (1) is determined to be economically significant as defined under E.O. 12866, and is likely to have a significant adverse effect on the supply, distribution, or use of energy; or (2) that is designated by the

[510] 66 FR 28355 (May 18, 2001).

Administrator of the Office of Information and Regulatory Affairs as a significant energy action. If the regulatory action meets either criterion, we must evaluate the adverse energy effects of the final rule and explain why the final regulation is preferable to other potentially effective and reasonably feasible alternatives considered by us.

The final rule seeks to establish passenger car and light truck fuel economy standards that will reduce the consumption of petroleum and will not have any adverse energy effects. Accordingly, this final rulemaking action is not designated as a significant energy action.

M. Department of Energy Review

In accordance with 49 U.S.C. § 32902(j)(2), we submitted this final rule to the Department of Energy for review.

N. Privacy Act

Anyone is able to search the electronic form of all comments received into any of our dockets by the name of the individual submitting the comment (or signing the comment, if submitted on behalf of an organization, business, labor union, etc.). You may review DOT's complete Privacy Act statement in the **FEDERAL REGISTER** published on April 11, 2000 (Volume 65, Number 70; Pages 19477-78) or you may visit http://www.dot.gov/privacy.html.

Appendix -- Preemption of State Regulations Regulating Tailpipe Emissions of Carbon Dioxide from Passenger Cars and Light Trucks[511]

D. Preemption

Summary of NHTSA's position

[511] This appendix contains a slightly revised and updated version of the preemption discussion in the final rule establishing the MY 2008-2011 CAFE standards for light trucks. 71 FED. REG 17566, 17654-17671

In mandating federal fuel economy standards under EPCA, Congress has expressly preempted any state laws or regulations relating to fuel economy standards. A State requirement limiting CO_2 emissions is such a law or regulation because it has the direct effect of regulating fuel consumption. CO_2 emissions are directly linked to fuel consumption because CO_2 is the ultimate end product of burning gasoline. Moreover, because there is but one pool of technologies for reducing tailpipe CO_2 emissions and increasing fuel economy available now and for the foreseeable future, regulation of CO_2 emissions and fuel consumption are inextricably linked. It is therefore NHTSA's conclusion that such regulation is expressly preempted.

A State requirement limiting CO_2 emissions is also impliedly preempted under EPCA. It would be inconsistent with the statutory scheme, as implemented by NHTSA, to allow another governmental entity to make inconsistent judgments made about how quickly and how much of that single pool of technology can and should be required to be installed, consistent with the need to conserve energy, technological feasibility, economic practicability, employment, vehicle safety and other relevant concerns.

NHTSA's statement in the NPRM about preemption

In the NPRM, NHTSA reaffirmed its judgment that State regulation of motor vehicle tailpipe emissions of CO_2 is both expressly and impliedly preempted by statute:

> We reaffirm our view that a state may not impose a legal requirement relating to fuel economy, whether by statute, regulation or otherwise, that conflicts with this rule. A state law that seeks to reduce motor vehicle carbon dioxide emissions is both expressly and impliedly preempted.
>
> Our statute contains a broad preemption provision making clear the need for a uniform, federal system: "When an average fuel economy standard prescribed under this chapter is in effect, a State or a political subdivision of a State may not adopt or enforce a law or regulation related to fuel economy standards or average fuel economy standards for

> automobiles covered by an average fuel economy standard under this chapter." 49 U.S.C. 32919(a). Since the way to reduce carbon dioxide emissions is to improve fuel economy, a state regulation seeking to reduce those emissions is a “regulation related to fuel economy standards or average fuel economy standards.”
>
> Further, such a regulation would be impliedly preempted, as it would interfere [with] our implementation of the CAFE statute. For example, it would interfere the careful balancing of various statutory factors and other related considerations, as contemplated in the conference report on EPCA, we must do in order to establish average fuel economy standards at the maximum feasible level. It would also interfere with our effort to reform CAFE so to achieve higher fuel savings, while reducing the risk of adverse economic and safety consequences.[512]

During the comment period on the NPRM, some commenters questioned the correctness of NHTSA’s judgment as well as the appropriateness of reaffirming it in the NPRM.

The appropriateness of our discussing preemption in the NPRM

We discussed our views about preemption in the NPRM for several reasons. First, the agency was guided by Executive Order 13132, Federalism, and by Section 3(b)(1)(B) of Executive Order 12988, Civil Justice Reform. Second, we were guided by a desire to obtain comments from State and local officials and other members of the public in order to inform fully the agency’s position on this important issue.

Third, we were also guided by statements of the Supreme Court, which has encouraged agencies to consider the preemptive effects of their rulemakings during the rulemaking process, rather than waiting until litigation ensues to do so.[513] Finally, from time to time over the years, NHTSA has raised the issue of preemption in its rulemaking notices when the agency judged it appropriate to do so, as have other agencies within the

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[512] 70 FED. REG. 51414, 51457.

[513] *See*, e.g., Hillsborough County v. Automated Medical Laboratories, Inc., 471 U.S. 707, 718 (1985); Medtronic, Inc., v. Lohr, 518 U.S. 470, 506 (1996) (Justice Breyer, in concurrence); and Geier v. American Honda Motor Co., 529 U.S. 861, 908 (2000) (Justice Stevens, in dissent).

Department of Transportation. E.g., 54 FED. REG. 11765 (March 1989); 58 FED. REG. 68274 (December 1993) and 70 FED. REG. 21844 (April 2005).

Public comments about the merits of our views on preemption

The motor vehicle manufacturers and their associations agreed with the agency's position regarding federal preemption under §32919(a) of EPCA. Nissan supported that position with a detailed legal analysis. Conversely, several of the environmental groups and States,[514] and a number of U.S. Senators and Representatives, disagreed with the agency's position that a State carbon dioxide (CO_2) standard is expressly and impliedly preempted.

Nissan argued that California's proposed CO_2 standard is expressly preempted by EPCA's broadly worded preemption provision. A State standard is preempted even if it does not directly address fuel economy; it is sufficient if it simply relates to fuel economy.

That commenter noted that the text of EPCA's preemption provision is similar to that of the preemption provision in the Employee Retirement Income Security Act (ERISA). The Supreme Court has found that a state law is "related to" a benefits plan under ERISA and thus preempted by ERISA's preemption provision "if it has a connection with or reference to such a plan."

Nissan said that California's greenhouse gas standard is connected to fuel economy. California's greenhouse gas regulation is, in effect, a fuel economy regulation. The emission of one greenhouse gas, CO_2, is related to fuel economy. The only means for vehicle manufacturers to reduce vehicular CO_2 emissions is through making

[514] California, Connecticut, Maine, Massachusetts, New York, New Jersey, Oregon, Pennsylvania, and Vermont.

improvements to fuel economy. This is evident from CARB's report, which discusses the maximum feasible and cost effective technologies available and the identification of technologies that are in fact fuel economy improvements.

Nissan also said that California's standard also interferes with the nationally uniform plan that CAFE establishes for governing the fuel efficiency of the U.S. fleet and is therefore impliedly preempted. A state law or standard may be impliedly pre-empted because the federal interest is so dominant that Congress intends to occupy a regulatory field with no room for state supplementation (field preemption) or because the federal government has enacted a complete regulatory scheme in an area such that any state action would be inconsistent with the federal legislation (conflict preemption).

Nissan concluded by arguing that individual state laws setting fuel economy standards would be impliedly as well as expressly preempted. It argued that those laws would conflict with EPCA, which authorizes DOT to develop and administer a national CAFE program. Neither the EPA, nor States are permitted to interfere with the CAFE regulatory regime currently established by Congress under EPCA. Because, as noted above, the emission of CO_2 is related to fuel economy and because the only way to reduce CO_2 is through fuel economy technologies, any effort to do so by EPA or the States would interfere with Congressional objectives under EPCA.

Taken together, the primary arguments of the opponents of preemption were as follows:

The opponents argued that the preemption waiver provision of the Clean Air Act expressly recognizes the right of California to adopt and enforce its own standards for "air pollutants" emitted by motor vehicles (i.e., emissions standards), and the right of the other States to adopt and enforce standards identical to California's standards.[515] They said that Congress ratified and strengthened the preemption waiver provision in 1977, two years after the enactment of EPCA in 1975. Thus, they argue, Congress could not have intended EPCA to limit the rights they believe are recognized by the Clean Air Act.

The opponents believe further that a State CO_2 standard, including California's GHG/CO_2 equivalent emissions standard, is not preempted under EPCA's express preemption provision, Section 32919(a). They offered two arguments in support of this belief.

First, they argued that EPCA does not expressly preempt a State CO_2 standard. They believe that statute's express preemption provision should be read narrowly, preempting State standards that regulate fuel economy itself, but not State standards that have a stated purpose other than improving fuel economy (i.e., reducing emissions) and merely have the effect of increasing fuel economy.

Second, they argued that the intent of Congress concerning the relationship between State motor vehicle emissions standards and CAFE standards under EPCA is expressed in the Act's provision setting out the factors to be considered in setting CAFE standards ("decisionmaking factors provision"), Section 32902(f), not its express preemption provision. The decisionmaking factors provision requires NHTSA to consider technological feasibility, economic practicability, the effect of other Government standards on fuel economy, and the need of the nation to conserve energy, in determining the level at which it should set each CAFE standard. The opponents said the decisionmaking factors provision subordinates the CAFE standards to all State emissions standards, not vice versa.

[515] Clean Air Act §§ 209(b), 177, 42 U.S.C. 7543 and 7507.

In addition, the opponents of preemption appear to have argued that there is no implied (conflict) preemption because State CO_2 standards and CAFE standards have different objectives and because NHTSA did not show how a State CO_2 standard would adversely affect the CAFE standards. They argue further that, in the event of a conflict, CAFE standards must give way to the emissions standards per the decisionmaking factors provision.

NHTSA's response to public comments on the merits

Background

Fuel Economy Provisions of the Energy Policy and Conservation Act

EPCA established the CAFE program, mandating the issuance and implementation of standards for passenger cars and light trucks. The statute specifies that the passenger car standard is 27.5 mpg unless the agency finds that the maximum feasible level for a model year is different, and sets it at that level. It directs NHTSA to establish light truck standards at the maximum feasible level, subject to four statutorily specified factors.[516]

The Act specifies that the agency is to determine the maximum feasible level after considering technological feasibility, economic practicability, the effect of other motor vehicle standards on fuel economy, and the need of the Nation to conserve energy.[517] The agency has historically included the potential for adverse safety consequences when deciding upon a maximum feasible level. The overarching principle that emerges from the enumerated factors and the court-sanctioned practice of considering safety and links them together is that CAFE standards should be set at a level that will achieve the

[516] 49 U.S.C. 32902(a).
[517] 49 U.S.C. 32902(f).

greatest amount of fuel savings without leading to significant adverse economic or other societal consequences.[518]

EPCA specifies that compliance with CAFE standards is to be determined in accordance with test and calculation procedures established by EPA. 49 U.S.C. 32904(c). Under the procedures established by EPA, compliance with the CAFE standards is based on the rates of emission of CO_2, CO, and hydrocarbons from covered vehicles, but primarily on the emission rates of CO_2. In the measurement and calculation of a given vehicle model's fuel economy for purposes of determining a manufacturer's compliance with federal fuel economy standards, the role of CO_2 is approximately 100 times greater than the combined role of the other two relevant carbon exhaust gases. Given that the amount of CO_2, CO, and hydrocarbons emitted by a vehicle varies directly with the amount of fuel it consumes, EPA can reliably and accurately convert the amount of those gases emitted by that vehicle into the miles per gallon achieved by that vehicle.

Congress explicitly and broadly preempted all state laws and standards relating to fuel economy standards:

> [w]hen an average fuel economy standard prescribed under this chapter [49 USCS §§ 32901 et seq.] is in effect, a State or a political subdivision of a State may not adopt or enforce a law or regulation related to fuel economy standards or average fuel economy standards for automobiles covered by an average fuel economy standard under this chapter.[519]

Congress did not include a provision authorizing any waivers of that preemption provision for any State for any reason.

Clean Air Act

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[518] Average Fuel Economy Standards for Light Trucks; Model Years 2008–2011, 70 FED. REG. 51414, 51424 (August 30, 2005) (to be codified at 49 C.F.R. pt. 533).
[519] 49 U.S.C. 32919(a).

Congress has also preempted any state standards relating to the control of new motor vehicle emissions:

> [n]o State or any political subdivision thereof shall adopt or attempt to enforce any standard relating to the control of emissions from new motor vehicles or new motor vehicle engines.[520]

However, Congress has also expressly authorized EPA to waive the preemption provision under the Clean Air Act for states that adopted emissions control standards before 1966.[521] While California is the only State that meets that criterion, and thus is the only state that can obtain a waiver of the preemption provision, the Clean Air Act permits other States to adopt California emission standards.[522]

Current State GHG standards[523]

The GHG standard purports to regulate four motor vehicle climate change emissions:

- CO_2, CH_4 and N_2O emissions resulting directly from operation of the vehicle,
- CO_2 emissions resulting from operating the air conditioning system,
- HFC (refrigerant) emissions from the air conditioning system due to either leakage, losses during recharging, or release from scrappage of the vehicle at end of life, and

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[520] 42 U.S.C. 7543 (a).
[521] 42 U.S.C. 7543 (b).
[522] 42 U.S.C. 7507.
[523] According to the National Academy of Sciences, Massachusetts, New York, New Jersey, Connecticut, Rhode Island, Vermont, and Maine have adopted the California GHG emissions standard. In addition, Washington State has adopted the standard contingent upon Oregon's adoption of it. Oregon "has adopted temporary rules…and is scheduled to proposed permanent rules in the summer of 2006." State and Federal Standards for Mobile Source Emissions, prepublication copy, 145 (2006).

This discussion of preemption focuses on the details of the California standard in order to provide the clearest possible expression of the underlying technical rationale for why that standard is not consistent with NHTSA's authority to regulate fuel economy. This specific discussion should not be interpreted to mean that other standards would be acceptable.

• Upstream emissions associated with the production of the fuel used by the vehicle.[524]

As is shown later in the discussion of preemption, compliance with the GHG standards will be based primarily on the CO_2 emission rates of vehicles. The States will measure the amounts of emissions of these four gases and then convert them into "CO_2-equivalent" emissions.[525] This reflects the status of CO_2 as the reference gas for measuring the global warming potential of greenhouse gases.

Constitutional basis for preemption

Preemption results from Article VI of the U.S. Constitution, which provides that federal law "shall be the supreme Law of the Land; and the Judges in every State shall be bound thereby, any Thing in the Constitution or Laws of any State to the Contrary notwithstanding."

Principles of preemption

The Supreme Court has held that preemption may be express or implied:

> State law may be preempted by express language in a congressional enactment,…by implication from the depth and breadth of a congressional scheme that occupies the legislative field …, or by implication because of a conflict with a congressional enactment.[526]

Discussion

In response to the public comments and letters from members of Congress, we have re-analyzed all issues carefully as set forth below, and determined, based on existing

[524] Title 13, California Code of Regulations (CCR) § 1961.1(a)(1)(B)1.a. For vehicles certified on conventional fuels (*e.g.*, gasoline), CARB's regulation does not encompass upstream emissions (i.e., emissions associated with the production and transportation of the fuel used by the vehicle).California Environmental Protection Agency, Air Resources Board, Regulations To Control Greenhouse Gas Emissions From Motor Vehicles, Final Statement Of Reasons (FSOR), at 6-7.
[525] California Environmental Protection Agency, Air Resources Board, Regulations To Control Greenhouse Gas Emissions From Motor Vehicles, Initial Statement Of Reasons (ISOR), p. 48
[526] Lorillard Tobacco Co. v. Reilly, 533 U.S. 525, 540 (2001).

and foreseeable technologies for reducing CO_2 emissions from motor vehicles, that the effect under EPCA and the Supremacy Clause of the U.S. Constitution is that State regulation of those emissions is preempted.

Any Regulation Governing Carbon Dioxide Emissions from Motor Vehicles Relates to Average Fuel Economy Standards and Is Expressly Preempted under 49 U.S.C. Chapter 329

EPCA contains a broadly worded provision expressly preempting any State standard or regulation that is "related to" a fuel economy standard:[527]

> [49 U.S.C.] § 32919. Preemption
> (a) General. When an average fuel economy standard prescribed under this chapter [49 USCS §§ 32901 et seq.] is in effect, a State or a political subdivision of a State may not adopt or enforce a law or regulation related to fuel economy standards or average fuel economy standards for automobiles covered by an average fuel economy standard under this chapter.

(Emphasis added.)

While the express preemption provision on its face uses expansive language, any ambiguity regarding the appropriate reading of the provision, particularly in relation to other statutory provisions, must be resolved in light of the policy considerations embodied in EPCA.

In NHTSA's judgment, this language includes, but is not limited to, explicit fuel economy standards issued by States. Because the only technologically feasible, practicable way for vehicle manufacturers to reduce CO_2 emissions is to improve fuel economy,[528] NHTSA's considered view is that a State regulation that requires vehicle

[527] 70 FED. REG., at 51457 (August 30, 2005).
[528] NHTSA recognizes that regulating the producers of motor vehicle fuels can contribute to the reduction of CO_2 emissions. The preemption provision of EPCA does not preempt State regulation of those fuels.

manufacturers to reduce those emissions is a "regulation related to fuel economy standards or average fuel economy standards."[529] This view is consistent with the legislative history of the preemption provision, and with the Supreme Court's interpretation of similar provisions.

The legislative history of that provision confirms that Congress intended to be broadly preemptive in the area of fuel economy regulation. The Senate bill[530] would have preempted State laws only if they were "inconsistent" with federal fuel economy standards, labeling, or advertising, while the House bill[531] would have preempted State laws only if they were not "identical to" a Federal requirement. The express preemption provision as enacted preempts all State laws that relate to fuel economy standards. No exception is made for State laws on the ground that they are consistent with or identical to federal requirements.

In interpreting the express preemption provisions of other statutes containing the identical "relates to" language found in EPCA, the Supreme Court has found this language to be very expansive. A State law relates to a Federal law if the State law "has a connection with or refers to" the subject of the Federal law. The Court made the latter finding first under ERISA[532] and then, based on its ERISA cases and the use of identical language, under the Airline Deregulation Act (ADA).[533] "Since the relevant language of the ADA is identical, we think it appropriate to adopt the same standard here…"[534]

However, it does preempt State regulation of the manufacturers of motor vehicles directly related to fuel economy, including regulation of CO_2 emissions of their vehicles.

[529] Id.

[530] S. 1883, 94th Cong., 1st Sess., § 509.

[531] H.R. 7014, 94th Cong., 1st Sess., § 507 as introduced, § 509 as reported.

[532] Shaw v. Delta Airlines, Inc., 463 U.S. 85, 97 (1983).

[533] Morales v. Trans World Airlines, Inc., 504 U.S. 374, 384 (1992).

[534] Ibid.

Particularly since the Airline Deregulation Act's situation is a law involving transportation, we think its interpretation of the phrase "relates to" is instructive here.

In particular, the Court has provided guidance on the ultimate limits of a strictly textual approach in interpreting either the phrase "relates to" or the phrase "has a connection with," given the existence of unending relationships and "infinite connections" and the resulting potential for an overly extensive application of ERISA's preemption provision, the Court declined to take that approach in interpreting that provision in Blue Cross & Blue Shield Plans v. Travelers Ins. Co.[535] The Court said that to determine whether a State law has a forbidden connection, it would instead look "both to the objectives of the ERISA statute as a guide to the scope of the state law that Congress understood would survive, as well as to the nature of the effect of the state law on ERISA plans. California Div. of Labor Standards Enforcement v. Dillingham Constr., N.A., Inc., 519 U.S. 316, 325 (1997), quoting Travelers,…, at 656…." (Emphasis added.) (Internal quotations omitted.)[536]

Even under that sort of analysis, however, the results would be unchanged here. Congress had a variety of interrelated goals in enacting EPCA and has charged NHTSA with balancing and achieving them. Among them was the overarching one of improving motor vehicle fuel economy.[537] To achieve that goal, Congress did not simply mandate the issuance of fuel economy standards set at whatever level NHTSA deemed appropriate. Nor did it simply say that levels must be set consistent with the criteria it specified in Section 32902(f). It went considerably further, mandating the setting of standards at the maximum feasible level.

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[535] 514 U.S. 645, 656, 658-662 (1995),

[536] Egelhoff v. Egelhoff, 532 U.S. 141, 147 (2001).

[537] Center for Auto Safety v. NHTSA, 793 F.2d 1322, 1340 (D.C. Cir. 1986)

Congress also sought national uniform fuel economy standards "[i]n order to avoid any manufacturer being required to comply with differing State and local regulations with respect to automobile or light-duty truck fuel economy."[538] To that end, it expressly preempted State and local laws and regulations relating to fuel economy standards.

Other congressional objectives underlying EPCA include avoiding serious adverse economic effects on manufacturers and maintaining a reasonable amount of consumer choice among a broad variety of vehicles. Congress was explicitly concerned that the CAFE program be carefully drafted so as to require levels of average fuel economy that do not have the effect of either "imposing impossible burdens or unduly limiting consumer choice as to capacity and performance of motor vehicles."[539] These concerns are equally applicable to the manner in which that program is implemented.

To guide the agency toward the selection of standards meeting these competing objectives, Congress specified four factors that NHTSA must consider in determining which level is the maximum feasible level of average fuel economy and thus the level at which each standard must be set. These are technological feasibility, economic practicability, the effect of other Government standards on fuel economy, and the need of the Nation to conserve energy. In addition, "NHTSA has always examined the safety consequences of the CAFE standards in its overall consideration of relevant factors since its earliest rulemaking under the CAFE program."[540]

While the Court in Travelers said State laws found to have "only a tenuous, remote, or peripheral connection" to ERISA's purposes, especially in areas of traditional

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[538] S. REP. NO. 94-179, 25 (1975).
[539] H. REP. NO. 94-340, 87 (1975).
[540] Competitive Enterprise Institute v. NHTSA, 901 F.2d 107, 120 at n.11 (D.C. Cir. 1990).

State regulation, are not preempted,[541] NHTSA has concluded that a State GHG standard is not such a law. As explained at length below, to the extent that it regulates tailpipe CO_2 emissions, a State GHG standard has a direct and very substantial effect on EPCA's objectives, placing it virtually at the very center of the reach of EPCA's express preemption provision, not at or even near its periphery. Thus, there is no need here to address issues about the definition or location of the outer reaches of the provision's application.

As explained below, CO_2 emissions account for over 90 percent of all CO_2 equivalent emissions from a motor vehicle. Accordingly, a State standard regulating GHG emissions expressed as CO_2 equivalent emissions is, to a very substantial extent, a State CO_2 emissions standard. To that extent, a State GHG standard is fuel economy standard in almost all but name and stated purpose. It would have virtually the same effects as a fuel economy standard. Thus, NHTSA has concluded that a State GHG standard does not incidentally affect vehicle manufacturers; it directly targets them.

Likewise, in NHTSA's view, such a standard does not incidentally affect decisions by manufacturers to add fuel saving technologies to their vehicles. Because the only currently practical way for vehicle manufacturers to reduce CO_2 tailpipe emissions is through application of fuel saving technologies[542] and no technologies are even under development that would make possible reduction of CO_2 emissions independent of reducing fuel consumption,[543] such a standard directly targets manufacturers and compels

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[541] Blue Cross & Blue Shield Plans v. Travelers Ins. Co., 514 U.S. 645, 658-662 (1995).

[542] Essentially all of the technologies identified by the California Air Resources Board for reducing CO_2 emissions are among the technologies listed by the National Academy of Science in its 2002 report on reforming the CAFE program and improving fuel economy. The essential identity of the two lists confirms the fact that, currently, the only method for reducing CO_2 emissions is to reduce fuel consumption.

[543] EPA has reached a similar conclusion. *See* 68 FED. REG 52922, 52929.

the use of those technologies. Therefore, the agency has concluded that the effect of a State GHG standard on vehicle design and performance is the same as that of fuel economy standards.

Commenters opposing preemption suggested that the purpose of a State law, not its effects, should determine whether there is preemption. Since the purpose of a State GHG regulation for motor vehicles is regulating CO_2 and other GHG emissions from motor vehicles, not fuel economy, they suggest that there can be no preemption under EPCA's express preemption provision. This limited view regarding the extent of preemption under that provision is inconsistent with NHTSA's expert analysis, which is guided by and comports with the Supreme Court's discussion of the similarly worded express preemption provisions in ERISA and the ADA. As noted above, in resolving ambiguity regarding preemption under a Federal law, the Court looks at the effects of a State law on the subject addressed by the Federal law to aid in determining if there is preemption.[544]

A federal statute's broadly worded express preemption provision does not lose its preemptive effect because a State cites a purpose other than or in addition to the purpose of that federal statute.[545] In Gade, the Supreme Court said that "[i]n assessing the impact of a state law on the federal scheme, we have refused to rely solely on the legislature's professed purpose and have looked as well to the effects of the law."[546]

[544] Egelhoff, at 147.
[545] Gade v. National Solid Wastes Management Ass'n., 505 U.S. 88, 105 (1992).
[546] *Id.*, at 106; *see* also Morales, at 386: "petitioner advances the notion that only state laws specifically addressed to the airline industry are pre-empted, whereas the ADA imposes no constraints on laws of general applicability. Besides creating an utterly irrational loophole (there is little reason why state impairment of the federal scheme should be deemed acceptable so long as it is effected by the particularized application of a general statute), this notion similarly ignores the sweep of the 'relating to' language. We have consistently rejected this precise argument in our ERISA cases: '[A] state law may "relate to"' a benefit plan, and thereby be

The agency's conclusions here that the EPCA preemption provision is expansive and preempts State emissions regulations that have the practical effect of regulating fuel economy are fully in keeping with earlier views expressed by the government. Further, they are consistent with views that EPA has articulated.

In June 2002, the U.S. District Court for the Eastern District of California issued an order granting plaintiff automobile manufacturers' and dealers' motion for preliminary injunction and issuing a preliminary injunction in Central Valley Chrysler-Plymouth v. California Air Resources Bd., No. CV-F-02-5017 REC/SMS, 2002 U.S. Dist. LEXIS 20403 (E.D. Cal. June 11, 2002) (enjoining California zero-emission-vehicle (ZEV) rule). The court found that the plaintiffs had shown that the ZEV rule was "related to" fuel economy standards because it had the purpose and practical effect of regulating fuel economy. The court also found that "preemption cannot be avoided by intertwining preempted requirements with nonpreempted requirements."

In October 2002, the United States filed an amicus curiae brief in support of affirming the June 2002 order in Central Valley Chrysler-Plymouth, Inc. et. al. v. Michael P. Kenny, No. 02-16395, (9th Cir. 2002), pointing out that EPCA contains a broadly stated provision expressly preempting state regulations "related to" fuel economy standards. The government further pointed out that, unlike the Clean Air Act, EPCA does not contain an exception allowing a state law that regulates fuel economy, regardless of the purpose of the law. Given that Congress had included some exceptions, but not that particular one, the government said that it would be inappropriate to read in or imply that exception.

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pre-empted, even if the law is not specifically designed to affect such plans, or the effect is only indirect.'" (Citations omitted.)

In December 2002, NHTSA published a CAFE NPRM for MY 2005-2007 light trucks in which the agency addressed certain court filings by the State of California relating to CAFE preemption. The agency noted that California had:

> [I]n recent court filings, asserted that NHTSA has not treated the CAFE statute as preempting state efforts to engage in CAFE related regulation, stating that "time and time again, NHTSA in setting CAFE standards has commented on the fuel economy effects of California's emissions regulations, and not once has it even suggested that these were preempted." *See* Appellants Opening Brief filed on behalf Michael P. Kenny in Central Valley Chrysler-Plymouth, Inc. et. al. v. Michael P. Kenny, No. 02-16395, at p. 33 (9th Cir. 2002). As a result, the State suggests that it may, consistent with federal law, issue regulations that relate to fuel economy.
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> The State misses the point. The agency reviews emissions requirements to ensure that we do not establish a standard that is infeasible in light of other public policy considerations, including federal and state efforts to regulate emissions. Thus, we consider potential fuel economy losses due to more stringent emissions requirements when we determine maximum feasible fuel economy levels.
>
> This does not mean that a state may issue a regulation that relates to fuel economy and which addresses the same public policy concern as the CAFE statute. Our statute contains a broad preemption provision making clear the need for a uniform, federal system: "When an average fuel economy standard prescribed under this chapter is in effect, a State or a political subdivision of a State may not adopt or enforce a law or regulation related to fuel economy standards or average fuel economy standards for automobiles covered by an average fuel economy standard under this chapter." 49 U.S.C. 32919(a).
>
> The fact that NHTSA had not expressly addressed this particular aspect of California's requirements should not have been interpreted as tacit acceptance. Indeed, the United States has taken the express position in the Kenny case that it has a substantial interest in enforcing the federal fuel economy standards and in ensuring that states adhere to the Congressional directive prohibiting them from adopting or enforcing any law or regulation related to fuel economy or average fuel economy standards.[547]

In its CAFE final rule for MY 2005-07 light trucks, NHTSA stated that its "position with regard to the relationship between state laws and our federal fuel economy

[547] Light Truck Average Fuel Economy Standards Model Years 2005-2007, 67 FED. REG. 77015, at 77025 (Proposal to establish standards December 16, 2002).

responsibility was set forth in the [December 2002] NPRM and has not changed. The EPCA statute contains a preemption provision intended to ensure a unified federal program to address motor vehicle fuel economy."

In September 2003, the Environmental Protection Agency specifically discussed the relationship between reducing tailpipe emissions of CO_2 and improving fuel economy. In denying an October 1999 petition by the International Center for Technology Assessment (ICTA) asking the EPA to regulate CO_2 and other greenhouse gas emissions from motor vehicles under the Clean Air Act for the purpose of addressing global climate change, the EPA included a discussion of this relationship:

> No technology currently exists or is under development that can capture and destroy or reduce emissions of CO_2, unlike other emissions from motor vehicle tailpipes. At present, the only practical way to reduce tailpipe emissions of CO_2 is to improve fuel economy.[548]

EPA further explained this position in its brief filed in early 2005 in the Court of Appeals for the D.C. Circuit in Commonwealth of Massachusetts v. EPA, No. 03-1361, in which 12 states and a number of environmental groups filed a petition for review challenging EPA's denial of ICTA's petition:

> [A]t present, the only practical way of making a meaningful reduction in motor vehicle emissions of CO_2 (the most significant greenhouse gas) is by increasing fuel economy. *See* 68 Fed. Reg. at 52929. …[A]ny motor vehicle standard EPA might set under the Act that required meaningful reductions in CO_2 emissions … would effectively require significant increases in the fuel economy of vehicles subject to EPCA. 68 Fed. Reg. at 52929.

NHTSA has Concluded that Any Effort to Regulate Carbon Dioxide Emissions from Motor Vehicles Is Related to Average Fuel Economy Standards for Motor Vehicles under 49 USC Chapter 329

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[548] Control of Emissions from New Highway Vehicles and Engines, 68 FED. REG. 52922, 52929 (denial of petition September 8, 2003).

1. Motor Vehicle Fuel Economy Is Directly Related To Emissions Of Carbon Dioxide

Fossil fuels such as petroleum contain mostly hydrocarbons (compounds containing hydrogen and carbon). In the combustion process, these fuels are oxidized to produce heat. In perfect combustion, the oxygen (O_2) in the air combines with all of the carbon (C) in the fuel to form carbon dioxide (CO_2) and all of the hydrogen (H) in the fuel to form water (H_2O).

Most light trucks are powered by gasoline internal combustion engines. The combustion of gasoline produces CO_2 in amounts that can be readily calculated. Based on its content (carbon and hydrogen), as a matter of basic chemistry, the burning of a gallon of gasoline produces about 20 pounds of CO_2.[549, 550]

In practice, the combustion process is not 100 percent efficient and engines produce several types of emissions as combustion byproducts or as a result of incomplete combustion. In an internal combustion engine, these include nitrogen oxides (NO_x) (from nitrogen and oxygen in the atmosphere), carbon monoxide (CO) and hydrocarbons (HC),

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549 Most of that weight comes from the oxygen in the air. A carbon atom has an atomic weight of 12, and each oxygen atom has an atomic weight of 16, giving each single molecule of CO_2 an atomic weight of 12 + (16 x 2) or 44. Therefore, to calculate the weight of the CO_2 produced from a gallon of gasoline, the weight of the carbon in the gasoline is multiplied by 44/12 or 3.7. Since gasoline is about 87% carbon and 13% hydrogen by weight, and since a gallon of gasoline weighs about 6.3 pounds, the carbon in a gallon of gasoline weighs (6.3 lbs. x .87) or 5.5 pounds. If the weight of the carbon (5.5 pounds) is then multiplied by 3.7, the answer is about 20 pounds. (Source: www.fueleconomy.gov/feg/co2.shtml. The website, www.fueleconomy.gov, is operated jointly by the Department of Energy and the Environmental Protection Agency.)

550 In addition, CO_2 emissions can be determined from the carbon content of the fuel by using a carbon content coefficient that reflects the amount of carbon per unit of energy in each fuel. CO_2 emissions = energy consumption [e.g., in Btu] *x* carbon content coefficient for the fuel *x* fraction of carbon oxidized [99% for petroleum] *x* 3.67 [conversion of carbon to carbon dioxide (44/12) based on molecular weights]. T.J. Blasing, G. Marland and C. Broniak, Estimates of Annual Fossil-Fuel CO_2 Emitted for Each State in the U.S.A. and the District of Columbia for Each Year from 1960 through 2001, at http://cdiac.ornl.gov/trends/emis_mon/stateemis/emis_state.htm. The carbon content coefficients for petroleum products have varied very little over time – less than one percent per year since 1990. Id. Reformulated gasoline introduced in the 1990s pursuant to the Clean Air Act Amendments of 1990 has a carbon emissions coefficient approximately one percent smaller than that of standard gasoline.

including methane. These emissions do not alter the fact that combustion of gasoline produces CO_2. Moreover, the amounts of CO_2 emitted per mile are far greater than the amounts of HC, CO, and NOx, singly or combined.[551, 552]

CO_2 emissions are always and directly linked to fuel consumption because CO_2 is the ultimate end product of burning gasoline.[553] The more fuel a vehicle burns or consumes, the more CO_2 it emits.[554] Viewed another way, fuel economy is directly related to emissions of greenhouse gases such as CO_2.[555] Fuel consumption and CO_2 emissions from a vehicle are two "indissociable" parameters.[556]

2. The Most Significant Factor in Determining the Compliance of Motor Vehicles with NHTSA's Fuel Economy Standards is their Rate of Carbon Dioxide Emissions

A manufacturer's compliance with the federal average fuel economy standards is based on the collective fuel economies of its covered vehicles. For purposes of determining compliance with federal fuel economy standards, EPA and manufacturers

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[551] U.S. EPA, *Average Annual Emissions and Fuel Consumption for Passenger Cars and Light Trucks*, EPA420-F-00-013, April 2000. Available on the Internet at http://www.epa.gov/otaq/consumer/f00013.pdf.

[552] Good, David, U.S. EPA, *2006 test-car-list-and analysis for DD 206.xls*, February 2006. (unpublished analysis of 2006 test car list available at http://www.epa.gov/otaq/tcldata.htm)

[553] *See* also EPA's denial of petition to regulate CO2 tailpipe emissions from motor vehicles, 68 FED. REG. 52922, 52931, September 8, 2003; Center for Biological Diversity (November 22, 2005, NHTSA 2005-22223-1382)(p. 2-3); RAND Europe, Preparation of Measures to Reduce CO2 Emissions from N1 Vehicles, Final Report, at 4, prepared for the European Commission, 11th April 2003

[554] "Vehicles with lower fuel economy burn more fuel, creating more CO_2. Your vehicle creates about 20 pounds of CO_2 (170 cu. ft.) per gallon of gasoline it consumes. Therefore, you can reduce your contribution to global climate change by choosing a vehicle with higher fuel economy. By choosing a vehicle that achieves 25 miles per gallon rather than 20, you can prevent the release of about 17 (260 thousand cu. ft.) tons of greenhouse gases over the lifetime of your vehicle." Model Year 2006 Fuel Economy Guide, at 2, Department of Energy and Environmental Protection Agency, DOE/EE-0309.

[555] 68 FED. REG. 52922, 52931; Light-Duty Automotive Technology and Fuel Economy Trends: 1975 through 2005 - Executive Summary, EPA420-S-05-0001, July 2005, at http://www.epa.gov/otaq/cert/mpg/fetrends/420s05001.htm.

[556] P. Leduc, B. Dubar, A. Ranini and G. Monnier, Downsizing of Gasoline Engine: an Efficient Way to Reduce CO2 Emissions, at 2, Institut Français du Pétrole, Division Techniques d'Applications Energétiques, 92852 Rueil-Malmaison Cedex - France)

measure the amount of CO_2, CO, and HC emitted from the vehicle. The regulations requiring this approach do so because of the scientific relationship between fuel consumption and carbon emissions.

As noted above, gasoline is comprised of carbon and hydrogen in the form of HC compounds. Carbon and hydrogen are basic elements that are not converted to other elements in either internal combustion engines or catalytic converters. As a component of the fuel, the carbon is conveyed to the engine, where combustion occurs. Thereafter, the carbon, largely in different compounds than in gasoline, is emitted through the tailpipe. Thus, if the carbon content of the fuel is known, the amount of fuel consumed by the engine can be determined by measuring tailpipe emissions of carbon-containing compounds.[557] Fully combusted carbon takes the form of CO_2. Partially combusted carbon takes the form of CO or HC (generally unburned hydrocarbons). Therefore, fuel consumption may be determined by measuring tailpipe emissions of CO_2, CO, and HC.

As a result of incomplete combustion, CO and HC are emitted from a vehicle's engine. However, in the years since vehicle manufacturers were first required to meet federal fuel economy standards, the manufacturers have also been required under the Clean Air Act to meet increasingly stringent standards for emission of CO, HC, NOx, and particulates.[558] They have been able to meet these standards because fuels have been reformulated to burn cleaner, and vehicle manufacturers have applied many significant technological advances to the engines and vehicles (*e.g.*, multipoint fuel injection, closed-loop computer-controlled mixture control, and close-coupled 3-way exhaust catalysts).

[557] DOT FHWA, Perspectives on Fuel Consumption and Air Contaminant Emission Rates by Highway Vehicles. http:// www.tfhrc.gov/structur/pdf/01100.pdf.

[558] As explained below in the final section of the discussion of preemption, NHTSA does not believe that regulation of these emissions is preempted by EPCA since it is the agency's judgment that such regulation only tangentially affects fuel economy.

As a result, emissions of CO and HC have fallen dramatically. Moreover, the technologies that produce these reductions in air pollution do so by more completely converting CO and HC to CO_2 (and water).[559] Over the same time period, there has not been a corresponding decline in CO_2 emissions, which, as noted above, are the necessary result of gasoline consumption. CO and HC play an increasingly and extremely minor role in the measurement of fuel economy, such that fuel economy has become virtually synonymous with CO_2 emission rates.

The fuel economy of a particular vehicle is determined by a formula promulgated by EPA. That formula (an equation) calculates fuel economy based on carbonaceous emissions from the vehicle, taking into account the normalization of the fuel to a standardized test fuel. Under the formula, in determining fuel economy, all carbon emissions -- *i.e.*, the CO_2 emission rate, HC emission rate, and CO emission rate -- are considered.

Significantly, as demonstrated by the example below, in determining fuel economy the role of CO_2 emissions greatly outweighs that of these other exhaust gases. This is reflected by the relative magnitudes of the CO_2 term and non-CO_2 terms in the equation. In other words, calculating fuel economy is largely a function of CO_2 emissions.

Under 40 CFR § 600.113, fuel economy (*mpg*) is calculated using the following equation:

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[559] Because carbon dioxide is, like water, an ultimate byproduct of combustion, it cannot be further converted on the vehicle to some other compound through any practical means.

$$mpg = \frac{51,740,000 \times CWF \times SG}{(CWF \times HC + 0.429 \times CO + 0.273 \times CO_2) \times (0.6 \times SG \times NHV + 5,471)}$$

where

HC = hydrocarbon emission rate (grams per mile)

CO = carbon monoxide emission rate (grams per mile)

CO_2 = carbon dioxide emission rate (grams per mile)

CWF = carbon weight fraction of test fuel

NHV = net heating value (by mass) of test fuel

SG = specific gravity of test fuel

Under the regulation, separate measurements and calculations under the Federal Test Procedure (*i.e.*, city cycle) and Federal Highway Fuel Economy Test Procedure (*i.e.*, highway cycle) are required, with the resultant city (mpg_c) and highway (mpg_h) fuel economy values being harmonically averaged using weights of 0.55 and 0.45, respectively.[560]

Determining the characteristics of a test fuel and inserting them into the above equation is a preliminary step toward assessing the relative importance of CO_2 emissions in determining compliance with the fuel economy standards.

For this purpose, we will use the characteristics of a test fuel set forth in the sample calculation in Appendix II to 40 CFR Part 600:

[560] 40 C.F.R. § 600.206-93.

$CWF = 0.868$

$NHV = 18{,}478$ Btu per pound

$SG = 0.745$

These values are within about 8 percent of other values in the record (given relatively minor variations, particularly in heating value, in gasolines) and are reasonable for the purposes of this assessment, although very precise data would be collected for a test for compliance with the rule.[561]

Substituting these values into EPA's general equation for fuel economy shown above yields

$$mpg = \frac{51{,}740{,}000 \times 0.868 \times 0.745}{\left(0.868 \times HC + 0.429 \times CO + 0.273 \times CO_2\right) \times \left(0.6 \times 0.745 \times 18{,}478 + 5{,}471\right)}$$

which algebraically reduces to the following:

$$mpg = \frac{2{,}437}{\left(0.868 \times HC + 0.429 \times CO + 0.273 \times CO_2\right)}$$

[561] *See*, *e.g.*, Fuel economy impact of reformulated gasoline (energy (NHV) of fuel, at http://www.epa.gov/otaq/rfgecon.htm; Motor Gasolines Technical Review, at http://www.chevron.com/products/prodserv/fuels/bulletin/motorgas/; Carbon Coefficients, at http://www.eia.doe.gov/oiaf/1605/87-92rpt/appa.html; and Specific Gravity – Liquids, at http://www.engineeringtoolbox.com/specific-gravity-liquids-d_336.html.

Based on EPA data[562] averaged across all MY 2006 truck test data available at http://www.epa.gov/otaq/tcldata.htm (which does not include production data), model year 2006 light trucks have the following city cycle emission rates as determined by testing by the Federal Test Procedure:

HC = 0.042 g/mi

CO = 0.056 g/mi

CO_2 = 471 g/mi

Substituting these values and the fuel characteristics noted above into the algebraically reduced equation shown above,

$$mpg_c = \frac{2,421}{\left(\underbrace{0.868 \times 0.042}_{HC\ term} + \underbrace{0.429 \times 0.56}_{CO\ term} + \underbrace{0.273 \times 471}_{CO_2\ term}\right)}$$

which produces the following city fuel economy in miles per gallon:

$$mpg_c = \frac{2,421}{(0.037 + 0.240 + 128.583)} = \frac{2,421}{\left(\underbrace{0.277}_{non-CO_2\ term} + \underbrace{128.583}_{CO_2\ term}\right)} = 18.8$$

[562] Good, David, *op. cit.*

The average model year 2006 light truck emission rates on the highway cycle were as follows:[563]

$HC = 0.011$ g/mi

$CO = 0.17$ g/mi

$CO_2 = 316$ g/mi

which, using the formula above, yields the following highway fuel economy in miles per gallon:

$$mpg_h = \frac{2,421}{\left(\underbrace{0.868 \times 0.011}_{HC\ term} + \underbrace{0.429 \times 0.17}_{CO\ term} + \underbrace{0.273 \times 316}_{CO_2\ term}\right)} = \frac{2,421}{\left(\underbrace{0.082}_{non-CO_2\ term} + \underbrace{86.268}_{CO_2\ term}\right)} = 28.0$$

For both the city and highway calculations, the controlling independent variable is the large number (term) in the denominator, given that the numerator is a fixed number. That number is the CO_2 term (86.268). The other numbers (denominated the HC term and the CO term) are not significant. More particularly, for the 2006 model year light trucks, the typical city and highway CO_2 terms for light trucks are more than four hundred and one thousand, respectively, times the magnitude of the corresponding non-CO_2 terms. NHTSA has concluded that this proportion will not change, especially in light of its conclusion that emission limitations on the other types of emissions are permissible under EPCA.

[563] *Ibid.*

As shown above, in the measurement and calculation of a given vehicle model's fuel economy for purposes of federal fuel economy standards, the role of CO_2 is controlling and far greater than the combined role of the other two relevant exhaust gases (CO and HC). A manufacturer's compliance with the applicable CAFE standard is determined by averaging model-specific fuel economy values. This demonstrates that compliance with federal fuel economy standards is based primarily on CO_2 emission rates of covered vehicles.[564]

3. NHTSA has Concluded that a Reduction of CO_2 Emissions from Motor Vehicles Is Possible only through the Incorporation of the same Technologies that Would Be Employed to Increase Fuel Economy

The technologies that would be employed to reduce CO_2 emissions are, in all relevant ways, the same technologies as underlie NHTSA's judgment about the appropriate CAFE standards for light trucks, as explained below.[565]

The CAFE standards promulgated by NHTSA are performance standards. As such, they do not require the employment of any particular technology. But the standards are the maximum feasible average fuel economy level that NHTSA decides the manufacturers can achieve in a particular year.[566] They are based on various technologies. Those technologies are addressed in the NHTSA CAFE rulemaking record.

[564] The vast majority of vehicles covered by NHTSA's light truck CAFE standard are powered by gasoline fueled engines. Hybrids are expected to comprise from 1.7 to 2.9 percent of the fleet of new vehicles, while diesels are expected to comprise from 0 to 2.6 percent. These non-gasoline fueled vehicles will have a minor effect on the average fuel economy of the overall fleet of new vehicles.

[565] The agency has not identified any technologies, let alone realistic ones, that could be added to vehicle exhaust pipes to reduce CO_2 emissions. Above and beyond the application of the technologies addressed in this discussion of preemption, to meet CO_2 standards, in theory the manufacturer could make the vehicle much smaller or substantially reduce the size of its engine, depending on the stringency of the CO_2 regulation. P. Leduc et al., *op cit*. see fn above; s*ee also*, www4.nationalacademies.org/news.nsf/isbn/0309076013?OpenDocument.

[566] *See* 49 U.S.C. § 32902(a).

In large measure, they are summarized in Table 3-2 of the 2002 National Academy of Sciences (NAS) CAFE study, which is reproduced below in Tables 18 and 19 (numbered as Tables 3-2 and 3-3, respectively, in the NAS study).

Table 18: Fuel Consumption Technology Matrix – SUVs and Minivans (Table 3-2 NAS Report)

Baseline (small SUV): overhead cams, 4-valve, fixed timing, roller finger follower. Baseline (others): 2-valve, fixed timing, roller finger follower.	Fuel Consumption Improvement (%)	Retail Price Equivalent (RPE) ($)		Small SUV			Mid SUV			Large SUV			Minivan		
		Low	High	1	2	3	1	2	3	1	2	3	1	2	3
Production-intent engine technology															
Engine friction reduction	1-5	35	140	x	x	x	x	x	x	x	x	x	x	x	x
Low-friction lubricants	1	8	11	x	x	x	x	x	x	x	x	x	x	x	x
Multivalve, overhead camshaft (2-V vs. 4-V)	2-5	105	140				x	x	x	x	x	x	x	x	x
Variable valve timing	2-3	35	140	x	x	x	x	x	x	x	x	x	x	x	x
Variable valve lift and timing	1-2	70	210		x	x		x	x		x	x		x	x
Cylinder deactivation	3-6	112	252				x	x		x	x			x	
Engine accessory improvement	1-2	84	112	x	x	x	x	x	x	x	x	x	x	x	x
Engine supercharging and downsizing	5-7	350	560			x			x			x			x
Production-intent transmission technology															
Five-speed automatic transmission	2-3	70	154	x			x	x		x	x	x	x	x	x
Continuously variable transmission	4-8	140	350		x	x			x						
Automatic transmission w/aggressive shift logic	1-3	0	70	x			x			x	x		x		
Six-speed automatic transmission	1-2	140	280					x			x	x		x	x
Production-intent vehicle technology															
Aero drag reduction	1-2	0	140		x	x		x	x		x	x		x	x
Improved rolling resistance	1-1.5	14	56	x	x	x	x	x	x	x	x	x	x	x	x
Safety technology															
Safety weight increase	–3 to –4	0	0	x	x	x	x	x	x	x	x	x	x	x	x
Emerging engine technology															
Intake valve throttling	3-6	210	420		x			x			x			x	
Camless valve actuation	5-10	280	560			x			x			x			x
Variable compression ratio	2-6	210	490			x			x			x			x
Emerging transmission technology															
Automatic shift/manual transmission (AST/AMT)	3-5	70	280					x				x		x	x
Advanced CVTs—allows higher torque	0-2	350	840						x						
Emerging vehicle technology															
42-V electrical systems	1-2	70	280		x	x		x	x		x	x		x	x
Integrated starter/generator (idle off–restart)	4-7	210	350		x	x		x	x		x	x		x	x
Electric power steering	1.5-2.5	105	150			x		x	x		x	x		x	x
Vehicle weight reduction (5%)	3-4	210	350						x			x			

NOTE: An *x* means the technology is applicable to the particular vehicle. Safety weight added (EPA baseline + 3.5%) to initial average mileage/consumption values.

Table 19: Fuel Consumption Technology Matrix – Pickup Trucks
(Table 3-3 NAS Report)

Baseline: 2-valve, fixed timing, roller finger follower.	Fuel Consumption Improvement (%)	Retail Price Equivalent (RPE) ($)		Small Pickup			Large Pickup		
		Low	High	1	2	3	1	2	3
Production-intent engine technology									
Engine friction reduction	1-5	35	140	x	x	x	x	x	x
Low-friction lubricants	1	8	11	x	x	x	x	x	x
Multivalve, overhead camshaft (2-V vs. 4-V)	2-5	105	140	x	x	x	x	x	x
Variable valve timing	2-3	35	140		x	x	x	x	x
Variable valve lift and timing	1-2	70	210		x	x		x	x
Cylinder deactivation	3-6	112	252	x	x			x	
Engine accessory improvement	1-2	84	112	x	x	x	x	x	x
Engine supercharging and downsizing	5-7	350	560			x		x	x
Production-intent transmission technology									
Five-speed automatic transmission	2-3	70	154	x	x		x	x	x
Continuously variable transmission	4-8	140	350			x			
Automatic transmission w/aggressive shift logic	1-3	0	70	x			x	x	
Six-speed automatic transmission	1-2	140	280		x			x	x
Production-intent vehicle technology									
Aero drag reduction	1-2	0	140		x	x		x	x
Improved rolling resistance	1-1.5	14	56	x	x	x	x	x	x
Safety technology									
5% safety weight increase	–3 to –4	0	0	x	x	x	x	x	x
Emerging engine technology									
Intake valve throttling	3-6	210	420		x			x	
Camless valve actuation	5-10	280	560			x			x
Variable compression ratio	2-6	210	490			x			x
Emerging transmission technology									
Automatic shift/manual transmission (AST/AMT)	3-5	70	280		x				x
Advanced CVTs	0-2	350	840			x			
Emerging vehicle technology									
42-V electrical systems	1-2	70	280		x	x		x	x
Integrated starter/generator (idle off–restart)	4-7	210	350		x	x		x	x
Electric power steering	1.5-2.5	105	150		x	x		x	x
Vehicle weight reduction (5%)	3-4	210	350						

NOTE: An *x* means the technology is applicable to the particular vehicle. Safety weight added (EPA baseline + 3.5%) to initial average mileage/consumption values.

If a state regulation required manufacturers to reduce CO_2 emissions from motor vehicles, the state regulation would be predicated on the manufacturers' employment of the same technologies they would employ to meet federal fuel economy standards. As an example, for discussion purposes, we will consider a California regulation. In 2005, CARB adopted amendments to its regulations that it referred to as "California Exhaust Emission Standards and Test Procedures for 2001 and Subsequent Model Passenger Cars, Light Duty Trucks and Medium Duty Vehicles."[567] In support of its regulations, CARB released a report that listed more than 20 technologies that manufacturers could be applied in order to achieve compliance with its CO_2-based standards.[568] The technologies identified in the State's report with respect to large trucks are identified in the second column of the table reproduced below from its report, which employs acronyms that are explained below.

[567] *See* http://www.arb.ca.gov/regact/grnhsgas/grnhsgas.htm. The regulations are codified at Title 13 of the California Code of Regulations (CCR). *See* 13 CCR § 1961.1 (2006).
[568] California Environmental Protection Agency, Air Resources Board, Regulations To Control Greenhouse Gas Emissions From Motor Vehicles, Initial Statement Of Reasons.

Table 20. CARB "Technology Packages" to reduce CO_2 Emissions from a Large Truck [569]

Light truck	Combined technology packages	CO_2 (g/mi)	Potential CO_2 reduction from 2002 baseline	Retail price equivalent 2002	Potential CO_2 reduction from 2009 baseline	Retail price equivalent 2009
	CCP, A6, (2009 baseline)	484	-5.5%	$126	0%	0%
Near Term 2009-2012	DVVL, DCP, A6	442	-13.6%	$549	-8.6%	$423
	CCP, DeAct, A6	433	-15.4%	$480	-10.5%	$354
	DCP, DeAct, A6	430	-15.9%	$845	-11.0%	$931
	DeAct, DVVL, CCP, A6, EHPS, ImpAlt	418	-18.4%	$789	-13.6%	$663
	DeAct, DVVL, CCP, AMT, EHPS, ImpAlt	396	-22.6%	$677	-18.1%	$551
Mid Term 2013-2015	CCP, DeAct, GDI-S, AMT, EHPS, ImpAlt	416	-18.6%	$827	-13.9%	$701
	DeAct, DVVL, CCP, A6, ISG, EHPS, eACC	378	-26.2%	$1885	-21.9%	$1759
	ehCVA, GDI-S, AMT, EHPS, ImpAlt	381	-25.5%	$1621	-21.2%	$1495
Long Term 2015-	GDI-L, AMT, EHPS, ImpAlt	354	-24.4%	$1460	-20.0%	$1334
	Mod HEV	372	-44.5%	$2630	-41.3%	$2504
	dHCCI, AMT, ISG, EPS, eACC	362	-29.3%	$2705	-25.2%	$2579
	GDI-L, AMT, ISG, EPS, ImpAlt	354	-30.7%	$2537	-26.7%	$2411
	HSDI, AdvHEV	244	-52.2%	$8363	-49.5%	$8237
	AdvHEV	241	-52.5%	$5311	-49.8%	$5185

The acronyms in the table above refer to the following technologies[570]:

A5: 5-speed automatic transmission

A6: 6-speed automatic transmission

AdvHEV: Advanced hybrid

AMT: Automatic Manual Transmission

CCP: Coupled cam phasing

CVVL: Continuous variable valve lift

DCP: Dual cam phasing

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[569] California Environmental Protection Agency, Air Resources Board, Regulations To Control Greenhouse Gas Emissions From Motor Vehicles Initial Statement of Reasons (CARB ISOR) at 68.
[570] The acronyms appear in the CARB ISOR report at 205-06.

DeAct:	Cylinder deactivation
dHCCI:	Diesel homogeneous charge compression ignition
DVVL:	Discrete variable valve lift
eACC:	Improved electric accessories
ehCVA:	Electrohydraulic camless valve actuation
EHPS:	Electrohydraulic power steering
EPS:	Electric power steering
GDI-S:	Stoichiometric gasoline direct injection
GDI-L:	Lean-burn gasoline direct injection
HSDI:	High-speed (diesel) direct injection
ImpAlt:	Improved efficiency alternator
ISG:	Integrated starter-generator systems
ModHEV:	Moderate hybrid
Turbo:	Turbocharging

As is evident from a comparison of the excerpt from the NAS report above with the excerpt from the CARB statement of reasons above, nearly all of the technologies relied upon by CARB are technologies that NHTSA largely relies on in formulating the federal average fuel economy standards. Thus, vehicle manufacturers would have to install many of the same types of technologies under the NHTSA CAFE rule and under the CARB greenhouse gas rule.

California's Regulation of Greenhouse Gas/Carbon Dioxide Equivalent Emissions from Motor Vehicles Is Related To Average Fuel Economy Standards For Motor Vehicles Under 49 USC Chapter 329 and therefore Preempted

California's GHG regulations include new requirements on greenhouse gas emissions from motor vehicles including model year 2009 and subsequent model year light duty trucks (LDT) and medium duty passenger vehicles (MDPV). The CARB greenhouse gas rules include two sets of standards for motor vehicles. One set applies to all passenger cars and to LDTs with a loaded vehicle weight (LVW) up to 3750 pounds. The other set applies to LDTs with a loaded vehicle weight of greater than 3750 pounds and to MDPVs with a gross vehicle weight of less than 10,000 pounds.

NHTSA's CAFE rulemaking covers MY 2008 – 2011 light trucks. It also includes MY 2011 MDPVs. Thus, the CARB regulations cover vehicles covered by NHTSA's rulemaking.

As noted above, CARB's regulations govern the emission of greenhouse gases from passenger cars, light duty trucks and medium duty passenger vehicles. Greenhouse gases (GHG) is defined to "mean[] the following gases: CO_2, methane, nitrous oxide, and hydrofluorocarbons."[571]

CARB's GHG regulation states that the fleet average greenhouse gas exhaust emission values from passenger cars, light-duty trucks and medium-duty passenger vehicles that are produced and delivered for sale in California shall not exceed specified values.[572] Table 21 provides the following requirements for Fleet Average Greenhouse Gas Exhaust Emissions, specified in terms of grams per mile CO_2 – equivalent:

[571] 13 CCR §§ 1961.1(d), (e)(4)
[572] 13 CCR § 1961.1(a)(1)(A).

Table 21.CARB Fleet Average Greenhouse Gas Exhaust Emission Requirements (in grams/mi CO_2-equivalent)

Model Year	LDTs 0 – 3750 lbs LVW and Passenger Cars	LDTs 3751 LVW– 8500 GVW and MDPVs
2009	323	439
2010	301	420
2011	267	390
2012	233	361
2013	227	355
2014	222	350
2015	213	341
2016+	205	332

As explained in CARB's "Final Statement of Reasons" for its vehicular GHG regulations, the following emission sources are covered:

> Vehicle climate change emissions comprise four main elements (1) CO_2, CH_4, and N_2O emissions resulting directly from the operation of the vehicle, (2) CO_2 emissions resulting from operating the air conditioning system (indirect AC emissions), (3) refrigerant emissions from the air conditioning system due to either leakage, losses during recharging, sudden releases due to accidents, or release from scrappage of the vehicle at the end of life (direct AC emissions), and (4) upstream emissions associated with the production of the fuel used by the vehicle. The climate change emission standard incorporates all of these elements.[573]

For vehicles certified on conventional fuels (*e.g.*, gasoline), CARB's regulation does not encompass upstream emissions (i.e., emissions associated with the production and transportation of the fuel used by the vehicle).[574]

More particularly, under the CARB regulation, for each GHG vehicle test group, a manufacturer shall calculate both a "city" grams per mile average of CO_2 equivalent value and a "highway" grams per mile average of CO_2 equivalent value.[575] The use of CO_2 equivalence is an approximation that CARB used to place the gases included in

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[573] California Environmental Protection Agency, Air Resources Board, Regulations To Control Greenhouse Gas Emissions From Motor Vehicles, Final Statement Of Reasons (FSOR), at 7-8.
[574] CARB, FSOR at 8
[575] 13 CCR § 1961.1(a)(1)(B)1.a.

CARB's definition of greenhouse gas on the same scale so that they could be added together. CARB based this on a statement of global warming potential:[576]

Table 22. GWP Values from CARB Initial Statement of Reasons, p. 48

Greenhouse Gas Compound	Global Warming Potential
Carbon Dioxide	1
Methane	23
Nitrous Oxide	296
HFC 134a	1300
HFC152a	120

Under the CARB GHG regulation, the basic calculation of a given vehicle model's GHG emission rate is as follows:[577]

CO_2 equivalent value = CO_2 + 296 x N_2O + 23 x CH_4 – A/C Direct Emissions Allowances - A/C Indirect Emissions Allowances.

This calculation may be expressed as follows:

$$GHG = \underbrace{CO_2}_{CO_2\ term} + \underbrace{\left(296 \times N_2O\right) + \left(23 \times CH_4\right)}_{non-CO_2\ term} - \underbrace{\left(\Delta AC_{direct} + \Delta AC_{indirect}\right)}_{AC\ term}$$

where

GHG = CO_2-equivalent greenhouse gas emission rate (per FTP and highway tests)

CO_2 = tailpipe carbon dioxide emission rate

N_2O = tailpipe nitrous oxide emission rate

CH_4 = tailpipe methane emission rate

ΔAC_{direct} = credit for reducing direct emissions from air conditioning system (refrigerant emissions from the air conditioning system)

576 The global warming potential is a relative index used to compare the climate impact of an emitted greenhouse gas, relative to an equal amount of carbon dioxide.
577 Ibid.

$\Delta AC_{indirect}$ = credit for reducing indirect emissions from air conditioning system use CO_2 emissions resulting from operating the air conditioning system,

As detailed in its "Initial Statement of Reasons," CARB estimates demonstrated that of the total covered GHG emissions, vehicle tailpipe CO_2 emissions would be a much larger component than CO_2-equivalent baseline emission rates for all the other components combined. The following table shows CARB's estimates of the baseline emission rate for each covered GHG component[578] (column 2) along with the NHTSA's arithmetic calculation of corresponding shares of baseline emissions reported by CARB (column 3).

Table 23. CARB Estimates of Baseline Greenhouse Gas Emission Rates

GHG Emissions Component	**Rate (CO_2-equiv. g/mi)**	**Calculated Share (% Total)**
CO_2 emissions resulting directly from the operation of the vehicle	291-512	92-95%
CH_4 emissions resulting directly from the operation of the vehicle	0.1	0.02-0.03%
N_2O emissions resulting directly from the operation of the vehicle	1.8	0.3-0.6%
CO_2 emissions resulting from operating the air conditioning system	13.5-19.0	4%
Refrigerant emissions from the air conditioning system	8.5	2-3%

As is evident from the above table, CO_2 emissions resulting directly from the operation of the vehicle account for more than ninety two percent of the emissions potentially covered by CARB's vehicular GHG regulation.[579] This demonstrates that

578 CARB ISOR at 48, 59, 70- 72, 75 and 79

579 A CARB memorandum recognizes that CO_2 emissions are by far the largest amount of emissions produced by motor vehicles. www.arb.ca.gov/msei/on-road/downloads/pubs/co2final.pdf

CO_2 emissions from the operation of the vehicle are the predominant factor under CARB's greenhouse gas regulation.

This is corroborated by data in the record. As discussed above, a reasonably representative MY2006 light truck emits 471 g/mi and 316 g/mi of CO_2 on the city and highway test cycles respectively. Like federal fuel economy standards, CARB's GHG regulation weights these cycles at 55% and 45% respectively[580], such that representative CO_2 value would be 401 gr/mile for a MY 2006 light truck. According to CARB's "Initial Statement of Reasons"[581], a typical baseline vehicle emits 0.005 grams per mile of CH_4. Under the regulation, manufacturers may use a default value of 0.006 grams per mile for N_2O in lieu of actually measuring emissions of that gas.[582] Also according to the regulation, manufacturers could be granted as much as 9 and 11 grams per mile in direct and indirect emissions allowances, respectively, for improvements to air conditioners.[583] Therefore, the CO_2-equivalent GHG emission rate for a typical light truck granted the maximum credit for air conditioner improvements might be computed as follows:

$$GHG = \underbrace{401}_{CO_2\ term} + \underbrace{(296 \times 0.006) + (23 \times 0.005)}_{non-CO_2\ term} - \underbrace{(9 + 11)}_{AC\ term}$$

which reduces, with rounding, to:

580 13 CCR 1961.1
581 ISOR at 48.
582 13 CCR § 1961.1(a)(1)(B)1.a.
583 California Code of Regulations, Title 13, § 1961.1(a)(1)(B)(1)(b) allows a direct emissions allowance of up to 9 grams per mile. § 1961.1(a)(1)(B)(1)(c) allows an indirect emissions allowance of up to 11 grams per mile.

$$GHG = \underbrace{401}_{CO_2\ term} + \underbrace{2}_{non-CO_2\ term} - \underbrace{20}_{AC\ term}$$

Therefore, for a typical light truck, the term representing CO_2 emissions that are also subject to regulation under federal CAFE standards (in the above equation, the term labeled "*CO_2 term"*) would have a magnitude about 200 times that of the term representing its other emissions ("*non-CO_2 term*" in the above), and about 20 times that of the term account for improvements to its air conditioning system ("*AC term*" in the above). Consistent with CARB's estimate, discussed above, that tailpipe CO_2 emissions dominate total GHG emissions considered by CARB, this calculation indicates that CO_2 emissions account for on the order of 95 per cent (1 – 22/(401 + 2 + 20) = 0.95) of the emissions that enter into the calculation of total GHG emissions under CARB's regulation.

Alternatively, using the MY2011 values of CARB's standards for total GHG emissions—267 and 390 grams per mile for lighter and heavier vehicles, respectively, corresponding CO_2 emissions resulting directly from vehicle operation would be 285 and 408 grams per mile, respectively:

$$267 = \underbrace{CO_2}_{CO_2\ term} + \underbrace{2}_{non-CO_2\ term} - \underbrace{20}_{AC\ term}$$

$$390 = \underbrace{CO_2}_{CO_2\ term} + \underbrace{2}_{non-CO_2\ term} - \underbrace{20}_{AC\ term}$$

Solving these two equations for CO_2 yields values of 285 and 408 grams per mile, respectively. At these rates, CO_2 accounts for either 93% (1 – 22/(285 + 2 + 20) = 0.93) or 95% (1 – 22/(408 + 2 + 20) = 0.95) of the emissions that enter into the calculation of total GHG emissions under CARB's regulation.

Just as in the case of compliance with federal fuel economy standards, compliance with CARB's regulation is largely a function of tailpipe CO_2 emissions.[584] The same emissions provide the primary basis for determining compliance with federal fuel economy standards. In addition, CARB's own analysis anticipates that manufacturers would comply with its GHG regulation primarily by applying technologies that increase fuel economy.

With only one exception—improvements to air conditioning systems —those technologies would have a parallel impact on fuel economy as measured for purposes of determining compliance with federal fuel economy standards.[585] For purposes of determining compliance with federal CAFE standards, testing is run with the air conditioning turned off. Thus, the federal CAFE rules do not "credit" improved air conditioning efficiency or reduced losses from air conditioners. CARB has included reductions in emissions associated with air conditioning (direct and indirect) in its GHG regulation, so the technologies it relies upon are in this one limited respect broader than those NHTSA relies on. However, those technologies are nevertheless fuel economy technologies in that they reduce CO_2 emissions by reducing the load on a vehicle's

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[584] This conclusion follows even if the CO_2 emission rates in the examples are changed considerably, in line with the baseline estimates in CARB's ISOR.

[585] As demonstrated above, the CARB regulation would have the substantially the same effect as the Federal fuel economy regulation in terms of many of the technologies that manufacturers likely would have to install to meet the requirements. In addition to covered large trucks, addressed above, CARB's ISOR addressed the technologies that likely would be installed in small trucks and minivans. (ISOR, pp. 66-7). In general, those technologies are the same as in the NAS report referred to above.

engine and in turn reduce fuel consumption. Further, air conditioning improvements are not the predominant factor in reducing CO_2-equivalent emissions under the CARB regulation.[586]

CARB's vehicle greenhouse gas regulation is, therefore, clearly related to fuel economy standards[587] and thus subject to the preemption provision in EPCA.

NHTSA has also Concluded that Regulation of Carbon Dioxide Emissions from Motor Vehicles Conflicts with and Is Impliedly Preempted under 49 U.S.C. Chapter 329

Pre-emption principles also provide that if a state law or regulation stands as an obstacle to the accomplishment and execution of the full purposes and objectives of Congress in enacting a statute, that law or regulation may be preempted.[588] The presence

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[586] Based on its own analysis of warming-potential weighted emissions, CARB estimates that upgrading to a low-leak HFC-152a air conditioning system or a CO_2 system would reduce GHG emissions by "approximately 8.5 or 9 CO_2-equivalent grams per mile, respectively." (ISOR, p. 72). CARB further states that "upgrading to a VDC with external controls, air recirculation, and HFC-152a as the refrigerant, the estimated indirect emission reduction is 7 CO_2-equivalent grams per mile for a small car, 8 CO_2-equivalent grams per mile for a large car, and 9.8 CO_2-equivalent grams per mile for minivans, small trucks, and large trucks." (ISOR, p. 75*)*. According to the regulation, combined direct and indirect emissions allowances for air conditioners could total as much as CO_2-equivalent 20 grams per mile. California Code of Regulations, Title 13, § 1961.1(a)(1)(B)(1)(b) allows a direct emissions allowance of up to 9 grams per mile. § 1961.1(a)(1)(B)(1)(c) allows an indirect emissions allowance of up to 11 grams per mile.

[587] A CARB memorandum recognizes that CO2 emissions are related to fuel economy. It points out that CO_2 emissions can be modeled to estimate fuel economy. It also noted in the context of CO_2, that emission rates for vehicles from a certain period (MY 1990 – MY 1997) were assumed to be the same as the preceding model year (1989) because CAFE standards did not change dramatically after the initial model year (MY 1989). www.arb.ca.gov/msei/on-road/downloads/pubs/co2final.pdf (this document apparently was prepared in the late 1990s, based on its reference to the EMFAC7G model, which was approved by EPA on April 16, 1998.) Similarly, a National Academies Press (NAP) release on Automotive Fuel Economy, recognized the relationship between automotive fuel economy and CO2 emission rates: "Fuel economy improvements in new light-duty vehicles will reduce carbon dioxide emissions per mile because less fuel will be consumed per vehicle mile driven." http://www.nap.edu/openbook/0309045304/html/7html. (NAP was created by the National Academies to publish the reports issued by the National Academy of Sciences, the National Academy of Engineering, the Institute of Medicine, and the National Research Council.) *See also* NAP report at http://www.nap.edu/books/0309076013/html/7.html. In addition, CARB recognized that the GHG (CO_2-equivalent) emission standards are related to fuel economy in another way. CARB recognized that the standards would result in savings in reduced operating costs. Those lower costs are based on lower costs for fuel based on improved fuel efficiency. (ISOR, p. 196; FSOR, pp. 166, 168).

[588] Spriestma v. Mercury Marine, 537 U.S. 51, 64-5 (2002).

of an express preemption provision in a statute neither precludes nor limits the ordinary working of conflict pre-emption principles, particularly in the absence of a saving clause.[589] Therefore, NHTSA has concluded that these principles are also fully operative under EPCA, in addition to its express preemption provision.

NHTSA has concluded that the State GHG standard, to the extent that it regulates tailpipe CO_2 emissions, would frustrate the objectives of Congress in establishing the CAFE program and conflict with the efforts of NHTSA to implement the program in a manner consistent with the commands of EPCA. Congress had a variety of interrelated objectives in enacting EPCA and has charged NHTSA with balancing and achieving them. Among them was improving motor vehicle fuel economy. To achieve that objective, Congress did not simply mandate the issuance of fuel economy standards set at whatever level NHTSA deemed appropriate. Nor did it simply say that levels must be set consistent with the criteria it specified in Section 32902(f). It went considerably further, mandating the setting of standards at the maximum feasible level.

Other congressional objectives underlying EPCA include avoiding serious adverse economic effects on manufacturers and maintaining a reasonable amount of consumer choice among a broad variety of vehicles. Congress was explicitly concerned that the CAFE program be carefully drafted so as to require levels of average fuel economy that do not have the effect of either "imposing impossible burdens or unduly limiting consumer choice as to capacity and performance of motor vehicles."[590] These concerns are equally applicable to the manner in which that program is implemented.

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[589] Geier v. Honda, 529 U.S. 861, 869 (2000).
[590] H. REP. NO. 94-340, 87 (1975).

To guide the agency toward the selection of standards meeting these competing objectives, Congress specified four factors that NHTSA must consider in determining which level is the maximum feasible level of average fuel economy and thus the level at which each standard must be set. These are technological feasibility, economic practicability, the effect of other Government standards on fuel economy, and the need of the Nation to conserve energy.[591] In addition, the agency had traditionally considered the safety consequences in selecting the level of future CAFE standards.

Congress expected the agency to balance these factors in a fashion that ensures the standards are neither too low, nor too high. The Conference Report for EPCA states that the fuel economy standards were to be the product of balancing the benefits of higher fuel economy levels against the difficulties individual manufacturers would face in achieving those levels:

> Such determination should take industry-wide considerations into account. For example, a determination of maximum feasible average fuel economy should not be keyed to the single manufacturer which might have the most difficulty achieving a given level of average fuel economy. Rather, the Secretary must weigh the benefits to the nation of a higher average fuel economy standard against the difficulties of individual automobile manufacturers. Such difficulties, however, should be given appropriate weight in setting the standard in light of the small number of domestic automobile manufacturers that currently exist, and the possible implications for the national economy and for reduced competition association [sic] with a severe strain on any manufacturer. However, it should also be noted that provision has been made for granting relief from penalties under Section 508(b) in situations where competition will suffer significantly if penalties are imposed.[592]

NHTSA has concluded that were a State to establish a fuel economy standard or de facto fuel economy standard, e.g., a CO_2 emission standard, it would not choose one that has the effect of requiring lower levels of average fuel economy than the CAFE

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[591] 49 U.S.C. 32902(f).

[592] S. REP. NO. 94-516, 154-155 (1975).

standards applicable under EPCA or even one requiring the same level of average fuel economy. Given that the only practical way to reduce tailpipe emissions of CO_2 is to improve fuel economy, such a State standard would be meaningless since it would not reduce CO_2 emissions to an extent greater than the CAFE standards.[593] Instead, a State would establish a standard that has the effect of requiring a higher level of average fuel economy.

Setting standards that are more stringent than the fuel economy standards promulgated under EPCA would upset the efforts of NHTSA to balance and achieve Congress's competing goals. Setting a standard too high, above the level judged by NHTSA to be consistent with the statutory consideration after careful consideration of these issues in a rulemaking proceeding, would negate the agency's analysis and decisionmaking. NHTSA makes its judgments only after considering extensive technical information such as detailed product information submitted by the vehicle manufacturers and NAS' report on the future of the CAFE program and conducting analyses of potential impacts on employment and safety.

As noted above, manufacturers confronted with requirements for the reduction of tailpipe CO_2 emissions would look at the same pool of technology used to reduce fuel consumption. NHTSA concludes that it is disruptive to the orderly implementation of the CAFE program, and to NHTSA's reasonable balancing of competing concerns, to have two different governmental entities assessing the need to conserve energy, technological feasibility, economic practicability, employment, vehicle safety and other concerns, and making inconsistent judgments made about how quickly and how much of that single pool of technology could and should be required to be installed consistent with those

[593] This is also EPA's conclusion. *See* 68 FED. REG. 52922, 52929.

concerns. EPCA does not specify how to weight each concern; thus, NHTSA determines the appropriate weighting based on the circumstances in each CAFE standard rulemaking. More important, ignoring the judgments made by NHTSA at the direction of Congress could result in setting standards at levels higher than NHTSA can legally justify under EPCA, increasing the risk of the harms that that body sought to avoid, e.g., serious adverse economic consequences for motor vehicle manufacturers and unduly limited choices for consumers.

Through EPCA, Congress committed the reasonable accommodation of these conflicting policies and concerns to NHTSA.[594] "Congress did not prescribe a precise formula by which NHTSA should determine the maximally-feasible fuel economy standard, but instead gave it broad guidelines within which to exercise its discretion."[595] A state's adoption and enforcement of a CO_2 standard for motor vehicles would infringe on NHTSA's discretion to establish CAFE standards consistent with Congress' guidance and threaten the goals that Congress directed NHTSA to achieve. The process of achieving those goals involves great expertise and care. The fuel economy standards delegated to NHTSA are to be the product of balancing the benefits of higher fuel economy levels against the difficulties individual manufacturers would face in achieving those levels.[596] The issuance and implementation of State standards regulating motor vehicle CO_2 emissions would abrogate EPCA's regime, nullifying NHTSA's careful balancing of the statutory and other considerations.

There appear to be two misconceptions that have clouded proper analysis of these implied preemption issues. One is that since the term "average fuel economy standard" is

594 901 F.2d 107, 120-21.
595 901 F.2d 107, 120-21.
596 793 F.2d 1322, 1338.

defined in EPCA as meaning "a performance standard specifying a minimum level of average fuel economy applicable to a manufacturer in a model year"[597] (emphasis added), there can be no conflict or incompatibility between CO_2 standards and CAFE standards. Indeed, it has been suggested that in defining this term in this fashion, Congress endorsed the setting of other standards having the effect of regulating fuel economy.[598] NHTSA does not interpret the statute in this manner, because EPCA requires that CAFE standards be set at the maximum feasible level, consistent with the agency's assessment of impacts on the nation, consumers and industry.

An interpretation that allowed more stringent State fuel economy standards would nullify the statutory limits that Congress placed in EPCA on the level of CAFE standards, and the efforts of NHTSA in its CAFE rulemaking to observe those limits. Congress expressly listed four analytical, decision guiding factors in EPCA because fuel economy was not the only value that Congress sought to protect and promote in the mandating the setting of CAFE standards. Congress did not want improved fuel economy to come at the price of adverse effects on sales, jobs, and consumer choice. Further, in choosing the level of future CAFE standards, NHTSA has traditionally considered the potential impact on safety.

In selecting the maximum feasible level, NHTSA strives to set the standards as high as it can without causing significant adverse consequences for the manufacturers or consumers. Since NHTSA should not, as a matter of sound public policy, and in fact may not as a matter of law, set standards above the level it determines to be the maximum feasible level, EPCA should not be interpreted as permitting the States to do so. Indeed,

[597] 49 U.S.C. 32901 (a)(6).
[598] This suggestion cannot be reconciled with Congress' decision to include an express preemption provision in EPCA. 49 U.S.C. 32919(a).

NHTSA has concluded that, under EPCA, States may not set actual or de facto fuel economy standards at any level.

Second, as noted above, regulating fuel economy and regulating CO_2 emissions are inextricably linked, given current and foreseeable automotive technology. There are not two different pools of technology, one for reducing tailpipe CO_2 emissions, and the other for improving fuel economy. Thus, there is nothing to be gained by setting both tailpipe CO_2 standards and CAFE standards.

If the technology does not improve fuel economy, it does not reduce tailpipe CO_2 emissions. The technologies listed in Part 5 of CARB's Initial Statement of Reasons for its GHG standard for reducing tailpipe CO_2 emissions reduce those emissions by improving fuel economy.

This dichotomy of perception or characterization about fuel economy and CO_2 emissions does not appear to exist in other countries. According to the International Energy Agency:

> The existing approaches for achieving CO2 reduction through fuel economy improvement in new cars vary considerably, with both regulatory approaches (China, Japan, US, CA) and voluntary approaches (EU). Some systems include financial incentives as well (Japanese tax credit for hybrids, US gas guzzler tax, various EU member country differential taxation schemes based on fuel economy, such as in the UK and Denmark).[599]

Further, in Europe, the studies conducted for the European Commission in support of efforts to provide public information on fuel economy and CO_2 emissions to induce

[599] FUELING THE FUTURE: Workshop on Automobile CO2 Reduction and Fuel Economy Improvement Policies, WORKSHOP REPORT, 13 October, 2004, Shanghai, China, http://www.iea.org/textbase/work/2004/shanghai/UNEP_IEA.PDF.

consumers to purchase vehicles with lower CO_2 emissions uniformly reflect the view that fuel economy and CO_2 emissions are directly related.[600]

Similarly, in 2001, one of the leading U.S. environmental groups participating in this rulemaking issued a report that identified a vehicle's fuel consumption rate as the single vehicle design factor determining the amount of a vehicle's CO_2 emissions:

> The CO_2 emitted by a motor vehicle is the product of three factors: the amount of driving, the vehicle's fuel consumption rate and the carbon intensity of the fuel consumed. The fuel consumption rate (e.g., the number of gallons needed to drive 100 miles) is the inverse of fuel economy (miles per gallon, or mpg). …[601]

Later, in the same report, it was observed in a footnote (#26) that "it is actual CAFE that determines fuel consumption and CO_2 emissions."[602]

EPCA's Provision Specifying Factors To Be Considered In Setting Average Fuel Economy Standards Does Not Limit Preemption Under 49 U.S.C. Chapter 329

EPCA does not include any exception to its preemption provision that would cover State GHG and CO_2 standards. Nevertheless, some commenters opposing preemption suggested that Section 32902(f), which lists the factors that NHTSA must

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[600] RAND Europe, at 4; D. Elst, N. Gense, I.J. Riemersma, H.C. van de Burgwal, Z. Samaras, G. Frontaras, I. Skinner, D. Haines, M. Fergusson, and P. ten Brink, Measuring and preparing reduction measures for CO2-emissions from N1 vehicles-final report the European Commission, Directorate-General for Environment, at 90, TNO TPD, (part of the Netherlands Organisation for Applied Scientific Research TNO), in partnership with Aristotle University of Thessaloniki and Institute for European Environmental Policy, Contract no. B4-3040/2003/364181/MAR/C1,December 2004 (observing that "… reduction of CO_2 is equivalent to fuel economy improvement …"); and A. Gartner, Study on the effectiveness of Directive 1999/94/EC relating to the availability of consumer information on fuel economy and CO_2 emissions in respect of the marketing of new passenger cars, Final report to the European Commission, Directorate-General for Environment, Contract No.: 07010401/2004/377013/MAR/C1, at 45 and 70, Allgemeine Deutsche Automobil-Club ADAC e.V., March 2005 (observing "… that most consumers are not aware of the correlation of fuel consumption and CO_2 emissions of passenger cars …" and that "… the CO_2 emissions (g/km) can be calculated from fuel consumption …").

[601] J. DeCicco and A. Feng, Automakers' Corporate Carbon Burden, Reframing Public Policy on Automobiles, Oil and Climate, at 7-8, Environmental Defense, 2001. The article explained that carbon intensity is how much CO2 is emitted per unit of fuel consumed. For gasoline, this amounts to 19.4 pounds per gallon. Id. at 8.

[602] *Ibid,* at 22-23.

consider in determining the level at which to set fuel economy standards, prevents preemption by requiring consideration, by NHTSA, of the effect of other Government standards, including emissions standards, on fuel economy.

EPCA's decisionmaking factor provision is neither a saving clause nor a waiver provision. Nor does NHTSA interpret it as saving state emissions standards that effectively regulate fuel economy from preemption. The agency interprets that provision only to direct NHTSA to consider those State standards that can otherwise be validly adopted and enforced under State and Federal law.

The decisionmaking factors provision does reflect an expectation by Congress that some state emissions standards would not be preempted under the express preemption provision. However, as an initial matter, NHTSA does not read the provision to imply a savings clause. This is particularly so given that Congress has considered and provided a different saving clause, i.e., the one for a State law or regulation on disclosure of fuel economy or fuel operating costs for an automobile.

Moreover, even if EPCA did contain the saving clause desired by those commenters, i.e., one saving authority that States had prior to EPCA, NHTSA would not give it effect here, as doing so "would upset the careful regulatory scheme established by federal law."[603]

First, and most important in this context, such a reading would upset the carefully calibrated CAFE regulatory program under which NHTSA is with setting CAFE standards at the maximum feasible level, taking care neither to set them too high nor too low. Congress did not simply mandate the setting of fuel economy standards. Instead, it mandated the setting of maximum feasible ones. Congress was aware that setting overly

[603] Geier v. American Honda Motor Co., 529 U.S. 861, 869 (2000). (Citations omitted.)

stringent standards would excessively reduce consumer choice about vehicle design and performance and threaten adverse economic consequences. The setting of State standards for CO_2 tailpipe emissions would upset and displace EPCA's regulatory regime for CAFE.

Second, the requirement to consider these decisionmaking factors must be reconciled with the express preemption provision. NHTSA has concluded that reading the express preemption provision in the manner suggested by commenters opposing preemption would irrationally limit that provision and leave NHTSA's role in administering the CAFE program open to a substantial risk of abrogation. By the same token, in NHTSA's view, it is equally important that the "relates to" language in the express preemption provision should not be given so broad a reading that even State emissions standards having only an incidental effect on fuel economy standards are deemed to be preempted by it.

NHTSA has concluded that these two extreme readings, with their unacceptable impacts in the first instance on EPCA and in the second on the Clean Air Act, including its provision for waiving CAA preemption, can be avoided under a carefully calibrated interpretation of EPCA's express preemption provision that harmonizes the two acts to the extent possible. NHTSA does not interpret EPCA's express preemption provision as preempting State emissions standards that only incidentally or tangentially affect fuel economy. These standards include, for example, given current and foreseeable technology, the existing emissions standards for CO, HC, NOx, and particulates. NHTSA considers such standards under the decisionmaking factors provision of EPCA since, under applicable law, they can be adopted and enforced and therefore can have an effect on fuel economy.

However, two groups of State emissions standards do not qualify under NHTSA's interpretation of the decisionmaking factors provision, and therefore would not be considered. One is State standards that cannot be adopted and enforced because there has been no waiver for California under the preemption waiver provision in of the Clean Air Act. The other is the State emissions standards that are expressly or impliedly preempted under EPCA, regardless of whether or not they have received such a waiver. Preempted standards include, for example:

(1) A fuel economy standard; and

(2) A law or regulation that has essentially all of the effects of a fuel economy standard, but is not labeled as one (example: State tailpipe CO_2 standard).

This reading of EPCA's express preemption provision allows that provision to function in a consistent way, without irrational limitation, to protect the national CAFE program from interference by any State standard effectively regulating fuel economy. It also simultaneously maximizes the ability of EPCA and the Clean Air Act waiver provision to achieve their respective purposes.

NHTSA's judgment is that the agency should distinguish between motor vehicle emission standards for emissions other than CO_2 (e.g., HC, CO, NOx and PM) and motor vehicle emission standards for CO_2. Those other emissions are not directly and inextricably linked to fuel economy. NHTSA's current view is that standards for emissions other than CO_2 merely affect the level of CAFE that is achievable and thus only incidentally affect fuel economy standards. Accordingly, we believe that regulation of these emissions is not rulemaking inconsistent with the operation of preemption principles under EPCA.

HC, CO, and PM all result from incomplete combustion. Therefore, the first step toward controlling emissions of these pollutants involves improving the combustion process. Doing so increases the production and emission of carbon dioxide. All three pollutants can also be substantially eliminated from tailpipe emissions by placing catalytic converters between the engine and the tailpipe. Catalytic converters reduce emissions of these pollutants through oxidation, which also increases the production and emission of carbon dioxide. PM emissions can also be controlled using PM traps, which temporarily trap and store PM. PM traps periodically regenerate by oxidizing away the stored PM. Doing so increases the production and emission of carbon dioxide.

NOx results from the oxidation of nitrogen at the high peak temperatures that occur in an efficiently-operating engine. The exposure of nitrogen to peak temperatures can be reduced by increasing turbulence in the combustion chamber, changing ignition and/or injection timing, and recirculating some exhaust gases through the engine. Increased turbulence and changes to ignition and/or injection timing tend to increase the production and emission of carbon dioxide. Catalytic converters can substantially eliminate NOx from the exhaust stream. However, doing so requires chemical reduction—oxidation in reverse. Modern catalytic converters perform both reduction and oxidation, reducing NOx to oxidize HC and CO, and further oxidizing HC and CO with oxygen available in the exhaust stream. These processes increase the production and emission of carbon dioxide.

Gasoline vehicles also emit HC through the evaporation of fuel. These emissions are controlled using canisters that temporarily store evaporated fuel. Periodically, these canisters are purged, releasing the stored fuel vapors to the engine to be combusted. Compared to simply releasing evaporative emissions to the atmosphere, these processes increase the formation and emission of carbon dioxide.

To summarize, the processes used to control HC, CO, NOx, and PM emissions increase the formation and emission of carbon dioxide. Because carbon dioxide is, like water, an ultimate byproduct of combustion, it cannot be further converted on the vehicle to some other compound through any practical means. Plants use sunlight to convert carbon dioxide and water to biomass (and oxygen) through photosynthesis, but vehicles produce far too much exhaust to be consumed by plants that could conceivably be sustained by the amount of sunlight to which vehicles are exposed. Even if enough sunlight were available, biomass would be produced at a rate requiring impractically frequent removal from the vehicle. Theoretically, on-board scrubbers could be used separate carbon dioxide from the exhaust stream. Chemical processes for removing carbon dioxide are currently used in underwater rebreathers and space applications (*e.g.*, the international space station), and are contemplated for stationary applications (*e.g.*, electric utilities). (*See*, *e.g.*, http://www.nas.nasa.gov/About/Education/SpaceSettlement/teacher/course/co2.html, http://www.frogdiver.com, and http://www.netl.doe.gov/publications/proceedings/01/carbon_seq/5a5.pdf.) However, for a variety of reasons (*e.g.*, size, cost, energy demands, use of dangerous reactants such as calcium hydroxide), these processes would not be even remotely practical for motor vehicles.

Even if a practical process to separate carbon dioxide from the exhaust stream were available, the carbon dioxide would, to prevent its release, need to be compressed or solidified for temporary onboard storage, and frequently removed for disposal (*e.g.*, in underground facilities). For example if fifteen gallons of gasoline are added at each refueling of a vehicle, about 290 pounds of carbon dioxide (or, without any separation of the carbon dioxide, about 1,400 pounds of exhaust gases) would be produced through the combustion of that fuel. (This example assumes gasoline with a density of 6 pounds per gallon and a carbon content (by mass) of 87%. Each pound of carbon dioxide contains 0.273 pounds of elemental carbon. The combustion of 1 pound of gasoline requires about 14.7 pounds of air.) At these rates of production, no practical means of onboard storage and periodic removal are foreseeable.

For these reasons, a CO_2 emissions standard stands apart from those other emissions standards. NHTSA has concluded that such a standard functions as a fuel economy standard, given the direct relationship between a vehicle's fuel economy and the amount of CO_2 it emits. In contrast, no such relationship exists between a vehicle's fuel economy and the emissions currently regulated by EPA.

Interpreting EPCA's preemption provision as preempting only those State regulations that directly regulate or have the effect of directly regulating fuel economy gives, to the extent possible, maximum effect both to EPCA and to the provision in the Clean Air Act for waiving preemption under that Act. This is necessary and appropriate, especially considering the importance of the goals of the Clean Air Act and the attention paid by Congress in drafting EPCA to the relationship of the CAFE program to the Clean Air Act. EPCA's express preemption provision cannot be interpreted as preempting all State laws relating to a fuel economy standard, no matter how tangential the relationship. Such an interpretation would largely, if not wholly, negate the Clean Air Act's preemption waiver provision and leave few, if any, emission standards to be considered by NHTSA under EPCA's decisionmaking factor provision. Our approach to reconciling EPCA and the Clean Air Act appropriately distinguishes between CO_2 and emissions other than CO_2. EPCA preempts State authority to regulate tailpipe emissions of CO_2, but not emissions other than CO_2, because of the nature of combustion and the availability of different technologies for regulating those other emissions.

Our approach also avoids interpreting EPCA's express preemption provision so narrowly as to produce the absurd and destructive result of preempting State fuel economy standards, but not State standards that are fuel economy standards in effect, but not in name. Giving EPCA this degree of primacy is particularly appropriate given the regulatory authority in this statute is quite narrow and specific: fuel economy standards, and their functional equivalents, CO_2 standards and GHG standards, to the extent that the latter regulate CO_2 emissions.

XV. Regulatory Text

List of Subjects in 49 CFR Parts 523, 531, 533, 534, 535, 536, and 537

Fuel economy, Reporting and recordkeeping requirements.

For the reasons discussed in the preamble, under the authority of 49 U.S.C. §§ 32901, 32902, 32903, and 32907, and delegation of authority at 49 CFR 1.50, NHTSA amends 49 CFR Chapter V as follows:

PART 523—VEHICLE CLASSIFICATION

1. Amend the authority citation for part 523 by revising to read as follows:

Authority: 49 U.S.C. 32901, delegation of authority at 49 CFR 1.50

2. Amend § 523.2 by adding, in alphabetical order, definitions of "base tire," "light truck," and "work truck" to read as follows:

§523.2 Definitions.

*** * * * ***

Base tire means the tire specified as standard equipment by a manufacturer on each vehicle configuration of a model type.

* * * * *

Light truck means a non-passenger automobile as defined in § 523.5.

* * * * *

Work truck means a vehicle that is rated at more than 8,500 and less than or equal to 10,000 pounds gross vehicle weight, and is not a medium-duty passenger vehicle as defined in 40 CFR 86.1803-01 effective as of December 20, 2007.

* * * * *

3. Amend § 523.3 by revising paragraph (a) to read as follows:

§ 523.3 Automobile.

(a) An automobile is any 4-wheeled vehicle that is propelled by fuel, or by alternative fuel, manufactured primarily for use on public streets, roads, and highways and rated at less than 10,000 pounds gross vehicle weight, except:

(1) a vehicle operated only on a rail line;

(2) a vehicle manufactured in different stages by 2 or more manufacturers, if no intermediate or final-stage manufacturer of that vehicle manufactures more than 10,000 multi-stage vehicles per year; or

(3) a work truck.

* * * * *

4. Revise § 523.5 to read as follows:

§ 523.5 Non-passenger Automobile.

A non-passenger automobile means an automobile that is not a passenger automobile or a work truck and includes vehicles described in paragraphs (a) and (b) of this section:

(a) An automobile designed to perform at least one of the following functions:

(1) Transport more than 10 persons;

(2) Provide temporary living quarters;

(3) Transport property on an open bed;

(4) Provide, as sold to the first retail purchaser, greater cargo-carrying than passenger-carrying volume, such as in a cargo van; if a vehicle is sold with a second-row seat, its cargo-carrying volume is determined with that seat installed, regardless of whether the manufacturer has described that seat as optional; or

(5) Permit expanded use of the automobile for cargo-carrying purposes or other nonpassenger-carrying purposes through:

(i) For non-passenger automobiles manufactured prior to model year 2012, the removal of seats by means installed for that purpose by the automobile's manufacturer or with simple tools, such as screwdrivers and wrenches, so as to create a flat, floor level, surface extending from the forwardmost point of installation of those seats to the rear of the automobile's interior; or

(ii) For non-passenger automobiles manufactured in model year 2008 and beyond, for vehicles equipped with at least 3 rows of designated seating positions as standard equipment, permit expanded use of the automobile for cargo-carrying purposes or other nonpassenger-carrying purposes through the removal or stowing of foldable or pivoting seats so as to create a flat, leveled cargo surface extending from the forwardmost point of installation of those seats to the rear of the automobile's interior.

(b) An automobile capable of off-highway operation, as indicated by the fact that it:

(1)(i) Has 4-wheel drive; or

(ii) Is rated at more than 6,000 pounds gross vehicle weight; and

(2) Has at least four of the following characteristics (see Figure 1) calculated when the automobile is at curb weight, on a level surface, with the front wheels parallel to the automobile's longitudinal centerline, and the tires inflated to the manufacturer's recommended pressure—

(i) Approach angle of not less than 28 degrees.

(ii) Breakover angle of not less than 14 degrees.

(iii) Departure angle of not less than 20 degrees.

(iv) Running clearance of not less than 20 centimeters.

(v) Front and rear axle clearances of not less than 18 centimeters each.

(Sec. 9, Pub. L. 89-670, 80 Stat. 981 (49 U.S.C. 1657); sec. 301, Pub. L. 94-163, 89 Stat. 901 (15 U.S.C. 2002); delegation of authority at 41 FR 25015, June 22, 1976)

PART 531—PASSENGER AUTOMOBILE AVERAGE FUEL ECONOMY STANDARDS

5. The authority citation for part 531 continues to read as follows:

Authority: 49 U.S.C. 32902; delegation of authority at 49 CFR 1.50.

6. Amend § 531.5 by revising paragraph (a), redesignating paragraph (b) as paragraph (d), and adding new paragraphs (b) and (c) to read as follows:

§ 531.5 Fuel economy standards.

(a) Except as provided in paragraph (d) of this section, each manufacturer of passenger automobiles shall comply with the average fuel economy standards in Table I, expressed in miles per gallon, in the model year specified as applicable:

TABLE I

Model year	Standard
1978…………………………………..	18.0
1979…………………………………..	19.0
1980…………………………………..	20.0
1981…………………………………..	22.0
1982…………………………………..	24.0
1983…………………………………..	26.0
1984…………………………………..	27.0
1985…………………………………..	27.5
1986…………………………………..	26.0
1987…………………………………..	26.0
1988……………………………………	26.0
1989……………………………………	26.5

1990-2010……………………………..	27.5

(b) For each of model years 2011 through 2015, a manufacturer's passenger automobile fleet shall comply with the fuel economy level calculated for that model year according to Figure 1 and the appropriate values in Table II.

FIGURE 1

$$Required\_Fuel\_Economy\_Level = \frac{N}{\sum_i \frac{N_i}{T_i}}$$

Where:

N is the total number (sum) of passenger automobiles produced by a manufacturer,

N_i is the number (sum) of the i^{th} model passenger automobile produced by the manufacturer, and

T_i is fuel economy target of the i^{th} model passenger automobile, which is determined according to the following formula, rounded to the nearest hundredth:

$$T = \frac{1}{\frac{1}{a} + \left(\frac{1}{b} - \frac{1}{a}\right)\frac{e^{(x-c)/d}}{1+e^{(x-c)/d}}}$$

Where,

Parameters a, b, c, and d are defined in Table II;

e = 2.718; and

x = footprint (in square feet, rounded to the nearest tenth) of the vehicle model

TABLE II—PARAMETERS FOR THE PASSENGER AUTOMOBILE FUEL ECONOMY TARGETS

Model year	Parameters			
	a	B	C	d
2011................................	31.20	24.00	51.41	1.91
2012................................	33.30	25.20	51.41	1.91
2013................................	35.80	26.60	51.41	1.91
2014................................	36.80	27.20	51.41	1.91
2015................................	38.70	28.20	51.41	1.91

(c) In addition to the requirement of paragraph (b) of this section, each manufacturer shall also meet the minimum standard for domestically manufactured passenger automobiles expressed in Table III:

TABLE III

Model year	Minimum Standard
2011…………………………………..	27.8
2012…………………………………..	29.5
2013…………………………………..	31.6
2014…………………………………..	32.6
2015…………………………………..	34.1

*   *   *   *   *

7. Add a new Appendix A to Part 531 to read as follows:

Appendix A to Part 531—Preemption of state regulations regulating tailpipe greenhouse gas emissions from passenger automobiles

(a) To the extent that any state regulation regulates tailpipe greenhouse gas emissions from passenger automobiles, such a regulation relates to average fuel economy standards within the meaning of 49 USC 32919.

1. Passenger automobile fuel economy is directly and very substantially related to automobile tailpipe emissions of greenhouse gases, especially carbon dioxide.

2. Carbon dioxide is the natural by-product of passenger automobile fuel consumption.

3. The most significant and controlling factor in making the measurements necessary to determine the compliance of passenger automobiles with the fuel economy standards in this Part is their rate of tailpipe carbon dioxide emissions.

4. Most of the technologically feasible reduction of tailpipe emissions of carbon dioxide is achievable only through improving fuel economy, thereby reducing both the consumption of fuel and the creation and emission of carbon dioxide.

5. Accordingly, as a practical matter, regulating fuel economy controls the amount of tailpipe emissions of carbon dioxide to a very substantial extent, and regulating the tailpipe emissions of carbon dioxide controls fuel economy to a very substantial extent.

(b) As a state regulation related to fuel economy standards, any state regulation regulating tailpipe greenhouse gas emissions from passenger automobiles is expressly preempted under 49 U.S.C. 32919.

(c) A state regulation regulating tailpipe greenhouse gas emissions from passenger automobiles, particularly a regulation that is not attribute-based and does not separately regulate passenger automobiles and light trucks, conflicts with

1. The fuel economy standards in this Part,

2. The judgments made by the agency in establishing those standards, and

3. The achievement of the objectives of the statute (49 U.S.C. Chapter 329) under which those standards were established, including objectives relating to reducing fuel consumption in a manner and to the extent consistent with manufacturer flexibility, consumer choice, and passenger automobile safety.

(d) Any state regulation regulating tailpipe greenhouse gas emissions from passenger automobiles is impliedly preempted under 49 U.S.C. Chapter 329.

(e) So long as the test procedures for determining compliance with the fuel economy standards under this part do not provide for air conditioners to be operated during testing, state regulation of passenger automobile air conditioner efficiency is not related and is therefore not preempted.

PART 533—LIGHT TRUCK FUEL ECONOMY STANDARDS

8. The authority citation for part 533 continues to read as follows:

Authority: 49 U.S.C. 32902; delegation of authority at 49 CFR 1.50.

9. Amend § 533.5 by revising Table V of paragraph (a) and revising paragraph (h) to read as follows:

§ 533.5 Requirements.

(a) * * *

TABLE V—PARAMETERS FOR THE LIGHT TRUCK FUEL ECONOMY TARGETS

Model year	Parameters			
	a	b	c	d

2008................................	28.56	19.99	49.30	5.58
2009................................	30.07	20.87	48.00	5.81
2010................................	29.96	21.20	48.49	5.50
2011................................	27.10	21.10	56.41	4.28
2012................................	28.10	21.70	56.41	4.28
2013................................	29.50	22.60	56.41	4.28
2014................................	30.30	23.00	56.41	4.28
2015................................	30.50	23.20	56.41	4.28

* * * * *

(h) For each of model years 2011-2015, a manufacturer's light truck fleet shall comply with the fuel economy level calculated for that model year according to Figure 1 and the appropriate values in Table V.

10. Add a new Appendix B to Part 533 to read as follows:

Appendix B to Part 533—Preemption of state regulations regulating tailpipe greenhouse gas emissions from light trucks

(a) To the extent that any state regulation regulates tailpipe greenhouse gas emissions from light trucks, such a regulation relates to average fuel economy standards within the meaning of 49 USC 32919.

1. Light truck fuel economy is directly and very substantially related to light truck tailpipe emissions of greenhouse gases, especially carbon dioxide.

2. Carbon dioxide is the natural by-product of light truck fuel consumption.

3. The most significant and controlling factor in making the measurements necessary to determine the compliance of light trucks with the fuel economy standards in this Part is their rate of tailpipe carbon dioxide emissions.

4. Most of the technologically feasible reduction of tailpipe emissions of carbon dioxide is achievable only through improving fuel economy, thereby reducing both the consumption of fuel and the creation and emission of carbon dioxide.

5. Accordingly, as a practical matter, regulating fuel economy controls the amount of tailpipe emissions of carbon dioxide to a very substantial extent, and regulating the tailpipe emissions of carbon dioxide controls fuel economy to a very substantial extent.

(b) As a state regulation related to fuel economy standards, any state regulation regulating tailpipe greenhouse gas emissions from light trucks is expressly preempted under 49 U.S.C. 32919.

(c) A state regulation regulating tailpipe greenhouse gas emissions from light trucks, particularly a regulation that is not attribute-based and does not separately regulate passenger cars and light trucks, conflicts with

1. The fuel economy standards in this Part,

2. The judgments made by the agency in establishing those standards, and

3. The achievement of the objectives of the statute (49 U.S.C. Chapter 329) under which those standards were established, including objectives relating to reducing fuel

consumption in a manner and to the extent consistent with manufacturer flexibility, consumer choice, and light truck safety.

(d) Any state regulation regulating tailpipe greenhouse gas emissions from light trucks is impliedly preempted under 49 U.S.C. Chapter 329.

(e) So long as the test procedures for determining compliance with the fuel economy standards under this part do not provide for air conditioners to be operated during testing, state regulation of light truck air conditioner efficiency is not related and is therefore not preempted.

PART 534—RIGHTS AND RESPONSIBILITIES OF MANUFACTURERS IN THE CONTEXT OF CHANGES IN CORPORATE RELATIONSHIPS

11. The authority citation for part 534 continues to read as follows:

Authority: 49 U.S.C. 32901; delegation of authority at 49 CFR 1.50.

12. Amend § 534.4 by revising paragraphs (c) and (d) to read as follows:

§ 534.4 Successors and predecessors.

* * * * *

(c) Credits earned by a predecessor before or during model year 2007 may be used by a successor, subject to the availability of credits and the general three-year restriction on carrying credits forward and the general three-year restriction on carrying credits backward. Credits earned by a predecessor after model year 2007 may be used by a successor, subject to the availability of credits and the general five-year restriction on carrying credits forward and the general three-year restriction on carrying credits backward.

(d) Credits earned by a successor before or during model year 2007 may be used to offset a predecessor's shortfall, subject to the availability of credits and the general three-year restriction on carrying credits forward and the general three-year restriction on carrying credits backward. Credits earned by a successor after model year 2007 may be used to offset a predecessor's shortfall, subject to the availability of credits and the general five-year restriction on carrying credits forward and the general three-year restriction on carrying credits backward.

13. Amend § 534.5 by revising paragraphs (c) and (d) to read as follows:

§ 534.5 Manufacturers within control relationships.

*   *   *   *   *

(c) Credits of a manufacturer within a control relationship may be used by the group of manufacturers within the control relationship to offset shortfalls, subject to the agreement of the other manufacturers, the availability of the credits, and the general three-year restriction on carrying credits forward or backward prior to or during model year 2007, or the general five-year restriction on carrying credits forward and the general three-year restriction on carrying credits backward after model year 2007.

(d) If a manufacturer within a group of manufacturers is sold or otherwise spun off so that it is no longer within that control relationship, the manufacturer may use credits that were earned by the group of manufacturers within the control relationship while the manufacturer was within that relationship, subject to the agreement of the other manufacturers, the availability of the credits, and the general three-year restriction on carrying credits forward or backward prior to or during model year 2007, or the general five-year restriction on carrying credits forward and the general three-year restriction on carrying credits backward after model year 2007.

* * * * *

PART 535—3-YEAR CARRYFORWARD AND CARRYBACK OF CREDITS OF LIGHT TRUCKS

14. Remove Part 535.

15. Part 536 is added to read as follows:

PART 536—TRANSFER AND TRADING OF FUEL ECONOMY CREDITS

Sec.

536.1 Scope.

536.2 Application.

536.3 Definitions.

536.4 Credits.

536.5 Trading infrastructure.

536.6 Treatment of credits earned prior to model year 2011.

536.7 Treatment of carryback credits.

536.8 Conditions for trading of credits.

536.9 Use of credits with regard to the domestically manufactured passenger automobile minimum standard.

536.10 Treatment of dual-fuel and alternative fuel vehicles—consistency with 49 CFR Part 538.

Authority: Sec. 104, Pub. L. 110-140 (49 U.S.C. 32903); delegation of authority at 49 CFR 1.50.

§ 536.1 Scope.

This part establishes regulations governing the use and application of CAFE credits up to three model years before and five model years after the model year in which the credit was earned. It also specifies requirements for manufacturers wishing to transfer fuel economy credits between their fleets and for manufacturers and other persons wishing to trade fuel economy credits to achieve compliance with prescribed fuel economy standards.

§ 536.2 Application.

This part applies to all credits earned (and transferable and tradable) for exceeding applicable average fuel economy standards in a given model year for domestically manufactured passenger cars, imported passenger cars, and light trucks.

§ 536.3 Definitions.

(a) Statutory terms. All terms defined in 49 U.S.C. § 32901(a) are used pursuant to their statutory meaning.

(b) Other terms.

Above standard fuel economy means, with respect to a compliance category, that the automobiles manufactured by a manufacturer in that compliance category in a particular model year have greater average fuel economy (calculated in a manner that reflects the incentives for alternative fuel automobiles per 49 U.S.C. § 32905) than that manufacturer's fuel economy standard for that compliance category and model year.

Adjustment factor means a factor used to adjust the value of a traded credit for compliance purposes to ensure that the compliance value of the credit when used reflects the total volume of oil saved when the credit was earned.

Below standard fuel economy means, with respect to a compliance category, that the automobiles manufactured by a manufacturer in that compliance category in a particular model year have lower average fuel economy (calculated in a manner that reflects the incentives for alternative fuel automobiles per 49 U.S.C. § 32905) than that manufacturer's fuel economy standard for that compliance category and model year.

Compliance means a manufacturer achieves compliance in a particular compliance category when

(1) the average fuel economy of the vehicles in that category exceed or meet the fuel economy standard for that category, or

(2) the average fuel economy of the vehicles in that category do not meet the fuel economy standard for that category, but the manufacturer proffers a sufficient number of valid credits, adjusted for total oil savings, to cover the gap between the average fuel economy of the vehicles in that category and the required average fuel economy.

A manufacturer achieves compliance for its fleet if conditions (1) or (2) are simultaneously met for all compliance categories.

Compliance category means any of three categories of automobiles subject to Federal fuel economy regulations. The three compliance categories recognized by 49 U.S.C. § 32903(g)(6) are domestically manufactured passenger automobiles, imported passenger automobiles, and non-passenger automobiles ("light trucks").

Credit holder (or holder) means a legal person that has valid possession of credits, either because they are a manufacturer who has earned credits by exceeding an applicable fuel economy standard, or because they are a designated recipient who has received credits from another holder. Credit holders need not be manufacturers, although all manufacturers may be credit holders.

Credits (or fuel economy credits) means an earned or purchased allowance recognizing that the average fuel economy of a particular manufacturer's vehicles within a particular compliance category and model year exceeds that manufacturer's fuel economy standard for that compliance category and model year. One credit is equal to 1/10 of a mile per gallon above the fuel economy standard per one vehicle within a compliance category. Credits are denominated according to model year in which they are earned (vintage), originating manufacturer, and compliance category.

Expiry date means the model year after which fuel economy credits may no longer be used to achieve compliance with fuel economy regulations. Expiry Dates are calculated in terms of model years: for example, if a manufacturer earns credits for model year 2011, these credits may be used for compliance in model years 2008-2016.

Fleet means all automobiles that are manufactured by a manufacturer in a particular model year and are subject to fuel economy standards under 49 CFR Parts 531 and 533. For the purposes of this regulation, a manufacturer's fleet means all domestically manufactured and imported passenger automobiles and non-passenger automobiles ("light trucks"). "Work trucks" and medium and heavy trucks are not included in this definition for purposes of this regulation.

Light truck means the same as "non-passenger automobile," as that term is defined in 49 U.S.C. § 32901(a)(17), and as "light truck," as that term is defined at 49 CFR § 523.5.

Originating manufacturer means the manufacturer that originally earned a particular credit. Each credit earned will be identified with the name of the originating manufacturer.

Trade means the receipt by NHTSA of an instruction from a credit holder to place one of its credits in the account of another credit holder. A credit that has been traded can be identified because the originating manufacturer will be a different party than the current credit holder. Traded credits are moved from one credit holder to the recipient credit holder within the same compliance category for which the credits were originally earned. If a credit has been traded to another credit holder and is subsequently traded back to the originating manufacturer, it will be deemed not to have been traded for compliance purposes.

Transfer means the application by a manufacturer of credits earned by that manufacturer in one compliance category or credits acquired by trade (and originally earned by another manufacturer in that category) to achieve compliance with fuel economy standards with respect to a different compliance category. For example, a manufacturer may purchase light truck credits from another manufacturer, and transfer them to achieve compliance in the manufacturer's domestically manufactured passenger car fleet.

Vintage means, with respect to a credit, the model year in which the credit was earned.

§ 536.4 Credits.

(a) Type and vintage. All credits are identified and distinguished in the accounts by originating manufacturer, compliance category, and model year of origin (vintage).

(b) Application of credits. All credits earned and applied are calculated, per 49 U.S.C. § 32903(c), in tenths of a mile per gallon by which the average fuel economy of vehicles in a particular compliance category manufactured by a manufacturer in the model year in which the credits are earned exceeds the applicable average fuel economy standard, multiplied by the number of vehicles sold in that compliance category. However, credits that have been traded, defined as credits that are used for compliance by a manufacturer other than the originating manufacturer, are valued for compliance purposes using the adjustment factor specified in subsection (c) below, pursuant to the "total oil savings" requirement of 49 U.S.C. § 32903(f)(1).

(c) Adjustment factor. When traded and used, fuel economy credits are adjusted to ensure fuel oil savings is preserved. The user (or buyer) of credits must multiply the calculated adjustment factor by the number of its shortfall credits it plans to offset in order to determine the number of equivalent credits to acquire from the earner (or seller). The adjustment factor is calculated by the following formula:

$$A = \left(\frac{\text{VMTu} * \text{MPGae} * \text{MPGse}}{\text{VMTe} * \text{MPGau} * \text{MPGsu}} \right)$$

Where A = Adjustment Factor applied to traded credits;

VMTe = Lifetime vehicle miles traveled for the compliance category in which the credit was earned: 150,922 miles for domestically manufactured and imported passenger cars, 172,552 miles for light trucks;

VMTu = Lifetime vehicle miles traveled for the compliance category in which the credit is used for compliance: 150,922 miles for domestically manufactured and imported passenger cars, 172,552 miles for light trucks;

MPGse = Required fuel economy standard for the originating (earning) manufacturer, compliance category, and model year in which the credit was earned;

MPGae = Actual fuel economy for the originating manufacturer, compliance category, and model year in which the credit was earned;

MPGsu = Required fuel economy standard for the user (buying) manufacturer, compliance category, and model year in which the credit is used for compliance;

MPGau = Actual fuel economy for the user manufacturer, compliance category, and model year in which the credit is used for compliance.

§ 536.5 Trading Infrastructure.

(a) Accounts. NHTSA maintains "accounts" for each credit holder. The account consists of a balance of credits in each compliance category and vintage held by the holder.

(b) Who may hold credits. Every manufacturer subject to fuel economy standards under 49 CFR parts 531 or 533 is automatically an account holder. If the manufacturer earns credits pursuant to this regulation, or receives credits from another party, so that the manufacturer's account has a non-zero balance, then the manufacturer is also a credit holder. Any party designated as a recipient of credits by a current credit holder will receive an account from NHTSA and become a credit holder, subject to the following conditions:

(1) A designated recipient must provide name, address, contacting information, and a valid taxpayer identification number or social security number;

(2) NHTSA does not grant a request to open a new account by any party other than a party designated as a recipient of credits by a credit holder;

(3) NHTSA maintains accounts with zero balances for a period of time, but reserves the right to close accounts that have had zero balances for more than one year.

(c) Automatic debits and credits of accounts.

(1) Upon receipt of a verified instruction to trade credits from an existing credit holder, NHTSA verifies the presence of sufficient credits in the account of the trader, then debits the account of the trader and credits the account of the recipient with credits of the vintage, origin, and compliance category designated. Traded credits identified by a specific compliance category are deposited into the recipient's account in that same compliance category. If the recipient is not a current account holder, NHTSA establishes the account subject to the conditions described in § 536.5(b), and adds the credits to the newly-opened account.

(2) NHTSA automatically deletes unused credits from holders' accounts as they reach their expiry date.

(d) Compliance.

(1) NHTSA assesses compliance with fuel economy standards each year, utilizing the certified and reported CAFE data provided by the Environmental Protection Agency for enforcement of the CAFE program pursuant to 49 U.S.C. § 32904(e). Credit values are calculated based on the CAFE data from the EPA. If a particular compliance category within a manufacturer's fleet has above standard fuel economy, NHTSA adds credits to the manufacturer's account for that

compliance category and vintage in the appropriate amount by which the manufacturer has exceeded the applicable standard.

(2) If a manufacturer's vehicles in a particular compliance category have below standard fuel economy, NHTSA will provide written notification to the manufacturer that it has failed to meet a particular fleet target standard. The manufacturer will be required to confirm the shortfall and must either (a) submit a plan indicating how it will allocate existing credits or earn, transfer and/or acquire credits, or (b) pay the appropriate civil penalty. The manufacturer must submit a plan or payment within 60 days of receiving agency notification.

(3) Credits used to offset shortfalls are subject to the three and five year limitations as described in section 536.6.

(4) Transferred credits are subject to the limitations specified by 49 U.S.C. § 32903(g)(3) and this regulation.

(5) The value, when used for compliance, of any credits received via trade is adjusted, using the adjustment factor described in section 536.4(c), pursuant to 49 U.S.C. § 32903(f)(1).

(6) Credit allocation plans received from a manufacturer will be reviewed and approved by NHTSA. NHTSA will approve a credit allocation plan unless it finds that the proposed credits are unavailable or that it is unlikely that the plan will result in the manufacturer earning sufficient credits to offset the subject credit shortfall. If a plan is approved, NHTSA will revise the respective manufacturer's credit account accordingly. If a plan is rejected, NHTSA will notify the

respective manufacturer and request a revised plan or payment of the appropriate fine.

(e) Reporting.

(1) NHTSA periodically publishes the names and credit holdings of all credit holders. NHTSA does not publish individual transactions, nor respond to individual requests for updated balances from any party other than the account holder.

(2) NHTSA issues an annual credit status letter to each party that is a credit holder at that time. The letter to a credit holder includes a credit accounting record that identifies the credit status of the credit holder including any activity (earned, expired, transferred, traded, carry-forward and carry-back credit transactions/allocations) that took place during the identified activity period.

§ 536.6 Treatment of credits earned prior to model year 2011.

(a) Credits earned in a compliance category before model year 2008 may be applied by the manufacturer that earned them to carryback plans for that compliance category approved up to three model years prior to the year in which the credits were earned, or may be applied to compliance in that compliance category for up to three model years after the year in which the credits were earned.

(b) Credits earned in a compliance category during and after model year 2008 may be applied by the manufacturer that earned them to carryback plans for that compliance category approved up to three years prior to the year in which the credits were earned, or may be held or applied for up to five model years after the year in which the credits were earned.

(c) Credits earned in a compliance category prior to model year 2011 may not be transferred or traded.

§ 536.7 Treatment of carryback credits.

(a) Carryback credits earned in a compliance category in any model year may be used in carryback plans approved by NHTSA, pursuant to 49 U.S.C. § 32903(b), for up to three model years prior to the year in which the credit was earned.

(b) For purposes of this regulation, NHTSA will treat the use of future credits for compliance, as through a carryback plan, as a deferral of penalties for non-compliance with an applicable fuel economy standard.

(c) If NHTSA receives and approves a manufacturer's carryback plan to earn future credits within the following three model years in order to comply with current regulatory obligations, NHTSA will defer levying fines for non-compliance until the date(s) when the manufacturer's approved plan indicates that credits will be earned or acquired to achieve compliance, and upon receiving confirmed CAFE data from EPA. If the manufacturer fails to acquire or earn sufficient credits by the plan dates, NHTSA will initiate compliance proceedings.

(d) In the event that NHTSA fails to receive or approve a plan for a non-compliant manufacturer, NHTSA will levy fines pursuant to statute. If within three years, the non-compliant manufacturer earns or acquires additional credits to reduce or eliminate the non-compliance, NHTSA will reduce any fines owed, or repay fines to the extent that credits received reduce the non-compliance.

(e) No credits from any source (earned, transferred and or traded) will be accepted in lieu of compliance if those credits are not identified as originating within one of the three model years after the model year of the confirmed shortfall.

§ 536.8 Conditions for trading of credits.

(a) Trading of credits. If a credit holder wishes to trade credits to another party, the current credit holder and the receiving party must jointly issue an instruction to NHTSA, identifying the quantity, vintage, compliance category, and originator of the credits to be traded. If the recipient is not a current account holder, the recipient must provide sufficient information for NHTSA to establish an account for the recipient. Once an account has been established or identified for the recipient, NHTSA completes the trade by debiting the transferor's account and crediting the recipient's account. NHTSA will track the quantity, vintage, compliance category, and originator of all credits held or traded by all account-holders.

(b) Trading between and within compliance categories. For credits earned in model year 2011 or thereafter, and used to satisfy compliance obligations for model year 2011 or thereafter:

(1) Manufacturers may use credits originally earned by another manufacturer in a particular compliance category to satisfy compliance obligations within the same compliance category.

(2) Once a manufacturer acquires by trade credits originally earned by another manufacturer in a particular compliance category, the manufacturer may transfer the credits to satisfy its compliance obligations in a different compliance category, but only to the extent that the CAFE increase attributable to the

transferred credits does not exceed the limits in 49 U.S.C. § 32903(g)(3). For any compliance category, the sum of a manufacturer's transferred credits earned by that manufacturer and transferred credits obtained by that manufacturer through trade must not exceed that limit.

(c) Changes in corporate ownership and control. Manufacturers must inform NHTSA of corporate relationship changes to ensure that credit accounts are identified correctly and credits are assigned and allocated properly.

(1) In general, if two manufacturers merge in any way, they must inform NHTSA how they plan to merge their credit accounts. NHTSA will subsequently assess corporate fuel economy and compliance status of the merged fleet instead of the original separate fleets.

(2) If a manufacturer divides or divests itself of a portion of its automobile manufacturing business, it must inform NHTSA how it plans to divide the manufacturer's credit holdings into two or more accounts. NHTSA will subsequently distribute holdings as directed by the manufacturer, subject to provision for reasonably anticipated compliance obligations.

(3) If a manufacturer is a successor to another manufacturer's business, it must inform NHTSA how it plans to allocate credits and resolve liabilities per 49 CFR Part 534, Rights and Responsibilities of Manufacturers in the Context of Corporate Relationships.

(d) No short or forward sales. NHTSA will not honor any instructions to trade or transfer more credits than are currently held in any account. NHTSA will not honor instructions to trade or transfer credits from any future vintage (i.e., credits not yet earned). NHTSA will not participate in or facilitate contingent trades.

(e) Cancellation of credits. A credit holder may instruct NHTSA to cancel its currently held credits, specifying the originating manufacturer, vintage, and compliance category of the credits to be cancelled. These credits will be permanently null and void; NHTSA will remove the specific credits from the credit holder's account, and will not reissue them to any other party.

(f) Errors or fraud in earning credits. If NHTSA determines that a manufacturer has been credited, through error or fraud, with earning credits, NHTSA will cancel those credits if possible. If the manufacturer credited with having earned those credits has already traded them when the error or fraud is discovered, NHTSA will hold the receiving manufacturer responsible for returning the same or equivalent credits to NHTSA for cancellation.

(g) Error or fraud in trading. In general, all trades are final and irrevocable once executed, and may only be reversed by a new, mutually-agreed transaction. If NHTSA executes an erroneous instruction to trade credits from one holder to another through error or fraud, NHTSA will reverse the transaction if possible. If those credits have been traded away, the recipient holder is responsible for obtaining the same or equivalent credits for return to the previous holder.

§ 536.9 Use of credits with regard to the domestically manufactured passenger automobile minimum standard.

(a) Each manufacturer is responsible for compliance with both the minimum standard and the attribute-based standard.

(b) In any particular model year, the domestically manufactured passenger automobile compliance category credit excess or shortfall is determined by comparing the actual CAFE value against either the required standard value or the minimum standard value, whichever is larger.

(c) Transferred or traded credits may not be used, pursuant to 49 U.S.C. § 32903(g)(4) and (f)(2), to meet the domestically manufactured passenger automobile minimum standard specified in 49 U.S.C. § 32902(b)(4).

(d) If a manufacturer's average fuel economy level for domestically manufactured passenger automobiles is lower than the attribute-based standard, but higher than the minimum standard, then the manufacturer may achieve compliance with the attribute-based standard by applying credits.

(e) If a manufacturer's average fuel economy level for domestically manufactured passenger automobiles is lower than the minimum standard, then the difference between the minimum standard and the manufacturer's actual fuel economy level may only be relieved by the use of credits earned by that manufacturer within the domestic passenger car compliance category which have not been transferred or traded. If the manufacturer does not have available earned credits to offset a credit shortage below the minimum standard then the manufacturer can submit a carry-back plan that indicates sufficient future credits will be earned in its domestic passenger car compliance category or will be subject to penalties.

§ 536.10 Treatment of dual-fuel and alternative fuel vehicles—consistency with 49 CFR Part 538.

(a) Statutory alternative fuel and dual-fuel vehicle fuel economy calculations are treated as a change in the underlying fuel economy of the vehicle for purposes of this regulation, not as a credit that may be transferred or traded. Improvements in alternative fuel or dual fuel vehicle fuel economy as calculated pursuant to 49 U.S.C. § 32905 and limited by 49 U.S.C. § 32906 are therefore attributable only to the particular compliance category and model year to which the alternative or dual-fuel vehicle belongs.

(b) If a manufacturer's calculated fuel economy for a particular compliance category, including any required calculations for alternative fuel and dual fuel vehicles, is higher or lower than the applicable fuel economy standard, manufacturers will earn credits or must apply credits or pay fines equal to the difference between the calculated fuel economy level in that compliance category and the applicable standard. Credits earned are the same as any other credits, and may be held, transferred, or traded by the manufacturer subject to the limitations of the statute and this regulation.

(c) If a manufacturer builds enough alternative fuel or dual fuel vehicles to improve the calculated fuel economy in a particular compliance category by more than the limits set forth in 49 U.S.C. § 32906(a), the improvement in fuel economy for compliance purposes is restricted to the statutory limit. Manufacturers may not earn credits nor reduce the application of credits or fines for calculated improvements in fuel economy based on alternative or dual fuel vehicles beyond the statutory limit.

PART 537—AUTOMOTIVE FUEL ECONOMY REPORTS

16. The authority citation for part 537 continues to read as follows:

Authority: 49 U.S.C. 32907, delegation of authority at 49 CFR 1.50.

17. Amend § 537.7 by revising paragraphs (b), (c)(4)(xvi)(A), and (c)(4)(xvi)(B) to read as follows:

§ 537.7 Pre-model year and mid-model year reports.

* * * * *

(b) Projected average and required fuel economy. (1) State the projected average fuel economy for the manufacturer's automobiles determined in accordance with § 537.9 and based upon the fuel economy values and projected sales figures provided under paragraph (c)(2) of this section.

(2) State the projected final average fuel economy that the manufacturer anticipates having if changes implemented during the model year will cause that average to be different from the average fuel economy projected under paragraph (b)(1) of this section.

(3) State the projected required fuel economy for the manufacturer's passenger automobiles and light trucks determined in accordance with 49 CFR 531.5(c) and 49 CFR 533.5(h) and based upon the projected sales figures provided under paragraph (c)(2) of this section.

(4) State the projected final required fuel economy that the manufacturer anticipates having if changes implemented during the model year will cause the

targets to be different from the target fuel economy projected under paragraph (b)(3) of this section.

(5) State whether the manufacturer believes that the projections it provides under paragraphs (b)(2) and (b)(4) of this section, or if it does not provide an average or target under those paragraphs, the projections it provides under paragraphs (b)(1) and (b)(3) of this section, sufficiently represent the manufacturer's average and target fuel economy for the current model year for purposes of the Act. In the case of a manufacturer that believes that the projections are not sufficiently representative for those purposes, state the specific nature of any reason for the insufficiency and the specific additional testing or derivation of fuel economy values by analytical methods believed by the manufacturer necessary to eliminate the insufficiency and any plans of the manufacturer to undertake that testing or derivation voluntarily and submit the resulting data to the Environmental Protection Agency under 40 CFR 600.509.

(c) * * *

(4) * * *

(xvi)(A) In the case of passenger automobiles:

(1) Interior volume index, determined in accordance with subpart D of 40 CFR part 600,

(2) Body style,

(3) Beginning model year 2010, base tire as defined in 49 CFR 523.2,

(4) Beginning model year 2010, track width as defined in 49 CFR 523.2,

(5) Beginning model year 2010, wheelbase as defined in 49 CFR 523.2, and

(6) Beginning model year 2010, footprint as defined in 49 CFR 523.2.

(B) In the case of light trucks:

(1) Passenger-carrying volume,

(2) Cargo-carrying volume,

(3) Beginning model year 2008, base tire as defined in 49 CFR 523.2,

(4) Beginning model year 2008, track width as defined in 49 CFR 523.2,

(5) Beginning model year 2008, wheelbase as defined in 49 CFR 523.2, and

(6) Beginning model year 2008, footprint as defined in 49 CFR 523.2.

Issued:

David Kelly
Acting Administrator

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