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Part II

Department of Transportation

National Highway Traffic Safety Administration

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

Average Fuel Economy Standards, Passenger Cars and Light Trucks; Model Years 2011-2015; Proposed Rule

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DEPARTMENT OF TRANSPORTATION

National Highway Traffic Safety Administration

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

[Docket No. NHTSA-2008-0089]
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: Notice of Proposed Rulemaking (NPRM).

SUMMARY: This document proposes substantial increases in the Corporate

Average Fuel Economy (CAFE) standards for passenger cars and light trucks that would enhance energy security by improving fuel economy. Since the carbon dioxide (CO2) emitted from the tailpipes of new motor vehicles is the natural by-product of the combustion of fuel, the increased standards would also address climate change by reducing tailpipe emissions of CO2. Those emissions represent 97 percent of the total greenhouse gas emissions from motor vehicles. Implementation of the new standards would dramatically add to the billions of barrels of fuel already saved since the beginning of the CAFE program in 1975.

DATES: Comments must be received on or before July 1, 2008.

ADDRESSES: You may submit comments to the docket number identified in the heading of this document by any of the following methods:

Federal eRulemaking Portal: Go to http://www.regulations.gov. Follow the online instructions for submitting comments.

Mail: Docket Management Facility, M-30, U.S. Department of Transportation, West Building, Ground Floor, Rm. W12-140, 1200 New Jersey Avenue, SE., Washington, DC 20590.

Hand Delivery or Courier: West Building Ground Floor, Room W12-140, 1200 New Jersey Avenue, SE., between 9 a.m. and 5 p.m. Eastern Time, Monday through Friday, except Federal holidays.

Fax: (202) 493-2251.

Regardless of how you submit your comments, you should mention the docket number of this document.

You may call the Docket Management Facility at 202-366-9826.

Instructions: For detailed instructions on submitting comments and additional information on the rulemaking process, see the Public Participation heading of the Supplementary Information section of this document. Note that all comments received will be posted without change to http://www.regulations.gov, including any personal information provided.

Privacy Act: Please see the Privacy Act heading under Rulemaking Analyses and Notices.

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 Schade, Office of the Chief Counsel, National Highway Traffic Safety Administration, 1200 New Jersey Avenue, SE., Washington, DC 20590. Telephone: (202) 366-2992.

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I. Executive overview

A. Summary

This document is being issued pursuant to the Energy Independence and Security Act of 2007 (EISA), which Congress passed in December 2007. EISA mandates the setting of separate maximum feasible standards for passenger cars and for light trucks at levels sufficient 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. That is a 40 percent increase above the average of approximately 25 miles per gallon for the current combined fleet.

Congress enabled NHTSA to require these substantial increases in fuel economy by 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 adopted by NHTSA for light trucks in 2006. The new approach is a substantial improvement over the old approach of specifying the same numerical standard for each manufacturer. It avoids creating undue risks of adverse safety and employment impacts and distributes compliance responsibilities among the vehicle manufacturers more equitably.

This document proposes standards for MYs 2011-2015, the maximum number of model years for which NHTSA can establish standards in a single rulemaking under EISA. Since lead time is a significant consideration in determining the stringency of future standards, the agency needs to establish the standards as far in advance as possible so as to maximize the amount of lead time for manufacturers to develop and implement plans for making the vehicle design changes necessary to achieve the requirements of EISA.

In developing the proposed standards, the agency 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) as well as other relevant considerations such as safety. After assessing what fuel saving technologies would be available, how effective they are, and how quickly they could be introduced, and then factoring that information into the computer model its uses for applying technologies to particular vehicle models, the agency then 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 the above process, the agency consulted with the Department of Energy and particularly the Environmental Protection Agency regarding a wide variety of matters, including, for example, the cost and effectiveness of available technologies, improvements to the computer model, and the selection of appropriate analytical assumptions.

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

NHTSA is also publishing two companion documents, one requesting vehicle manufacturers to provide up-to-date product plans for the model years covered by this document, and the other inviting Federal, State, and local agencies, Indian tribes, and the public to participate in identifying the environmental issues and reasonable alternatives to be examined in an environmental impact statement.

B. Energy Independence and Security Act of 2007

The Energy Independence and Security Act of 2007 (EISA)\1\ 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 confronting global climate change.

\1\ Pub. L. 110-140, 121 Stat. 1492 (Dec. 18, 2007).

EISA will help reduce America's dependence on oil by reducing U.S. demand for oil by setting a national fuel economy standard of at least 35 miles per gallon by 2020--which will increase fuel economy standards by 40 percent and save billions of gallons of fuel. In January 2007, the President called for the first statutory increase in fuel economy standards for passenger

automobiles (referred to below as ``passenger cars'') since those standards were mandated in 1975, and EISA delivers on that request. EISA also includes an important reform the President has called for that allows the Transportation Department to issue ``attribute-based standards,'' which will ensure that increased fuel efficiency does not come at the expense of automotive safety. EISA also mandates increases in the use of renewable fuels by setting a mandatory Renewable Fuel Standard requiring fuel producers to use at least 36 billion gallons of renewable fuels in 2022.

As the President noted in signing EISA, the combined effect of the various actions required by the Act will be to produce some of the largest CO_2 emission reductions in our nation's history.

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:

Replaces the old statutory default standard of 27.5 mpg for passenger cars with a mandate to establish separate passenger car and light truck standards annually, beginning with MY 2011, set at the maximum feasible level. The standards for MYs 2011-2020 must, as a minimum, be set sufficiently high to ensure that the average fuel economy of the combined industrywide fleet of all new passenger cars and light trucks sold in the United States during MY 2020 is at least 35 mpg.\2\

\2\ 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.

Limits to five the number of years for which standards can be established in a single rulemaking. That requirement, in combination with the requirement to start rulemaking with MY 2011, necessitates limiting this rulemaking to MYs 2011-2015.

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, the domestic passenger cars of each manufacturer of those cars must achieve a measured average fuel economy that is not less than 92 percent of the average fuel economy of the combined fleet of domestic and non-domestic passenger cars sold in the United States in that model year.

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 for exceeding CAFE standards, (b) allowing a manufacturer to transfer the credits it has earned from one of its classes of automobiles to another, and (c) authorizing the trading of credits between manufacturers.

C. Proposal

1. Standards

a. Stringency

This document proposes to set attribute-based fuel economy standards for passenger cars and light trucks consistent with the Reformed CAFE approach that NHTSA used in establishing the light truck standards for MY 2008-2011 light trucks. Separate passenger car standards would be set for MYs 2011-2015, and light truck standards would be set for MYs 2011-2015. As noted above, EISA limits the number of model years for which standards may be established in a single rulemaking to five. We are proposing to establish standards for five years to maximize the amount of lead time that we can provide the manufacturers. This is necessary to make it possible to achieve the levels of average fuel economy required by MY 2020.

Each vehicle manufacturer's required level of CAFE would be 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 would be defined by vehicle footprint. The level of the performance target for each footprint would reflect the technological and economic capabilities of the industry. The target for each footprint would be the same for all manufacturers, regardless of differences in their overall fleet mix. Compliance would 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 proposed standards were developed using a computer model (known as the ``Volpe Model'') that, for any given model year, applies technologies to a manufacturer's fleet until the manufacturer reaches compliance with the standard under consideration. The standards were tentatively set at levels such that, considering the seven largest manufacturers, the cost of the last technology application equaled the benefits of the improvement in fuel economy resulting from that application. We reviewed these proposed standards to consider the underlying increased use of technologies and the associated impact on the industry. This process recognizes that the relevance of costs in achieving benefits, and uses benefit figures that include the value of reducing the negative externalities (economic and environmental) from producing and consuming fuel. These environmental externalities include, among other things, reducing tailpipe emissions of CO_2.\3\ In view of the process used to develop the proposed standards, they are also referred to as ``optimized standards.''

\3\ 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.

Compared to the 2006 rulemaking that established the MY 2008-11 CAFE standards for light trucks, this rulemaking much more fully captures the value of the costs and benefits of setting CAFE standards. This is important because assumptions regarding gasoline price projections, along with assumptions for externalities, are based on changed economic and environmental and energy security conditions and play a big role in the agency's balancing of the statutory considerations in arriving at a determination of maximum feasible. In light of EISA and the need to balance the statutory considerations in a way that reflects the current need of the nation to conserve energy, including the current assessment of the climate change problem, the agency revisited the various assumptions used in the Volpe Model to determine the level of the standards. Specifically, in running the Volpe Model and stopping at a point where marginal costs equaled marginal benefits or where net benefits to society are maximized, 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 technology list. 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. These changes to the inputs to the model had a major impact on increasing the benefits in certain model years by allowing for greater penetration of technologies.

The agency cannot set out the exact level of CAFE that each manufacturer will be required to meet for each model year under the proposed 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 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 is the estimated associated level of tailpipe emissions of CO2 that would be achieved.\4\

\4\ Given the contributions made by CAFE standards to addressing not only energy independence and security, but also to reducing tailpipe emissions of CO2, fleet performance is stated in the above discussion both in terms of fuel economy and the associated reductions in tailpipe emissions of CO2 since the CAFE standard will 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 CO2 per gallon of gasoline). (Last accessed April 20, 2008.) The CO2 emission rates shown are 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 proposed CAFE standards--will cause the actual CO2 emission rate corresponding to any given CAFE level to be slightly higher than shown here. (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.) Conversely (and hypothetically), applying the same CO2 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.

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)
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 is approximately 4.5 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 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 would need to be only 2.1 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 \5\ for that model year, whichever is higher. This requirement results in the following alternative minimum standard (not attribute-based) for domestic passenger cars:

\5\ Those numbers set out several paragraphs above.

MY 2011: 28.7 mpg (310 g/mi of tailpipe emissions of CO_2)
MY 2012: 30.2 mpg (294 g/mi of tailpipe emissions of CO_2)
MY 2013: 31.3 mpg (284 g/mi of tailpipe emissions of CO_2)
MY 2014: 32.0 mpg (278 g/mi of tailpipe emissions of CO_2)
MY 2015: 32.9 mpg (270 g/mi of tailpipe emissions of CO_2)

The agency is also issuing, along with this document, a notice requesting updated product plan information and other data to assist in developing a final rule. We recognize that the manufacturer product plans relied upon in developing this proposal--those plans received in late spring of 2007 in response to an early 2007 request for information--may already be outdated in some respects. We fully expect that manufacturers have revised those plans to reflect subsequent developments, especially the enactment of EISA.

We solicit comment on all aspects of this proposal, including the methodology, economic assumptions, analysis and tentative conclusions. In particular, we solicit comment on whether the proposed levels of CAFE satisfy EPCA, e.g., reflect an appropriate balancing of the explicit statutory factors and other relevant factors. Other specific areas where we request comments are identified elsewhere in this preamble and in the Preliminary Regulatory Impact Analysis (PRIA). Based on public comments and other information, including new data and analysis, and updated product plans,\6\ the standards adopted in the final rule could well be different from those proposed in this document.

\6\ The proposed standards are, in the first instance, based on the confidential product plans submitted by the manufacturers in the spring of 2006. The final rule will be based on the confidential plans submitted in the next several months. The agency anticipates that those new plans, which presumably will reflect in some measure the enactment of EISA and the issuance of this proposal, will project higher levels of average fuel economy than the 2006 product plans.

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b. Benefits

We estimate that the proposed standards for passenger cars would save approximately 18.7 billion gallons of fuel and avoid tailpipe CO2 emissions by 178 billion 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).

We estimate that the value of the total benefits of the proposed passenger car standards would be approximately $31 billion \7\ 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.

\7\ The $22 billion estimate is based on a 7% discount rate for valuing future impacts. NHTSA estimated benefits using both 7% and 3% discount rates. Under a 3% rate, net consumer benefits for passenger car CAFE improvements total $28 million.

We estimate that the proposed standards for light trucks would save approximately 36 billion gallons of fuel and prevent the tailpipe emission of 343 million metric tons of CO2 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. We estimate that the value of the total benefits of the proposed light truck standards would be approximately $57 billion \8\ 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.

\8\ The $56 billion estimate is based on a 7% discount rate for valuing future impacts. NHTSA estimated benefits using both 7% and 3% discount rates. Under a 3% rate, net consumer benefits for light truck CAFE improvements total $70 million.

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c. Costs

The total costs for manufacturers just complying with the standards for MY 2011-2015 passenger cars 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 passenger cars would be recovered or paid back \9\ in additional fuel savings in an average of 56 months, assuming fuel prices ranging from $2.26 per gallon in 2016 to $2.51 per gallon in 2030.\10\

\9\ See Section V.A.7 below for discussion of payback period.

\10\ The fuel prices (shown here in 2006 dollars) used to calculate the length of the payback period are those projected (Annual Energy Outlook 2008, revised early release) by the Energy Information Administration over the life of the MY 2011-2015 light trucks, not current fuel prices.

The total costs for manufacturers just complying with the standards for MY 2011-2015 light trucks would be approximately $31 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 in an average of 50 months, assuming fuel prices ranging from $2.26 to $2.51 per gallon.

d. Flexibilities

The agency's 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 proposed standards. In reality, however, manufacturers are likely to rely to some extent on flexibility mechanisms provided by EPCA (as described in Section VI) and will thereby reduce the cost of complying with the proposed standards to a meaningful extent.

2. Credits

NHTSA is also proposing 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.\11\ 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 the proposed 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 the proposed Part 536 is available in section IX below.

\11\ 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.

II. Background

A. Contribution of Fuel Economy Improvements to Addressing Energy Independence and Security and Climate Change

1. Relationship Between Fuel Economy and CO2 Tailpipe Emissions

Improving fuel economy reduces the amount of tailpipe emissions of CO2. CO2 emissions are directly linked to fuel consumption because CO2 is the ultimate end product of burning gasoline. The more fuel a vehicle burns, the more CO2 it emits. Since the CO2 emissions are essentially constant per gallon of fuel combusted, the amount of fuel consumption per mile is directly related to the amount of CO2 emissions per mile. Thus, requiring improvements in fuel economy indirectly, but necessarily requires reductions in tailpipe emissions of CO2 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 CO2 emissions as a tailpipe CO2 emission standard of 423.2 g/mi of CO2, and vice versa.\12\

\12\ To the extent that manufacturers comply with a CAFE standard with diesel automobiles instead of gasoline ones, the level of CO2 tailpipe emissions would be less. 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 CO2 tailpipe emissions of a diesel powered passenger car are 15 percent higher than those of a comparable gasoline power passenger car.

Table II-1.--CAFE Standards (mpg) and the Limits They Indirectly Place on Tailpipe Emissions of CO2 (g/mi)*

CAFE Std	CO2	CAFE Std	CO2	CAFE Std	CO2	CAFE Std	CO2	CAFE Std	CO2	CAFE Std	CO2
21.0	444.4	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	188.3
23.0	386.4	28.0	317.4	33.0	269.3	38.0	233.9	43.0	206.7	48.0	189.1
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 CO2 per gallon of gasoline consumed, based on characteristics of gasoline vehicle certification fuel. To convert a mpg value into CO2 g/mi, divide 8,887 by the mpg value.

2. Fuel Economy Improvements/CO2 Tailpipe Emission Reductions Since 1975

The need to take action to reduce greenhouse gas emissions, e.g., motor vehicle tailpipe emissions of CO2, in order to forestall and even mitigate climate change is well recognized.\13\ Less well recognized are two related facts. First, improving fuel economy is the only method available to motor vehicle manufacturers for making significant reductions in the CO2 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 in some measure to market conditions as well, have directly caused reductions in the rate of CO_2 tailpipe emissions per vehicle.

\13\ 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.

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 passenger cars had increased to 31.3 mpg, causing g/mi of CO_2 to fall to 283.9. Similarly, in 1975, light trucks averaged 13.7 mpg (648.7 g/mi of CO_2). By 2007, the average fuel economy of light trucks had risen to 23.1 mpg, causing g/mi of CO_2 to fall to 384.7.

Table II-2.--Improvements in MPG/Reductions in G/MI of CO2 Passenger Cars
[1975-2007]

	MPG	G/MI of CO2
1975..	15.8	562.5
2007..	31.3	283.9

Table II-3.--Improvements in MPG/Reductions in G/MI of CO2 Light Trucks
[1975-2007]

	MPG	G/MI of CO2
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.
BILLING CODE 4910-59-P

[GRAPHIC] [TIFF OMITTED] TP02MY08.000

B. Chronology of Events Since the National Academy of Sciences Called for Reforming and Increasing CAFE Standards

1. National Academy of Sciences CAFE Report (February 2002)
a. Significantly Increasing CAFE Standards Without Reforming Them Would Adversely Affect Safety

In the congressionally-mandated report entitled ``Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards,'' \14\ 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 created an incentive for 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 these problems 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. 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.

\14\ 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 April 20, 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.

Looking to the future, the committee said that while it is 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 will 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 increases in fuel economy requirements must be considered seriously. Any reduction in vehicle size and weight would have safety implications.

The committee cautioned that the safety effects of downsizing and downweighting are likely to be hidden by the generally increasing safety of the light-duty vehicle fleet.\15\ 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 is one of the measures) will be more difficult to identify in light of the continuing improvement in traffic safety. Although it is anticipated that these safety innovations will improve the safety of vehicles of all sizes, that does not mean that downsizing to achieve fuel economy improvements will not have any safety costs. If two vehicles of the same size are modified, one both by downsizing it and adding the safety innovations and the other just by adding the safety innovations, the latter vehicle will in all likelihood be safer.

\15\ 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 are structured in a way that encourages either downsizing or the increased production of smaller vehicles, some additional traffic fatalities would be expected. 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.\16\

\16\ NAS, p. 9.

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 \17\ benefits of these reforms will depend in part on whether the unreformed, non-attribute based greenhouse 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 should 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.

\17\ 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.

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b. Environmental and Other Externalities Justify Increasing the CAFE Standards

The 2002 NAS report also concluded that the CAFE standards have contributed to 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 greenhouse gas), relative to what they otherwise would have been. If fuel economy had not improved, gasoline consumption (and crude oil imports) would be about 2.8 million barrels per day (mmbd) greater than it is.\18\ Reducing fuel consumption in vehicles also reduces carbon dioxide emissions. If the nation were using 2.8 mmbd more gasoline, carbon emissions would be 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 have reduced overall U.S. emissions by about 7 percent.\19\

\18\ NAS, pp. 3 and 20.

\19\ NAS, p. 20.

The report concluded that technologies exist that could significantly further reduce fuel consumption by passenger cars and light trucks within 15 years, while maintaining vehicle size, weight, utility and performance.\20\ Light duty trucks were said to offer the greatest potential for reducing fuel consumption.\21\ 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.'' \22\

\20\ NAS, p. 3 (Finding 5).
\21\ NAS, p. 4 (Finding 5).
\22\ NAS, pp. 4 (Finding 6) and 64.

The committee emphasized that it is critically important to be clear about the reasons for considering improved fuel economy. While the dollar value of the saved fuel would be 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.\23\

\23\ NAS, pp. 8-9.

The committee said that there are two compelling concerns that justify a government mandated increase in fuel economy, both relating to externalities. The most important concern, it argued, is the one about the accumulation in the atmosphere of greenhouse gases, principally carbon dioxide.\24\

\24\ 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.\25\

\25\ NAS, pp. 4 and 85-86.

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.\26\ Further, 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.'' \27\ 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.'' \28\

\26\ NAS, pp. 4-5 (Finding 10).
\27\ NAS, p. 29.
\28\ NAS, p. 3 (Finding 2).

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.'' \29\ 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.\30\

\29\ NAS, p. 5 (Finding 12).
\30\ NAS, p. 87.

In February 2002, Secretary Mineta asked Congress ``to provide the Department of Transportation with the necessary authority to reform the CAFE program, guided by the NAS report's suggestions.''

2. 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 and established higher CAFE standards for MY 2008-2011 light trucks.\31\ Reforming the CAFE program enables it to achieve larger fuel savings, while enhancing safety and preventing adverse economic consequences.

\31\ 71 FR 17566; April 6, 2006.

During a transition period of MYs 2008-2010, manufacturers may comply with CAFE standards established under the reformed structure (Reformed CAFE) or with standards established in the traditional way (Unreformed CAFE). This permits manufacturers and the agency to gain experience with implementing the Reformed CAFE standards. Under the 2006 rule, all manufacturers were required to comply with a Reformed CAFE standard in MY 2011.

Under Reformed CAFE, fuel economy standards were restructured so that they are based on a measure of vehicle size called ``footprint,'' which is the product of multiplying a vehicle's wheelbase by average 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 have lower targets. A particular manufacturer's compliance obligation for a model year will be calculated as the harmonic average of the fuel economy targets for the manufacturer's vehicles, weighted by the distribution of manufacturer's production volumes among the footprint increments.

Thus, each manufacturer will be 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 such technology. These targets translate into required levels of average fuel economy that are technologically feasible because manufacturers can achieve them using available technologies. 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.

The Unreformed CAFE standards are: 22.5 miles per gallon (mpg) for MY 2008, 23.1 mpg for MY 2009, and 23.5 mpg for MY 2010. To aid the transition to Reformed CAFE, the Reformed CAFE standards for those years were set at levels intended to ensure that the industry-wide costs of the Reformed standards are roughly equivalent to the industry-wide costs of the Unreformed CAFE standards in those model years. For MY 2011, the Reformed CAFE standard was set at the level that maximizes net benefits. Net benefits include the increase in light truck prices due to technology improvements, the decrease in fuel consumption, and a number of other factors. All of the standards were set at the maximum feasible level, while accounting for technological feasibility, economic practicability and other relevant factors.

We carefully balanced the costs of the rule with the benefits of reducing energy consumption. Compared to Unreformed CAFE, Reformed CAFE enhances overall fuel savings while providing vehicle manufacturers with the flexibility they need to respond to changing market conditions. Reformed CAFE will also provide 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 eliminate the incentive to downsize some of their fleet as a CAFE compliance strategy, thereby reducing the adverse safety risks associated with the Unreformed CAFE program.

3. 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) 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.

4. Request for Passenger Car and Light Truck Product Plans (February 2007)

In late February 2007, NHTSA published a notice to acquire new and updated information regarding vehicle manufacturers' future product plans to aid in implementing the President's plan for reforming and increasing CAFE standards for passenger cars and further increasing the already reformed light truck standards. More specifically, the agency said:

> * * * we are seeking information related to fuel economy improvements for MY 2007-2017 passenger cars and MY 2010-2017 light trucks. The agency is seeking information in anticipation of obtaining statutory authority to reform the passenger car CAFE program and to set standards under that structure for MY 2010-2017 passenger cars. The agency is also seeking this information in anticipation of setting standards for MY 2012-2017 light trucks.\32\

\32\ 72 FR 8664; February 27, 2007.
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5. Supreme Court Decision in Massachusetts v. EPA (April 2007)

On April 2, 2007, the U.S. Supreme Court issued its opinion in Massachusetts v. EPA.\33\ The Court ruled that the state of Massachusetts had standing 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 portion of this harm was traceable to the absence of a regulation issued by EPA requiring reductions in GHG emissions (CO_2 emissions, most notably) by motor vehicles; and that issuance of such an EPA regulation by EPA would reduce the risk of further harm to Massachusetts. 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 EPA makes the necessary findings and determinations under section 202 of the Act.

\33\ 127 S.Ct. 1438 (2007).

The Court considered EPCA briefly, noting that it and the Clean Air Act have different overall purposes. It noted further that the two acts overlap, but did not define the nature or extent of that overlap. It concluded that EPCA did not relieve EPA of its statutory obligations and expressed confidence that the two acts could be consistently administered. The Court did not address the express preemption provision in EPCA.

6. Coordination Between NHTSA and EPA on Development of Rulemaking Proposals (Summer-Fall 2007)

In the wake of the Supreme Court's decision and in the 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 asked them ``to listen to public input, to carefully consider safety, science, and available technologies, and evaluate the benefits and costs before they put forth the new regulation.'' 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 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 proposals being published today are based on NHTSA's assessments of how they meet EPCA, as amended by EISA.

7. Ninth Circuit 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,\34\ 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. It cautioned, however, that it had not reviewed whether the agency's balancing of the statutory factors in setting those standards was arbitrary and capricious. In that regard, it noted that much had changed since a court of appeals had last (i.e., in the late 1980's) reviewed the agency's balancing of those factors in a rulemaking. Specifically, it noted increases in scientific knowledge of climate change

and in the need to reduce importation of petroleum since that time.

\34\ 508 F.3d 508.

Further, the Court found that NHTSA had been arbitrary and capricious in its treatment of the following issues:

NHTSA's decision not to monetize the benefit of reducing CO2 emissions and use that value in conducting its marginal benefit-cost analysis based on its view that the value of the benefit of CO2 emission reductions resulting from fuel consumption reductions was too uncertain to permit the agency to determine a value for those emission reductions;\35\

\35\ The agency has developed a value for those reductions and used it in the analyses underlying the standards proposed in this NPRM. For further discussion, see section V of this preamble.

NHTSA's decision not to establish a ``backstop'' (i.e., a fixed minimum CAFE standard applicable to manufacturers); \36\

\36\ EISA's requirement that standards be based on one or more vehicle attributes and its specification for domestic passenger cars, but not for nondomestic passenger cars or light trucks of an absolute CAFE level appear 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.

NHTSA's decision not to proceed 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; \37\

\37\ In this NPRM, NHTSA examines the legislative history of the statutory definitions of ``automobile'' and ``passenger automobile'' and the term ``nonpassenger automobile'' and analyses 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 VIII of this preamble.

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; \38\

\38\ 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.

NHTSA's limited assessment of cumulative impacts and regulatory alternatives in its Environmental Assessment (EA) under the National Environmental Policy Act (NEPA), and its decision to prepare and publish an EA, coupled with a finding of no significant impact, instead of an Environmental Impact Statement (EIS).\39\

\39\ On February 9, NHTSA filed a petition with the Ninth Circuit for rehearing en banc on the issue of whether the panel in CBD acted within its authority in ordering the agency to prepare an EIS instead of remanding the issue to the agency and directing it to conduct a new, fuller environmental analysis and decide whether an EIS is required. In addition, NHTSA has published a notice of intent to prepare an environmental impact statement, thus beginning the EIS process for this rulemaking, as discussed in Section XIII.B. of this NPRM.

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.\40\ Under the decision, the standards established by the April 2006 final rule would remain in effect unless and until amended by NHTSA.

\40\ 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 is sufficient time to gather all of the necessary information, conduct the necessary analyses and complete a rulemaking is MY 2011. As noted earlier in this document, however, EISA requires that a new standard be established for that model year. This rulemaking is being conducted pursuant to that requirement.

On February 6, 2008, the Government petitioned for en banc rehearing by the Ninth 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.

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

8. Enactment of 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).

C. Energy Policy and Conservation Act, as Amended

EPCA, which was enacted in 1975, mandates a motor vehicle fuel economy regulatory program to improve the nation's energy security and energy efficiency. It gives the authority under EPCA to regulate fuel economy to DOT, which has delegated that authority to NHTSA at 49 CFR 1.50. EPCA allocates the responsibility for implementing the program 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. We request comment on how EPCA should be implemented to achieve the goals and meet the requirements of EISA. For example, what assumptions, methodologies and computations should be used in establishing and implementing the new standards?

1. Vehicles Subject to Standards for Automobiles

With two exceptions, 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 \41\ and multi-stage vehicles. Work trucks are defined as vehicles that are:

\41\ 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.

--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).\42\

\42\ 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 lbs 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.\43\

\43\ 49 U.S.C. 32902(a)(3).

Under EPCA, as it existed before EISA, the agency had discretion whether to regulate vehicles with a GVWR between 6,000 and 10,000 lbs., 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 lbs. 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

As amended by EISA, EPCA requires that the agency establish standards for all new automobiles for each model year 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 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 model years 2011-2020, several special requirements, in addition to the maximum feasible requirement, are specified.\44\ Each of the requirements must be interpreted in light of the other requirements. For those model years, 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. The 35 mpg figure is not a standard applicable to any individual manufacturer. 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 MY 2020. 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 this level is achieved, the standard for MY 2020 passenger cars would have to be above 35 mpg and the one for MY 2020 light trucks might or might not be below 35 mpg. Similarly, the CAFE of some manufacturers' combined fleet of passenger cars and light trucks would be above 35 mpg, while the combined fleet of others might or might not be below 35 mpg. The standards for passenger cars and those for light trucks must increase ratably each year. 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 passenger cars for that model year.

\44\ Under EPCA, prior to its amendment by EISA, the standard for passenger cars was 27.5 mpg unless amended to a higher or lower level by DOT. Per EISA, the standard will remain at 27.5 mpg through MY 2010.

EPCA, as it existed before EISA, EPCA 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.

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'' means 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'' means 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.'' \45\ 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 expensive technologies are not likely to be accepted by consumers.

\45\ 67 FR 77015, 77021; December 16, 2002.

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.''\46\ 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 American roads, while protecting motor vehicle safety and the totality of American jobs and the overall United States economy.

\46\ CEI-I, 793 F.2d 1322, 1352 (DC Cir. 1986).

``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.\47\

\47\ 49 U.S.C. 32919 and 71 FR 17566, 17654-70; April 6, 2006.

``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,\48\ the agency defined the ``need of the Nation to conserve energy'' in the late 1970's as including ``the consumer cost, national balance of payments, environmental, and foreign policy implications of our need for large quantities of petroleum, especially imported petroleum.'' \49\ 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.\50\ In the late 1980's, 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 \51\ and for declining to reduce the standard for MY 1990 passenger cars.\52\ 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 \53\ and other information, NHTSA is monetizing the reductions in tailpipe emissions of CO2 that will result from the CAFE standards and is proposing to set the MY 2011-15 CAFE standards at levels that reflect the value of those reductions in CO2. as well as the value of other benefits of those standards. In setting CAFE standards, NHTSA also considers environmental impacts under NEPA, 42 U.S.C. 4321-4347.

\48\ Center for Auto Safety v. NHTSA, 793 F.2d 1322, 1325 n. 12 (DC Cir. 1986); Public Citizen v. NHTSA, 848 F.2d 256, 262-3 n. 27 (DC 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).

\49\ 42 FR 63,184, 63,188 (Dec. 15, 1977) (emphasis added).

\50\ 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.

\51\ 53 FR 39,275, 39,302; October 6, 1988.

\52\ 54 FR 21985,

\53\ The IPCC 2007 reports can be found at http://www.ipcc.ch/. (Last accessed April 20, 2008.)

In addition, the agency is permitted to consider additional relevant societal considerations. For example, historically, it has considered the potential for adverse safety consequences when deciding upon a maximum feasible level. This practice is sanctioned in case law.\54\

\54\ See, e.g., Center for Auto Safety v. NHTSA (CAS), 793 F. 2d 1322 (DC 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 (DC Cir. 1990).

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 35 mpg requirement for MY 2020. NHTSA interprets this 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.

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 II, 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

EPCA provides that NHTSA is to consult with the Department of Energy (DOE) and Environmental Protection Agency in prescribing CAFE standards. It provides further that NHTSA is to provide DOE with an opportunity to provide written comments on draft proposed and final CAFE standards.\55\

\55\ 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.

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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 \56\ to use the EPA test

procedures in place as of 1975 (or procedures that give comparable results), which are the city and highway tests of today, with adjustments for procedural changes that have occurred since 1975.

\56\ 49 U.S.C. 32904(c).

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 make up for the deficit in credits. NHTSA must examine and determine whether to approve the plan.

III. Fuel Economy Enhancing Technologies

In the Agency's last two rulemakings covering light truck CAFE standards for MYs 2005-2007 and MYs 2008-2011, the agency relied on the 2002 National Academy of Sciences' report, Effectiveness and Impact of Corporate Average Fuel Economy Standards (``the 2002 NAS Report'') \57\ for estimating potential fuel economy benefits and associated retail costs of applying combinations of technologies in 10 classes of production vehicles. The NAS cost and effectiveness numbers were the best available estimates at this time, determined by a panel of experts formed by the National Academy of Sciences, and the report had been 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 Council. However, since the publication of the 2002 NAS Report, there has been substantial advancement in fuel-saving technologies, including technologies not discussed in the NAS Report that are expected to appear on vehicles in the MY 2011-2015 timeframe. There also have been reports issued and studies conducted by several other organizations and companies that discuss fuel economy technologies and their benefits and costs. NHTSA has contracted with the NAS to update the fuel economy section, Chapter 3, of the 2002 NAS Report. However, this update will not be available in time for this rulemaking. Due to the expedited nature of this rulemaking, NHTSA, in consultation with the Environmental Protection Agency (EPA), developed an updated technology cost and effectiveness list to be used in this document.

\57\ 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 April 20, 2008).

This list presents NHTSA and EPA technical staff's current assessment of the costs and effectiveness from a broad range of technologies which can be applied to cars and light-duty trucks. EPA published the results of this collaboration in a report and submitted it to the NAS committee.\58\ A copy of the report and other studies used in the technology update will be placed in NHTSA's docket.

\58\ 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 believes that the estimates used for this document, which rely on the best available public and confidential information, are defensible and reasonable predictions for the next five years. Nevertheless, NHTSA still believes that the ideal source for this information comes from a peer reviewed process such as the NAS. NHTSA will continue to work with NAS to update this list on a five year interval as required by the Energy Independence and Security Act of 2007.

The majority of the technologies discussed in this section are in production and available on vehicles today, either in the United States, Japan, or Europe. A number of the technologies are commonly available, while others have only recently been introduced into the market. In a few cases, we provide estimates on technologies which are not currently in production, but are expected to be so in the next few years. These are technologies which can be applied to cars and trucks that are capable of achieving significant improvements in fuel economy and reductions in carbon dioxide emissions, and improve vehicle fuel economy, at reasonable costs.

NHTSA and EPA conducted the technology examination using concepts from the 2002 NAS report which constituted a starting point for the analysis. In the NAS Report, there were three exemplary technology paths or scenarios identified for each class of production vehicles, which lead to successively greater improvements in fuel consumption and greater costs. Path I included production-intent technologies that will be available within 10 years and could be implemented under current economic and regulatory conditions. Path II included more costly production-intent technologies that are technically feasible for introduction within 10 years if economic and regulatory conditions justify their use. Path III included emerging technologies that will be available within 10 to 15 years but that may require further development prior to commercial introduction. These three paths represented vehicle development steps that would offer increasing levels of fuel economy gains (as incremental gains) at incrementally increasing cost. As stated earlier, since the publication of the 2002 NAS Report, automotive technology has continued to advance and many of the technologies that were identified in the report as emerging have already entered the marketplace.

In this rulemaking, NHTSA in consultation with EPA have examined a variety of technologies, looking beyond path I and path II to path III and to emerging technologies beyond path III. These technologies were in their infancy when the 2002 NAS Report was being formulated. In addition, unlike for past rulemakings where NHTSA projected the use of different variants of a technology as a combined technology, in this rulemaking, NHTSA working with EPA examined advanced forms and subcategories of existing technologies and reflected the effectiveness and cost for each of the variants separately for all ten vehicle classes. The specific technologies affected are variable valve timing (VVT), variable valve lift and timing (VVLT) and cylinder deactivation. Manufacturers are currently using many different types of VVTs and VVLTs, which have a variety of different names and methods. This rulemaking employs specific cost and effectiveness estimates for variants of VVT, including Intake Camshaft Phasing (ICP), Coupled Camshaft Phasing (CCP), and Dual (Independent) Camshaft Phasing (DCP). It also employs specific cost and effectiveness estimates for variants of VVLT, including Discrete Variable Valve Lift (DVVL) and Continuous Variable Valve Lift (CVVL). We also now include the effectiveness and cost estimates for each of the variants of cylinder deactivation. The most common type of cylinder deactivation is one in which an eight-cylinder overhead

valve engine disables four of its cylinders under light loads. Cylinder deactivation could be incorporated on overhead cam engines, and can be applied to four and six cylinder engines as well (we have restricted application to 6 and 8 cylinder engines). Thus, the variants of cylinder deactivation that now have specific cost and effectiveness estimates include both overhead valve engine cylinder deactivation and overhead cam engine cylinder deactivation.

The update also revisited technology lead time issues and took a fresh look at technology application rates, how to link certain technologies to certain redesign and refresh patterns, synergistic impacts resulting from adding technology packaging, and learning costs.

A. Data Sources for Technology Assumptions

A large number of technical reports and papers are available which contain data and estimates of the fuel economy improvements of various vehicle technologies. In addition to specific peer-reviewed papers respecting individual technologies, we also utilized a number of recent reports which had been utilized by various State and Federal Agencies and which were specifically undertaken for the purpose of estimating future vehicle fuel economy reduction effectiveness or improvements in fuel economy. The reports we utilized most frequently were:

2002 National Academy of Science (NAS) report titled ``Effectiveness and Impact of Corporate Average Fuel Economy Standards''. At the time it was published, the NAS report was considered by many to be the most comprehensive summary of current and future fuel efficiencies improvements which could be obtained by the application of individual technologies. The focus of this report was fuel economy, which can be directly correlated with CO_2 emissions. The 2002 NAS report contains effectiveness estimates for ten different vehicle classifications (small car, mid-SUV, large truck, etc), but did not differentiate these effectiveness values across the classes. Where other sources or engineering principles indicated that a differentiation was warranted, we utilized the 2002 NAS effectiveness estimates as a starting point and further refined the estimate to one of the vehicle classes using engineering judgment or by consulting additional reliable sources.

2004 Northeast States Center for a Clean Air Future (NESCCAF) report ``Reducing Greenhouse Gas Emissions from Light-Duty Motor Vehicles''. This report, which was utilized by the California Air Resources Board for their 2004 regulatory action on vehicle CO_2 emissions, includes a comprehensive vehicle simulation study undertaken by AVL, a world-recognized leader in automotive technology and engineering. In addition, the report included cost estimates developed by the Martec Group, a market-based research and consulting firm which provides services to the automotive industry. The NESCCAF report considered a number of technologies not examined in the 2002 NAS report. In addition, through the use of vehicle simulation modeling, the 2004 NESCCAF report provides a scientifically rigorous estimation of the synergistic impacts of applying multiple fuel economy technologies to a given vehicle.

2006 Energy and Environmental Analysis Inc (EEA) report ``Technology to Improve the Fuel Economy of Light Duty Trucks to 2015'' Prepared for The U.S. Department of Energy and The U.S. Department of Transportation. This update of technology characteristics is based on new data obtained by EEA from technology suppliers and auto-manufacturers, and these data are compared to data from studies conducted earlier by EEA, the National Academy of Sciences (NAS), the Northeast States Center for a Clean Air future (NESCCAF) and California Air Resources Board (CARB).

Data from Vehicle Manufacturers, Component Suppliers, and other reports. We also evaluated confidential data from a number of vehicle manufacturers as well as a number of technology component suppliers. In February of 2007, the NHTSA published a detailed Request for Comment (RFC) in the Federal Register. This RFC included, among other items, a request for information from automotive manufacturers and the public on the fuel economy improvement potential of a large number of vehicle technologies. The manufacturer's submissions to this RFC were supplemented by confidential briefing and data provided by vehicle component suppliers, who for many of the technologies considered are the actual manufacturers of the specific technology and often undertake their own development and testing efforts to investigate the fuel economy improvement potential of their products. Manufacturers that provided NHTSA and EPA with fuel economy cost and effectiveness estimates include BMW, Chrysler, Ford, General Motors, Honda, Nissan, Toyota and Volkswagen. The major suppliers that provided NHTSA with fuel economy cost and effectiveness estimates include Borg-Warner, Bosch, Corning, Delphi, and Siemens.

Finally, to verify that the fuel economy cost and effectiveness estimates for each of the technologies was reasonable and within currently available estimates for these technologies, NHTSA examined those estimates provided by other reports or sources, such as the Martec (contained in the 2004 NESCAFF report) and Sierra Research reports.\59\

B. Technologies and Estimates of Costs and Effectiveness

This section describes each technology and associated cost and effectiveness numbers. The technologies can be classified into five main groups similar to how they were classified in the NAS Report: engine technologies; transmission technologies; accessory technologies; vehicle technologies; and hybrid technologies.

While NHTSA and EPA followed the general approach taken by the NAS in estimating the cost and effectiveness numbers, we decided to update some of these estimates to reflect better the changed marketplace and regulatory environment, as well as the advancement in and greater penetration of some production-intent and emerging technologies, which have led to lower costs. The values contained in the 2002 NAS report were used to establish a baseline for the fuel economy cost and effectiveness estimates for each of the technologies. We then examined all other estimates provided by manufacturers and major suppliers or other sources. In examining these values, we gave more weight to values or estimates provided by manufacturers that have already implemented these technologies in their fleet, especially those that have introduced them in the largest quantities. Likewise, for technologies that have not penetrated the fleet to date, but will by early in the next decade (according to confidential manufacturer plans), we gave more weight to values or estimates provided by manufacturers that have stated that they will be introducing these technologies in their fleet, especially those that plan to introduce them in the largest quantities. In addition, for the technologies that will appear on vehicles by early in the next decade, we carefully examined the values provided

by those suppliers who have developed these technologies and may have contracts in place to provide them to manufacturers.

Because not all technologies can be applied on all types of vehicles, engines or transmissions, we separately evaluated 10 classes of vehicles to estimate fuel economy cost and effectiveness for each of the technologies. As discussed above, these ten classes, also used in NHTSA's 2006 light truck CAFE rule, were derived from the 2002 NAS Report, which estimated the feasibility, potential incremental fuel consumption benefit and the incremental cost of three product development paths for the following ten vehicle classes: Subcompact passenger cars, compact passenger cars, midsize passenger cars, large passenger cars, small sport utility vehicles, midsize sport utility vehicles, large sport utility vehicles, small pickups, large pickups, and minivans.

\59\ ``Alternative and Future Technologies for Reducing Greenhouse Gas Emission from Road Vehicles'' Sierra Research Report for Environment Canada, 1999 (SR99-07-01). http://www.sierraresearch.com/ReportListing.htm (Last accessed April 20, 2008.)

The application of technologies to a vehicle class is limited not only by whether the manufacturer is capable of applying it within a particular development cycle, but also by whether the technology may physically be applied to the vehicle. For example, continuously variable transmissions (CVTs) were only allowed to be projected on vehicles with unibody construction, which includes all passenger cars and minivans and some small and midsize SUVs. CVTs could not be projected for use on vehicles with ladder-frame construction, which includes all pickups and large SUVs and some small and midsize SUVs. Another example is cylinder deactivation being limited to vehicles with 6- or 8-cylinder engines. To simplify the analysis, NHTSA assumed that each class of vehicles would typically have vehicle construction and engines with a specific number of cylinders that is most representative of that vehicle class.

Although we looked at ten vehicle classes separately, for some technologies the estimated incremental fuel consumption benefit and incremental cost were the same across all vehicle classes (as for engine accessory improvement), while for other technologies the estimated incremental fuel consumption benefit and incremental cost differed across classes (as for hybrid drivetrains). The main difference was with which path(s) each technology was expected to be associated.

The exact cost and benefit of a given technology depends on specific vehicle characteristics (size, weight, base engine, etc.) and the existence of additional technologies that were already applied to the vehicle. In the section below, ranges of incremental cost and fuel consumption reduction values are listed where the values depend on vehicle characteristics and are independent of the order in which they are applied to a vehicle. All costs, which are reflective of estimated retail price equivalents (RPEs) were inflated by the producer price index (if needed) and are presented in year 2006 dollars, because this is the last year for which final economic indexing is available. Some cost estimates are based on supplier costs. In those instances, multipliers were included in those costs so that they would be treated in the same manner as cost estimates that are based on manufacturer costs. These incremental values were calculated by subtracting out all same-path synergies associated with a given technology and any preceding items on the same path. Essentially, the incremental percent reduction in fuel consumption and cost impacts represent improvements beyond the ones realized due to technologies already applied to the vehicle. As an example, a 5-speed automatic transmission could incrementally reduce fuel consumption by 2 to 3 percent at an incremental cost of $75 to $165 per vehicle, relative to a 4-speed automatic transmission. In turn, a 6-speed automatic transmission could incrementally reduce fuel consumption by 4.5 to 6.5 percent at an incremental cost of $10 to $20 per vehicle, relative to a 5-speed transmission.

NHTSA acknowledges that this approach is different from the one it followed in establishing the reformed light truck standards for MYs 2008-2011, where we relied nearly exclusively on the 2002 NAS report's estimates. Our preference remains to rely upon peer-review and credible studies, such as the 2002 NAS report; however we believe that the estimates made by the joint EPA/NHTSA team are accurate and defensible. The agency seeks comments on our assumptions and the cost, effectiveness and availability estimates provided. NHTSA also seeks comments on whether the order in which these technologies was applied by the Volpe model is proper and whether we have accurately accounted for technologies already included on vehicles and whether we have accurately accounted for technologies that are projected to be applied to vehicles. The agency also seeks comments on the ``synergy'' factors (discussed below) it has applied in order to adjust the estimated incremental effectiveness of some pairs of technology and on whether similar adjustments to the estimated incremental cost of some technologies should be made. In preparation for a final rule, NHTSA intends to update its technology-related methodologies and estimates, and expects that these anticipated updates will affect the form and stringency of the final standards.

a. Engine Technologies

Low-Friction Lubricants

The use of lower viscosity engine and transmission lubricants can reduce fuel consumption. More advanced multi-viscosity engine and transmission oils are now available with improved performance in a wider temperature band, with better lubricating properties. However, even without any changes to fuel economy standards, 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. This may directionally benefit the fuel economy improvements of valvetrain technologies such as cylinder deactivation, which rely on a minimum oil temperature (viscosity) for operation. Most manufacturers therefore attributed smaller potential fuel economy reductions and cost increases to lubricant improvements.

The NAS Report estimated that low-friction lubricants could incrementally reduce fuel consumption by 1 percent at an incremental cost of $8 to $11.\60\ The NESCCAF study projected that low-friction lubricants could incrementally reduce fuel consumption by 1 percent at an incremental cost of $5 to $15; while the EEA report projected that low-friction lubricants could incrementally reduce fuel consumption by 1 percent at an incremental cost of $10 to $20. In contrast, manufacturer data projected an estimated fuel consumption potential of 0 percent to 1 percent at an incremental cost that ranged from $1 to $11, with many of them stating the costs as ranging from $1 to $5. NHTSA believes that these manufacturer estimates are more accurate and estimates that low-friction lubricants could reduce fuel consumption by 0.5 percent for all vehicle types at an incremental cost of $3, which represents the mid-point of $2.50, rounded up to the next dollar.

\60\ The price increases noted in this chapter are slightly higher than shown in the NAS study, since they have been converted into calendar year 2006 prices.

Reduction of Engine Friction Losses

All reciprocating and rotating components in the engine are candidates for friction reduction, and minute improvements in several

components can add to a measurable fuel economy improvement. The amount of energy an engine loses to friction can be reduced in a variety of ways. Improvements in the design of engine components and subsystems will result in friction reduction, improved engine operation, greater fuel economy and reduced emissions. Examples include low-tension piston rings, roller cam followers, crankshaft design, improved material coatings, material substitution, more optimal thermal management, piston surface treatments, and as lubricant friction reduction. Additionally, as computer-aided modeling software continues to improve, more opportunities for incremental friction reduction might become apparent. Even without any changes to fuel economy standards, most MY 2010-2015 vehicles are likely to employ one or more such techniques to reduce engine friction and other mechanical and hydrodynamic losses.

The NAS Report estimated that such technologies could incrementally reduce fuel consumption by 1 to 5 percent at an incremental cost of $36 to $146. NESCCAF predicted that such technologies could incrementally reduce fuel consumption by 0.5 percent at an incremental cost of $5 to $15; while the EEA report predicted that such technologies could reduce fuel consumption at an incremental cost of $10 to $55. Confidential manufacturer data indicates that engine friction reduction could incrementally reduce fuel consumption by 1 to 3 percent at an incremental cost of $0 to $168. Based on available information from these reports and confidential manufacturer data, NHTSA estimates that friction reduction could reduce fuel consumption for all vehicles by 1 to 3 percent at a cost of $21 per cylinder. Thus, the incremental cost of engine friction reduction for a 4-cylinder engine is $0 to $84 (applicable to subcompact and compact cars); for a 6-cylinder engine is $0 to $126 (applicable to midsize cars, large cars, small pickups, small SUVs, minivans and midsize SUVs); and for an 8-cylinder engine is $0 to $168 (applicable to large pickups and SUVs).

Multi-Valve Overhead Camshaft Engine

It appears likely that many vehicles would still use overhead valve (OHV) engines with pushrods and one intake and one exhaust valve per cylinder during the early part of the next decade. Engines with overhead cams (OHC) and more than two valves per cylinder achieve increased airflow at high engine speeds and reductions of the valve train's moving mass and enable central positioning of spark plugs. Such engines, which are already used in some light trucks, typically develop higher power at high engine speeds. The NAS Report projected that multi-valve OHC engines could incrementally reduce fuel consumption by 2 percent to 5 percent at an incremental cost of $109 to $146, and NHTSA found no sources to update these projections.

For purposes of this rule, OHV engines and OHC engines were considered separately, and the model was generally not allowed to apply multivalve OHC technology to OHV engines, except where continuous variable valve timing and lift (CVVL) is applied to OHV engines. In that case, the model assumes conversion to DOHC valvetrain, because DOHC valvetrains are prerequisites for the application of any advanced engine technology over and above CVVL. Since applying CVVL to an OHV is the last improvement that could be made to such an engine, it's logical to assume that manufacturers would redesign that engine as a DOHC and include CVVL as part of that redesign.

For 4-cylinder engines we estimated that the cost to redesign an OHV engine as a DOHC that includes CVVL would be $599 ($169 for conversion to DVVL, $254 for conversion to CVVL, and $176 for conversion to DOHC, which comprises an additional camshaft and valves), with estimated fuel consumption reduction of 2 to 3 percent. For 6-cylinder engines we estimated that the cost to redesign an OHV engine as a DOHC that includes CVVL would be $1262 ($246 for conversion to DVVL, $488 for conversion to CVVL, and $550 for conversion to DOHC, which comprises an additional camshaft and valves), with estimated fuel consumption reduction of 1 to 4 percent. For 8-cylinder engines we estimated that the cost to redesign an OHV engine as a DOHC that includes CVVL would be $1380 ($322 for conversion to DVVL, $508 for conversion to CVVL, and $550 for conversion to DOHC, which comprises an additional camshaft and valves), with estimated fuel consumption reduction of 2 to 3 percent. Incremental cost estimates for DVVL and CVVL are discussed below.

NHTSA believes that the NESCCAF report and confidential manufacturer data are more accurate, and thereby estimates that a conversion of an OHV engine to a DOHC engine with CVVL could incrementally reduce fuel consumption by 1 to 4 percent at an incremental cost of $599 to $1,380 compared to an OHV with VVT.

Cylinder Deactivation

For the vast majority of vehicles, each cylinder is always active while the engine is running. Under partial load conditions, the engine's specific fuel consumption could be reduced if some cylinders could be disabled, such that the active cylinders operate at higher load. In cylinder deactivation, some (usually half) of the cylinders are ``shut down'' during light load operation--the valves are kept closed, and no fuel is injected--as a result, the trapped air within the deactivated cylinders is simply compressed and expanded as an air spring, with minimal friction and heat losses. The active cylinders combust at almost double the load required if all of the cylinders were operating. Pumping losses are significantly reduced as long as the engine is operated in this ``part-cylinder'' mode.

The theoretical engine operating region for cylinder deactivation is limited to no more than roughly 50 percent of peak power at any given engine speed. In practice, however, cylinder deactivation is employed primarily at lower engine cruising loads and speeds, where the transitions in and out of deactivation mode are less apparent to the operator and where the noise and vibration (NVH) associated with fewer firing cylinders may be less of an issue. Manufacturers are exploring the possibilities of increasing the amount of time that part-cylinder mode might be suitable to a vehicle with more refined powertrain and NVH treatment strategies.

General Motors and Chrysler Group have incorporated cylinder deactivation across a substantial portion of their V8-powered lineups. Honda (Odyssey, Pilot) and General Motors (Impala, Monte Carlo) offer V6 models with cylinder deactivation.

There are two variants of cylinder deactivation. The most common type of cylinder deactivation is one in which an eight-cylinder overhead valve engine disables four cylinders under light loads. Thus an eight-cylinder engine could disable four cylinders under light loads, such as when the vehicle is cruising at highway speed. This technology could be applied to four and six cylinder engines as well. General Motors and Chrysler Group have incorporated cylinder deactivation across a substantial portion of their V8-powered overhead valve lineups.

Cylinder deactivation could be incorporated on overhead cam engines and can be applied to four and six cylinder engines as well. Honda has already begun offering three V6 models

with cylinder deactivation (Accord, Odyssey, and Pilot) and GM will soon release cylinder deactivation on its 3.9L 6-cylinder engine. Fuel economy improvement potential scales roughly with engine displacement-to-vehicle weight ratio: the higher displacement-to-weight vehicles, operating at lower relative loads for normal driving, have the potential to operate in part-cylinder mode more frequently.

Honda's technology includes the use of active engine mounts and noise damping amongst other items added to its V6 engines with cylinder deactivation. This, of course, increases the cost relative to a four or eight cylinder OHC engine.

Some manufacturers are getting results in excess of 6 percent and most are at the high end of the range. This higher number is supported by official fuel economy test data on a V6 Honda Odyssey with cylinder deactivation compared to the same vehicle (and engine displacement) without cylinder deactivation and by confidential manufacturer information.

The NAS Report projected that cylinder deactivation could incrementally reduce fuel consumption by 3 percent to 6 percent at an incremental cost of $112 to $252. The NESCCAF study projected that cylinder deactivation could incrementally reduce fuel consumption by 1.7 percent to 4.2 percent at an incremental cost of $161 to $210; while the EEA report projected that cylinder deactivation could incrementally reduce fuel consumption by 5.2 percent to 7.2 percent at an incremental cost of $105 to $135. Confidential manufacturer data and official fuel economy test data indicates that cylinder deactivation could incrementally reduce fuel consumption by at least 6 percent at an incremental cost of $203 to $229. NHTSA believes that these manufacturer estimates are more accurate and thus estimates that cylinder deactivation could reduce fuel consumption by 4.5 percent to 6 percent at an incremental cost of $203 to $229.

Variable Valve Timing

Variable valve timing 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 residual gases. 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.

Variable valve timing has been available in the market for quite a while. By the early 1990s, VVT had made a significant market penetration with the arrival of Honda's ``VTEC'' line of engines. 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 valve timing. Therefore, the degree of further improvement across the fleet is limited to vehicles that have not already implemented this technology.

Manufacturers are currently using many different types of variable valve timing, which have a variety of different names and methods. The major types of VVT are listed below:

Intake Camshaft Phasing (ICP)

Valvetrains with ICP--the simplest type of cam phasing--can modify the timing of the intake valve while the exhaust valve timing remains fixed. This requires the addition of a cam phaser for each bank of intake valves on the engine. An in-line 4-cylinder engine has one bank of intake valves, while V-configured engines would have two banks of intake valves. The NAS Report projected that ICP could incrementally reduce fuel consumption by 3 percent to 6 percent at an incremental cost of $35; while the EEA report projected that ICP could reduce fuel consumption at an incremental cost of $35. The NESCCAF study projected that ICP could incrementally reduce fuel consumption by 1 percent to 2 percent at an incremental cost of $49. Consistent with the EEA report and NESCCAF study, we have used this $35 manufacturer cost to arrive at incremental cost of $59 per cam phaser or $59 for an in-line 4 cylinder and $119 for a V-type, thus NHTSA estimates that ICP could incrementally reduce fuel consumption by 1 to 2 percent at an incremental cost of $59 to $119.

Coupled Camshaft Phasing (CCP)

Coupled (or coordinated) cam phasing is a design in which both the intake and exhaust valve timing are varied with the same cam phaser. For an overhead cam engine, the same phaser added for ICP would be used for CCP control. As a result, its costs should be identical to those for ICP. For an overhead valve engine, only one phaser would be required for both inline and V-configured engines since only one camshaft exists. Therefore, for overhead valve engines, the cost is estimated at $59 regardless of engine configuration, using the logic provided for ICP.

The NESCCAF study projected that CCP could incrementally reduce fuel consumption by 1 percent to 3 percent above that obtained by ICP. Confidential manufacturer data also projects that that CCP could incrementally reduce fuel consumption by 1 percent to 3 percent above that obtained by ICP. According to the NESCCAF report and confidential manufacturer data, NHTSA estimates that CCP could incrementally reduce fuel consumption by 1 to 3 percent at an incremental cost of $59 to $119 above ICP valvetrains.

Dual (Independent) Camshaft Phasing (DCP)

The most flexible VVT design is dual cam phasing, where the intake and exhaust valve opening and closing events are controlled independently. This design allows the option of controlling valve overlap, which can be used as an internal EGR strategy. Our estimated incremental compliance cost for this technology is built upon that for VVT-ICP where an additional cam phaser is added to control each bank of exhaust valves less the cost to the manufacturer of the removed EGR valve. The incremental compliance cost for a 4-cylinder engine is estimated to be $59 for each bank of valves, plus an estimated piece cost of $30 for the valves, for a total incremental compliance cost of $89. The incremental compliance cost for a V6 or a V8 engine is estimated to be $59 for each bank of intake valves (i.e., two banks times $59/bank = $119), $59 for each bank of exhaust valves (i.e., another $119) minus an estimated $29 incremental compliance cost for the removed EGR valve; the total incremental compliance cost being $209.

According to the NESCCAF report and confidential manufacturer data, it is estimated that DCP could incrementally reduce fuel consumption by 1 to 3 percent at an incremental cost of $89 to $209 compared to engines with ICP or CCP.

Because ICP and CCP have the same cost and similar effectiveness, it is assumed that manufacturers will choose the technology that best fits the specific engine architecture and application.

Variable Valve Lift and Timing

Some vehicles have engines for which both valve timing and lift can be at least partially optimized based on engine operating conditions. Engines with variable valve timing and lift (VVLT) can achieve further reductions in pumping losses and further increases in thermal efficiency. Controlling the lift

height of the valves provides additional flexibility and potential for further fuel consumption reduction. By reducing the valve lift, engines can decrease the volumetric flow at lower operating loads, improving fuel-air mixing and in-cylinder mixture motion which results in improved thermodynamic efficiency and also potentially reduced overall valvetrain friction. Also, by moving the throttling losses further downstream of the throttle valve, the heat transfer losses that occur from the throttling process are directed into the fresh charge-air mixture just prior to compression, delaying the onset of knock-limited combustion processes. At the same time, such systems may also incur increased parasitic losses associated with their actuation mechanisms.

The NAS report projected that VVLT could incrementally reduce fuel consumption by 1 to 2 percent over VVT alone at an incremental cost of $73 to 218.

Manufacturers are currently using many different types of variable valve lift and timing, which have a variety of different names and methods. The major types of VVLT are listed below:

Discrete Variable Valve Lift

Discrete variable valve lift (DVVL) is a method in which the valvetrain switches between multiple cam profiles, usually 2 or 3, for each valve. These cam profiles consist of a low and a high-lift lobe, and may include an inert or blank lobe to incorporate cylinder deactivation (in the case of a 3-step DVVL system). According to the NESCCAF report and confidential manufacturer data, it is estimated that DVVL could incrementally reduce fuel consumption by 0.5 to 3 percent at an incremental cost of $169 to $322 compared to VVT depending on engine size and overhead cam versus overhead valve engines. Included in this cost estimate is $25 for controls and associated oil supply needs (these costs not reflected in the NESCCAF study). We also project that a single valve lifter could control valve pairs, thus engines with dual intake and/or dual exhaust valves would require only one lifter per pair of valves. Due to this, the estimated costs for applying DVVL to overhead cam and overhead valve engines are the same.

Continuous Variable Valve Lift

Continuous variable valve lift (CVVL) employs a mechanism that varies the pivot point in the rocker arm. This design is realistically limited to overhead cam engines. Currently, BMW has implemented this type of system in its Valvetronic engines, which employs fully flexible valve timing to allow an extra set of rocker arms to vary the valve lift height. CVVL enables intake valve throttling in engines, which allows for the use of more complex systems of sensors and electronic controls to enable further optimization of valve lift.

The NESCCAF study projected incremental costs from $210 to $420, depending on vehicle class, while the EEA report projected incremental costs of $180 to $350, depending on vehicle class. Confidential manufacturer data projects that CVVL could incrementally reduce fuel consumption by 1.5 by 4 percent at an incremental cost of $200 to $515. NHTSA believes that these manufacturer estimates are more accurate than NESCCAF estimates, thus it gives more weight to them. According to the NESCCAF report and confidential manufacturer data, NHTSA estimates that CVVL could incrementally reduce fuel consumption by 1.5 by 4 percent at an incremental cost of $254 to $508 compared to VVT with cost estimates varying from $254, $466, and $508 for a 4-, 6-, and 8-cylinder engine, respectively.

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.

Camless valvetrains have been under research for many decades due to the design flexibility and the attractive fuel economy improvement potential they might provide. Despite the promising features of camless valvetrains, significant challenges remain. High costs and design complexity have reduced manufacturers' enthusiasm for camless engines in light of other competing valvetrain technologies. The advances in VVT, VVLT, and cylinder deactivation systems demonstrated in recent years have reduced the potential efficiency advantage of camless valvetrains.

The NAS Report projected that camless valve actuation could incrementally reduce fuel consumption by 5 to 10 percent over VVLT at an incremental cost of $336 to $673. Confidential manufacturer information provides incremental fuel consumption losses that range from 2 to 10 percent at costs that range from $300 to $1,100. The NESCCAF study projected that camless valve actuation could incrementally reduce fuel consumption by 11 to 13 percent at an incremental cost of $805 to $1,820; while the EEA report projected that camless valve actuation could incrementally reduce fuel consumption by 10 to 14 percent at an incremental cost of $210 to $600. These benefits and costs are believed to be incremental to engines with VVT.

In reviewing our sources for costs, we have determined that the adjusted costs presented in the 2002 NAS study, which ranged from $336 to $673--depending on vehicle class--represent the best available estimates. Subtracting out the improvements associated with the application of VVLT provides an estimated fuel consumption reduction of 2.5 percent.

Stoichiometric Gasoline Direct Injection Technology

Gasoline direct injection (GDI, or SIDI) engines inject fuel at high pressure directly into the combustion chamber (rather than the intake port in port fuel injection). Direct injection improves cooling of the air/fuel charge within the cylinder, which allows for higher compression ratios and increased thermodynamic efficiency. Injector design advances and increases in fuel pressure have promoted better mixing of the air and fuel, enhancing combustion rates, increasing exhaust gas tolerance and improving cold start emissions. GDI engines achieve higher power density and match well with other technologies, such as boosting and variable valvetrain designs.

Several manufacturers (Audi, BMW, and Volkswagen) have recently released GDI engines while General Motors and Toyota will be introducing GDI engines. In addition, BMW and GM have announced their plans to dramatically increase the number of GDI engines in their portfolios.

The NESCCAF report projected that the incremental cost for GDI of $189 to $294; while the EEA report projected an incremental cost of $77 to $135. Confidential manufacturer data provides data with higher upper end costs than these estimates, with incremental fuel consumption estimates ranging from 1

to 2 percent. For our analysis, we have estimated the costs of individual components of a GDI system and used a ``bottom up'' approach looking at incremental costs for injectors, fuel pumps, etc., to arrive at system incremental compliance costs ranging from $122 to $420 for small cars and up to $228 to $525 for large trucks. The lower end of the ranges represents our best estimate using a bottom up approach while the upper end of the ranges represent levels more consistent with the manufacturer CBI submittals. As a result, we estimate that stoichiometric GDI could incrementally reduce fuel consumption by 1 to 2 percent at an incremental cost of $122 to $525 compared to engines of similar power output.

Gasoline Engine Turbocharging and Engine Downsizing

The specific power of a naturally aspirated engine is limited, in part, by the rate at which the engine is able to draw air into the combustion chambers. Turbocharging and supercharging are two methods to increase the intake manifold pressure and cylinder charge-air mass above naturally aspirated levels. By increasing the pressure differential between the atmosphere and the charging cylinders, superchargers and turbochargers increase this available airflow, and thus increase the specific power level, and with it the ability to reduce engine size while maintaining performance. This effectively reduces the pumping losses at lighter loads in comparison to a larger, naturally aspirated engine, while at the same time reducing net friction losses

Almost every major manufacturer currently markets a vehicle with some form of boosting. While boosting has been a common practice for increasing performance for several decades, it has considerable fuel economy potential when the engine displacement is reduced. Specific power levels for a boosted engine often exceed 100 hp/L--compared to average naturally aspirated engine power density of roughly 70 hp/L. As a result, engines can conservatively be downsized roughly 30 percent to achieve similar peak output levels.

In the last decade, improvements to turbine design have improved their reliability and performance across the entire engine operating range. New variable geometry turbines spool up to speed faster (eliminating the once-common ``turbo lag'') while maintaining high flow rates for increased boost at high speeds.

Turbocharging and downsizing involve the addition of a boost system, removal of two cylinders in most cases (from an 8-cylinder to a 6, or a 6 to a 4) and associated valves, and the addition of some form of cold start control system (e.g., air injection) to address possible cold start emission control. The NAS Report projected that turbocharging and downsizing could incrementally reduce fuel consumption by 5 to 7 percent at an incremental cost of $364 to $582. The EEA report projected turbocharging and downsizing could incrementally reduce fuel consumption by 5.2 to 7.8 percent.

In developing estimated costs for turbocharging and downsizing an engine, NHTSA, in conjunction with EPA, relied upon piece cost estimates contained in the NESCCAF report. The cost estimates provided by the NESCCAF report are as follows: $600 for the turbocharger and associated parts; $90 for an air injection pump and associated parts (each turbocharger requires an air injection pump); $75 per cylinder and associated components; $15 per each valve and associated components; and $150 per camshaft.

In developing the cost estimates for each of the 10 classes of vehicles, we determined the most logical type of downsizing that would occur for each class and starting with the turbocharger and air injector cost, either added or deleted cost, depending on the situation. For subcompact and compact cars, we determined that the downsizing wouldn't involve the removal of any cylinders, valves and camshafts, but instead would result in a manufacturer using a smaller displacement 4-cylinder engine and adding the turbocharger and the air injector to the smaller engine. Thus, for subcompact and compact cars, we estimated the cost of turbocharging and downsizing to be $690 ($600 for the turbocharger plus $90 for the air injector).

For large trucks and large SUVs we determined that the most logical engine downsizing would involve replacing an 8-cylinder overhead valve engine with a turbocharged 6-cylinder dual overhead cam engine. This change would result in the removal of 2 cylinders, and the addition of a turbocharger, an air injector, 8 valves and 2 camshafts. Thus, we have estimated the cost of turbocharging and downsizing to be $810 ($600 for the turbocharger plus $90 for the air injector, plus $120 for eight valves plus $150 for a camshaft and minus $150 for the removal of two cylinders).

For midsize cars, large cars, small trucks, small SUVs, midsize SUVs and minivans, we determined that the most logical engine downsizing would involve replacing a 6-cylinder dual overhead cam engine with a turbocharged 4-cylinder dual overhead cam engine. This change would result in the removal of 2 cylinders, 8 valves and 2 camshafts and the addition of a turbocharger and air injector. Thus, we have estimated the cost of turbocharging and downsizing to be $120 ($600 for the turbocharger plus $90 for the air injector, minus $150 for the removal of two cylinders, minus $120 for the removal of eight valves and minus $300 for the removal of two camshafts).

Thus, we have estimated the cost for a boosted/downsized engine system at $690 for small cars, $810 for large trucks, and $120 for other vehicle classes. Projections of the fuel consumption reduction potential of a turbocharged and downsized engine from the NAS Report are backed by EEA estimates and confidential manufacturer data. According to the NAS Report, the EEA report, cost estimates developed in conjunction with EPA and confidential manufacturer data, NHTSA estimates that downsized turbocharged engines could incrementally reduce fuel consumption from 5 to 7.5 percent at an incremental cost of $120 to $810.

Diesel Engine

Diesel engines have several characteristics that give them superior fuel efficiency to conventional gasoline, spark-ignited engines. Pumping losses are greatly reduced 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 typically at much higher torque levels than an equivalent-displacement gasoline engine. 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. However, diesel engines have emissions characteristics that present challenges to meeting Tier 2 emissions standards.

Compliance strategies are expected to include a combination of combustion improvements and after-treatment. Several key advances in diesel technology have made it possible to reduce emissions coming from the engine (prior to after-treatment). 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 to reduce NOX, lower

compression ratios and advanced turbocharging systems.

For after-treatment, the traditional 3-way catalyst found on gasoline-powered vehicles is ineffective due to the lean-burn combustion of a diesel. All diesels will require a particulate filter, an oxidation catalyst, and a NOX reduction strategy to comply with Tier 2 emissions standards.

The NOX reduction strategies most common are outlined below:

Lean NOX Trap Catalyst After-Treatment

A lean NOX trap (LNT) operates, in principle, by storing NOX (NO and NO2) when the engine is running in its normal (lean) state. When the control system determines (via mathematical model or a NOX sensor) that the trap is saturated with NOX, it switches to a rich operating mode. This rich mode produces excess hydrocarbons that act as a reducing agent to convert the stored NOX to N2 and water, thereby ``regenerating'' the LNT and opening up more locations for NOX to be stored. LNTs are sensitive to sulfur deposits which can reduce catalytic performance, but periodically undergo a desulfation engine operating mode to clean it of sulfur buildup.

According to confidential manufacturer data, NHTSA estimates that LNT-based diesels can incrementally reduce fuel consumption by 8 to 15 percent at an incremental cost of $1,500 to $1,600 compared to a direct injected turbocharged and downsized internal combustion engine. These costs are 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.

Selective Catalytic Reduction NOX After-Treatment

SCR uses a reductant (typically, ammonia derived from urea) continuously injected into the exhaust stream ahead of the SCR catalyst. Ammonia combines with NOX in the SCR catalyst to form N2 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 there is no required rich engine operating mode prescribed for NOX reduction, the urea is typically injected at a rate of 3 to 4 percent of that of fuel consumed. Manufacturers designing SCR systems are intending to align urea tank refills with standard maintenance practices such as oil changes. Incremental fuel consumption reduction estimates for diesel engines with an SCR system range from 11 to 20 percent at an incremental cost of $2,051 to $2,411 compared to a direct injected turbocharged and downsized internal combustion engine. These costs are 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.

Based on public information and on recent discussions that NHTSA and EPA have had with auto manufacturers and aftertreatment device manufacturers, NHTSA has 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 primary reason given for this choice is the trade off between the rhodium needed for the LNT and the urea injection system needed for SCR. The breakeven point between these two cost factors appears to occur around 3.0 liters. Thus, it is believed that it is cheaper to manufacture diesel engines smaller than 3.0 liters with an LNT system, and that conversely, it is cheaper to manufacture diesel engines larger than 3.0 liters with a SCR system. Of course, there are other factors that influence a manufacturer's decision on which system to use, but we have used this rule-of-thumb for our analysis.

b. Transmission Technologies

Five-, Six-, Seven-, and Eight-Speed Automatic Transmissions

The number of available transmission speeds influences the width of gear ratio spacing and overall coverage and, therefore, the degree of transmission ratio optimization available under different operating conditions. In general, transmissions can offer a greater available degree of engine optimization and can therefore achieve higher fuel economy when the number of gears is increased. However, potential gains may be reduced by increases in transmission weight and rotating mass. Regardless of possible changes to fuel economy standards, manufacturers are increasingly introducing 5- and 6-speed automatic transmissions on their vehicles. Additionally, some manufacturers are introducing 7-, and 8-speed automatic transmissions, with 7-speed automatic transmissions appearing with increasing frequency.

Automatic 5-Speed Transmissions

As automatic transmissions have been developed over the years, more forward speeds have been added to improve fuel efficiency and performance. Increasing the number of available ratios provides the opportunity to optimize engine operation under a wider variety of vehicle speeds and load conditions. Also, additional gears allow for overdrive ratios (where the output shaft of the transmission is turning at a higher speed than the input shaft) which can lower the engine speed at a given road speed (provided the engine has sufficient power at the lower rpm point) to reduce pumping losses. However, additional gears can add weight, rotating mass, and friction. Nevertheless, manufacturers are increasingly adding 5-speed automatic transmissions to replace 3- and 4-speed automatic transmissions.

The 2002 NAS study projected that 5-speed automatic transmissions could incrementally reduce fuel consumption by 2 to 3 percent at an incremental cost of $76 to $167. The NESCCAF study projected that 5-speed automatic transmissions could incrementally reduce fuel consumption by 1 percent at an incremental cost of $140; while the EEA report projected that 5-speed automatic transmissions could incrementally reduce fuel consumption by 2 to 3 percent at an incremental cost of $130. Confidential manufacturer data projected that 5-speed automatic transmissions could incrementally reduce fuel consumption by 1 to 6 percent at an incremental cost of from $60 to $281. NHTSA believes that the NAS study's estimates are still valid and estimates that 5-speed automatic transmissions could incrementally reduce fuel consumption by 2.5 percent at an incremental cost of $76 to $167 (relative to a 4-speed automatic transmission).

Automatic 6-, 7-, and 8-Speed Transmissions

In addition to 5-speed automatic transmissions, manufacturers can also choose to utilize 6-, 7-, or 8-speed automatic transmissions. Additional ratios allow for further optimization of engine operation over a wider range of conditions, but this is subject to diminishing returns as the number of speeds increases. As additional planetary gear sets are added (which may be necessary in some cases to achieve the higher number of ratios), additional weight and friction are introduced. Also, the additional shifting of such a transmission can be perceived as bothersome to some consumers, so manufacturers need to develop strategies for smooth shifts. Some manufacturers are replacing 4-speed automatics with 6-speed automatics (there are also increasing numbers of 5-speed automatic transmissions that are

being replaced by 6-speed automatic transmissions), and 7-, and 8-speed automatics have entered production, albeit in lower-volume applications.

The NAS study projected that 6-, 7- or 8-speed transmissions could incrementally reduce fuel consumption by 1 to 2 percent at an incremental cost of $70 to $126. Confidential manufacturer data projected that 6-, 7-or 8-speed transmissions could incrementally reduce fuel consumption by 1 to 3 percent at an incremental cost of $20 to $120. However, according to the EEA report, a Lepelletier gear set design provides for 6-speeds at the same cost as a 5-speed automatic. Based on that analysis, we have estimated the cost of a 6-speed automatic to be equivalent to that for a 5-speed automatic. We have not developed any estimate costs for 7-or 8-speed transmissions because of the diminishing returns in efficiency versus the costs for transmissions beyond 6-speeds. NHTSA estimates that 6-, 7-, or 8-speed automatic transmissions could incrementally reduce fuel consumption by 0.5 to 2.5 percent at an incremental cost of $0 to $20 (relative to a 5-speed automatic transmission). We are estimating up to an additional $20 in costs because we have tried to account for the engineering effort in addition to the hardware which we believe the EEA did not and we wanted to capture some of the higher costs reported by manufacturers.

Aggressive Shift Logic

In operation, an automatic transmission's controller decides when to upshift or downshift based on a variety of inputs such as vehicle speed and throttle position according to programmed logic. Aggressive shift logic (ASL) can be employed so that a transmission is engineered in such a way as to maximize fuel efficiency by upshifting earlier and inhibiting downshifts under some conditions. Through partial lock-up under some operating conditions and early lock-up under others, automatic transmissions can achieve some reduction in overall fuel consumption. Aggressive shift logic is applicable to all vehicle types with automatic transmissions, and since in most cases it would require no significant hardware modifications, it can be adopted during vehicle redesign or refresh or even in the middle of a vehicle's product cycle. The application of this technology does, however, require a manufacturer to confirm that driveability, durability, and noise, vibration, and harshness (NVH) are not significantly degraded.

The NAS study projected that aggressive shift logic could incrementally reduce fuel consumption by 1 to 2 percent at an incremental cost of $0 to $70. Confidential manufacturer data projected that aggressive shift logic could incrementally reduce fuel consumption by 0.5 to 3 percent at an incremental cost of $18 to $70. The NAS study estimates and confidential manufacturer data are within the same ranges, thus NHTSA believes that the NAS estimates are still accurate. Thus, NHTSA estimates aggressive shift logic could incrementally reduce fuel consumption by 1 to 2 percent at an incremental cost of $38, which is approximately the average of the midpoint of the NAS cost range and the manufacturer cost range.

Early Torque Converter Lockup

A torque converter is a fluid coupling located between the engine and transmission in vehicles with automatic transmissions and continuously-variable transmissions (CVTs). This fluid coupling allows for slip so the engine can run while the vehicle is idling in gear, provides for smoothness of the powertrain, and also provides for torque multiplication during acceleration. During light acceleration and cruising, this slip causes increased fuel consumption, so modern automatic transmissions utilize a clutch in the torque converter to lock it and prevent this slippage. Fuel consumption can be further reduced by locking up the torque converter early, and/or by using partial-lockup strategies to reduce slippage.

Some torque converters will require upgraded clutch materials to withstand additional loading and the slipping conditions during partial lock-up. As with aggressive shift logic, confirmation of acceptable driveability, performance, durability and NVH characteristics is required to successfully implement this technology.

The 2002 NAS study did not include any estimates for this technology. The NESCCAF study projected that early torque converter lockup could incrementally reduce fuel consumption by 0.5 percent at an incremental cost of $0 to $10; while the EEA report projected that low-friction lubricants could incrementally reduce fuel consumption by 0.5 percent at an incremental cost of $5. NHTSA estimates the cost of this technology (i.e., the calibration effort) at $30 based in part on NESCCAF and the CBI submissions which provided costs with a midpoint of $30. We have used a higher value here than NESCCAF and EEA because we have tried to account for the engineering effort in addition to the hardware which we believe NESCCAF and EEA did not do and which were captured in the manufacturers' higher costs.

NHTSA estimates that early torque converter lockup could incrementally reduce fuel consumption by approximately 0.5 percent at an incremental cost of approximately $30.

Automated Shift Manual Transmissions

An automated manual transmission (AMT) is mechanically similar to a conventional transmission, but shifting and launch functions are controlled by the vehicle. There are two basic types of AMTs, single-clutch and dual-clutch. A single-clutch AMT is essentially a manual transmission with automated clutch and shifting. Because there are some shift quality issues with single-clutch designs, dual-clutch AMTs are more common. A dual-clutch AMT uses separate clutches for the even-numbered gears and odd-numbered gears. In this way, the next expected gear is pre-selected, which allows for faster and smoother shifting.

Overall, AMTs likely offer the greatest potential for fuel consumption reduction among the various transmission options presented in this report because they offer the inherently lower losses of a manual transmission with the efficiency and shift quality advantages of computer control. AMTs offer the lower losses of a manual transmission with the efficiency advantages of computer control. The lower losses stem from the elimination of the conventional lock-up torque converter and a greatly reduced need for high pressure hydraulic circuits to hold clutches to maintain gear ratios (in automatic transmissions) or hold pulleys in position to maintain gear ratio (in continuously variable transmissions, discussed below). However, the lack of a torque converter will affect how the vehicle launches from rest, so an AMT will most likely be paired with an engine that offers enough torque in the low-RPM range to allow for adequate launch performance.

An AMT is mechanically similar to a conventional manual transmission, but shifting and launch functions are controlled by the vehicle rather than the driver. A switch from a conventional automatic transmission with torque converter to an AMT incurs some costs but also allows for some cost savings. Savings can be realized through elimination of the torque converter which is a very costly part of a traditional automatic transmission, and through reduced need for high pressure hydraulic circuits to hold clutches (to maintain gear ratios in automatic transmissions) or hold pulleys (to maintain gear ratios in Continuously

Variable Transmissions). Cost increases would be incurred in the form of calibration efforts since transmission calibrations would have to be redone, and the addition of a clutch assembly for launce and gear changes.

The NESCCAF study projected that AMTs could incrementally reduce fuel consumption by 5 to 8 percent at an incremental cost of $0 to $280; while the EEA report projected that low-friction lubricants could incrementally reduce fuel consumption by 6 to 7 percent at an incremental cost of $195 to $225. Confidential manufacturer data projected that AMTs could incrementally reduce fuel consumption by 2 to 5 percent at an incremental cost of $70 to $400.

Taking all these estimates into consideration, NHTSA estimates that AMTs could incrementally reduce fuel consumption by 4.5 to 7.5 percent at an incremental cost of approximately $141. We believe that, overall, the hardware associated with an AMT, whether single clutch or dual clutch, is no more costly than that for a traditional automatic transmission given the savings associated with removal of the torque converter and high pressure hydraulic circuits, which is estimated to amount to at least $30. Nonetheless, given the need for engineering effort (e.g., calibration and vehicle integration work) when transitioning from a traditional automatic to an AMT, we have estimated the incremental compliance cost at $141, independent of vehicle class, which is the midpoint of the NESCCAF estimates and within the range provided confidential manufacturer data.

Continuously Variable Transmission

A Continuously Variable Transmission (CVT) is unique in that it does not use gears to provide ratios for operation. Unlike manual and automatic transmissions with fixed transmission ratios, CVTs provide, within their operating ranges, fully variable transmission ratios with an infinite number of gears. This enables even finer optimization of the transmission ratio under different operating conditions and, therefore, some reduction of pumping and engine friction losses. CVTs use either a belt or chain on a system of two pulleys.

The main advantage of a CVT is that the engine can operate at its most efficient point more often, since there are no fixed ratios. Also, CVTs often have a wider range of ratios than conventional automatic transmissions.

The most common CVT design uses two V-shaped pulleys connected by a metal belt. Each pulley is split in half and a hydraulic actuator moves the pulley halves together or apart. This causes the belt to ride on either a larger or smaller diameter section of the pulley which changes the effective ratio of the input to the output shafts.

It is assumed that CVTs will only be used on cars, small SUVs, midsize crossover vehicles and minivans because they are currently used mainly in lower-torque applications. While a high-torque CVT could be developed for small pickup trucks and large pickup trucks and large SUVs, it would likely have to be treated separately in terms of effectiveness. We do not see development in the area of high-torque CVTs and therefore did not include this type in our analysis.

The 2002 NAS study projected that CVTs could incrementally reduce fuel consumption by 4 to 8 percent at an incremental cost of $140 to $350. The NESCCAF study projected that CVTs could incrementally reduce fuel consumption by 4 percent at an incremental cost of $210 to $245. Confidential manufacturer data projected that CVTs could incrementally reduce fuel consumption by 3 to 9 percent at an incremental cost of $140 to $800. These values are incremental to a 4-speed transmission.

Based on an aggregation of manufacturers' information, we estimate a CVT benefit of about 6 percent over a 4-speed automatic. This is above the NESCCAF value, but in the range of NAS. In reviewing our sources for costs, we have determined that the adjusted costs presented in the 2002 NESCCAF study represent the best available estimates. Subtracting the estimated fuel consumption reduction and costs of replacing a 4-speed automatic transmission with a 5-speed automatic transmission results in NHTSA's projecting that CVTs could incrementally reduce fuel consumption by 3.5 percent when compared to a conventional 5-speed automatic transmission at an incremental cost of $100 to $139.

Manual 6-, 7-, and 8-Speed Transmissions

As with automatic transmissions, 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 at a given speed. Typically, this is achieved through adding additional overdrive ratios to reduce engine speed (which saves fuel through reduced pumping losses). Six-speed manual transmissions have already achieved significant market penetration, so manufacturers have considerable experience with them and the associated costs. For those vehicles with five-speed manual transmissions, an upgrade to a six-speed could incrementally reduce fuel consumption by 0.5 percent. Based on CBI submissions, which provided costs with a midpoint of $107, NHTSA estimates that 6-speed manual transmissions could incrementally reduce fuel consumption by 0.5 percent when compared to 5-speed automatic transmission at an incremental cost of $107.

c. Vehicle Technologies

Rolling Resistance Reduction

Tire characteristics (e.g., materials, construction, and tread design) influence durability, traction control, vehicle handling, and comfort. They also influence rolling resistance--the 30 frictional losses associated mainly with the energy dissipated in the deformation of the tires under load--and therefore, CO_2 emissions. This technology is applicable to all vehicles, except for body-on-frame light trucks and performance vehicles (described in the next section). Based on a 2006 NAS/NRC report, a 10 percent rolling resistance reduction would provide an increase in fuel economy of 1 to 2 percent. The same report estimates a $1 per tire cost for low rolling resistance tires. For four tires, our incremental compliance cost estimate is $6 per vehicle, independent of vehicle class, although not applicable to large trucks.

Low Drag Brakes

Low drag brakes reduce the sliding friction of disc brake pads on rotors when the brakes are not engaged because the brake shoes are pulled away from the rotating drum. While most passenger cars have already adopted this technology, there are indications that this technology is still available for body-on-frame trucks. According to confidential manufacturer data, low drag brakes could incrementally reduce fuel consumption by 1 to 2 percent at an incremental cost of $85 to $90. NHTSA has adopted these values for its analysis.

Front or Secondary Axle Disconnect for Four-Wheel Drive Systems

To provide shift-on-the-fly capabilities, many part-time four-wheel drive systems use some type of axle disconnect: Front axle disconnect in ladder-frame vehicles, and secondary (i.e., either front or rear) axle disconnect in unibody vehicles. Front and secondary axle disconnects serve two basic purposes. Using front axle

disconnect as an example, in two-wheel drive mode, the technology disengages the front axle from the front driveline so the front wheels do not turn the front driveline at road speed, saving wear and tear. Then, when shifting from two- to four-wheel drive ``on the fly'' (while moving), the front axle disconnect couples the front axle to the front differential side gear only when the transfer case's synchronizing mechanism has spun the front driveshaft up to the same speed as the rear driveshaft.

Four-wheel drive systems that have axle disconnect typically do not have either manual- or automatic-locking hubs. To isolate (for example) 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.

This technology has been used by ladder-frame vehicles for some time, but has only started to appear on unibody vehicles recently. The incremental costs and benefits of applying front axle disconnect differ, depending on the vehicle's type of construction. According to confidential manufacturer data, front axle disconnects for ladder frame vehicles could achieve incremental fuel consumption reductions of 1.5 percent at an incremental cost of $114, while secondary axle disconnects for unibody vehicles could achieve incremental fuel consumption reductions of 1 percent at an incremental cost of $676. NHTSA has adopted these estimates for its analysis.

Aerodynamic Drag Reduction

A vehicle's size and shape determine the amount of power needed to push the vehicle through the air at different speeds. Changes in vehicle shape or frontal area can therefore reduce CO2 emissions. Areas for potential aerodynamic drag improvements include skirts, air dams, underbody covers, and more aerodynamic side view mirrors. NHTSA and EPA estimate a fleet average of 20 percent total aerodynamic drag reduction is attainable for passenger cars, whereas a fleet average of 10 percent reduction is more realistic for trucks (with a caveat for ``high-performance'' vehicles, described below). These drag reductions equate to increases in fuel economy of 2 percent and 3 percent for trucks and cars, respectively. These numbers are in agreement with the technical literature and supported by confidential manufacturer information. The CBI submittals generally showed the RPE associated with these changes at less than $100. NHTSA and EPA estimate that the incremental compliance cost to range from $0 to $75, independent of vehicle class.

Aerodynamic drag reduction technologies are readily available today, although the phase-in time required to distribute over a manufacturer's fleet is relatively long (6 years or so).

Weight Reduction

The term weight reduction encompasses a variety of techniques with a variety of costs and lead times. These include lighter-weight materials, higher strength materials, component redesign, 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 on-going process to reduce costs and/or weight of components, while improving performance and reliability. An example would be a subsystem replacing multiple components and mounting hardware.

The cost of reducing weight is difficult to determine and is dependent 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.

For purposes of this proposed rule, NHTSA has considered only vehicles weighing greater than 5,000 pounds for weight reduction through materials substitution. Provided that those vehicles remain above 5,000 pounds weight, vehicles may realize up to roughly 2 percent incremental fuel consumption through materials substitution (corresponding to a 3 percent reduction in vehicle weight) at incremental costs of $0.75 to $1.25 per pound reduced.

d. Accessory Technologies

Electric Power Steering

Electric power steering (EPS) is advantageous over hydraulic steering in that it only draws power when the wheels are being turned, which is only a small percentage of a vehicle's operating time. EPS may be implemented on many vehicles with a standard 12V system; however, for heavier vehicles, a 42V system may be required, which adds cost and complexity.

The NAS study projected that a 12V EPS system could incrementally reduce fuel consumption by 1.5 to 2.5 percent at an incremental cost of $105 to $150. The NESCCAF study projected that a 12V EPS could incrementally reduce fuel consumption by 1 percent at an incremental cost of $28 to $56; while the EEA report projected that a 12V EPS could incrementally reduce fuel consumption by 1.5 to 1.9 percent at an incremental cost of $70 to $90. According to confidential manufacturer data, electric power steering could achieve incremental fuel consumption reductions of 1.5 to 2.0 percent at an incremental cost of $118 to $197.

NHTSA believes that these manufacturer estimates are more accurate and thus estimates that a 12V EPS system could incrementally reduce fuel consumption by 1.5 to 2 percent at an incremental cost of $118 to $197, independent of vehicle class.

Engine Accessory Improvement

The accessories on an engine, like the alternator, coolant, and oil pumps, are traditionally driven by the accessory belt. Improving the efficiency or outright electrification (12V) of these accessories (in the case of the mechanically driven pumps) would provide an opportunity to reduce the accessory loads on the engine. However, the potential for such replacement will be greater for vehicles with 42V electrical systems. Some large trucks also employ mechanical fans, some of which could also be improved or electrified. Additionally, there are now higher efficiency alternators which require less of an accessory load to achieve the same power flow to the battery.

According to the NAS Report engine accessory improvement could achieve incremental fuel consumption reductions of 1 to 2 percent at an incremental cost of $124 to $166. Confidential manufacturer information is also within these ranges. The NESCCAF study estimated a cost of $56, but that estimate included only a high efficiency generator and did not include electrification of other accessories. In reviewing our sources for costs, we have determined that the adjusted costs presented in the 2002 NAS study, which ranged from $124 to $166--depending on vehicle class--represent the best available estimates. Based on the NAS study and confidential manufacturer information, NHTSA estimates that accessory improvement could incrementally reduce fuel consumption by 1 to 2 percent at an incremental cost of $124 to $166.

Forty-Two Volt (42V) Electrical System

Most vehicles today (aside from hybrids) operate on 12V electrical systems. At higher voltages, which appear to be under consideration to meet expected increases in on-board electrical demands, the power density of motors, solenoids, and other electrical components may increase to the point that new and more efficient systems, such as electric power steering, may be feasible. A 42V system can also accommodate an integrated starter generator. According to the NAS Report, 42V engine accessory improvement could achieve incremental fuel consumption reductions of 1 to 2 percent at an incremental cost of $194 to $259. According to confidential manufacturer data, a 42V system could achieve incremental fuel consumption reductions of 0 to 4 percent at an incremental cost of $62 to $280.

We believe that the state of 42V technology has evolved to where it is on par with the incremental costs and benefits of 12V engine accessory improvement. In reviewing our sources, we have determined that the numbers provided in the 2002 NAS study, which estimated that engine accessory improvement could achieve incremental fuel consumption reductions of 1 to 2 percent at an incremental cost of $124 to $166--depending on vehicle class--represent the best available estimates for both 12V and 42V systems. Thus, we are estimating that a 42V electrical system could achieve incremental fuel consumption reductions of 1 to 2 percent at an incremental cost of $124 to $166. These estimates are independent of vehicle class and exclusive of improvements to the efficiencies or electrification of 12V accessories. These estimates are incremental to a 12V system, regardless of whether the 12V system has improved efficiency or not.

e. Hybrid Technologies

A hybrid describes a vehicle that combines two or more sources of propulsion energy, where one uses a consumable fuel (like gasoline) and one is rechargeable (during operation, or by another energy source). Hybrids reduce fuel consumption through three major mechanisms: by optimizing the operation of the internal combustion engine (through downsizing, or other control techniques) to operate at or near its most efficient point more of the time; by recapturing lost braking energy and storing it for later use; and by turning off the engine when it is not needed, such as when the vehicle is coasting or when stopped.

Hybrid vehicles utilize some combination of the above three mechanisms to reduce fuel consumption. The effectiveness of a hybrid depends on the utilization of the above mechanisms and how aggressively they are pursued. Different hybrid concepts utilize these mechanisms differently, so they are treated separately in this analysis. Below is a discussion of the major hybrid concepts judged to be available for use within the timeframe of this rulemaking.

Integrated Starter-Generator With Idle-Off

Integrated Starter-Generator (ISG) systems are the most basic of hybrid systems and offer mainly idle-stop capability. They offer the least power assist and regeneration capability of the hybrid approaches, but their low cost and easy adaptability to existing powertrains and platforms can make them attractive for some applications. ISG systems operate at around 42V and so have smaller electric motors and less battery capacity than other HEV designs because of their lower power demand.

ISG systems replace the conventional belt-driven alternator with a belt-driven, higher power starter-alternator. The starter-alternator starts the engine during idle-stop operation, but often a conventional 12V gear-reduction starter is retained to ensure cold-weather startability. 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 added. These components are similar to those that would be used in other hybrid designs. An ISG system could be capable of providing some launch assist, but it would be limited in comparison to other hybrid concepts. According to the NAS Report, an EEA report and confidential manufacturer data, ISG systems could achieve incremental fuel consumption reductions that range from 5 to 10 percent.

In addition, when idle-off is used (i.e., the petroleum fuelled engine is shut off during idle operation), an electric power steering and auxiliary transmission pump are added to provide for functioning of these systems which, in a traditional vehicle, were powered by the petroleum engine. The 2002 NAS study estimated the cost of these systems at $210 to $350 with a 12V electrical system and independent of vehicle class, while the NESCCAF study estimated the cost for these systems at $280 with a 12 Volt electrical system for a small car. The 2002 NAS study estimated the cost of these systems to be $210 to $350 with a 12 volt electrical system and independent of vehicle class, while the NESCCAF study estimated the cost for these systems of $280 with a 12 volt electrical system for a small car. Confidential manufacturer information provides cost estimates for ISGs that range from $418 to $800. We believe that the NAS and the NESCCAF estimates are still accurate for ISGs with a 12V system. Thus, if you add these cost estimates to those we estimated for 42V systems plus associated equipment, which results an estimated incremental compliance cost of these systems, including the costs associated with upgrading to a 42 volt electrical system of $563 to $600, depending on vehicle class.

Therefore, NHTSA estimates that ISG systems could achieve incremental fuel consumption reductions of 5 to 10 percent at incremental costs of $563 to $600, depending on vehicle class (this includes the costs associated with upgrading to a 42 volt electrical system).

Integrated Motor Assist (IMA)/Integrated Starter-Alternator-Dampener (ISAD) Hybrid

Honda is the only manufacturer that uses Integrated Motor Assist (IMA), which utilizes a thin axial electric motor bolted to the engine's crankshaft and connected to the transmission through a torque converter or clutch. This electric motor 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 the electrical system's main generator. Since it is rigidly fixed to the engine, if the motor turns, the engine must turn also, but combustion does not necessarily need to occur. The Civic Hybrid uses cylinder deactivation on all four cylinders for decelerations and some cruise conditions.

The main advantage of the IMA system is that it is relatively low cost and adapts readily to conventional vehicles and powertrains, while providing excellent efficiency gains. Packaging space is a concern for the physically longer engine-motor-transmission assembly as well as the necessary battery pack, cabling and power electronics. According to EPA test data and confidential manufacturer data, the IMA system could achieve incremental fuel consumption reductions of 3.5 to 8.5 percent.\61\ NHTSA has adopted these estimates for its analysis.

\61\ The cost estimates are protected as confidential business information.

The 2002 NAS study did not consider this technology while the NESCCAF study estimated the cost for these systems at $2,310 to $2,940 for a small car and large car, respectively. We have used these estimates combined with confidential manufacturer data as the basis for our incremental compliance costs of $1,636 for the small car and $2,274 for the large car, expressed in 2006 dollars. We have not estimated incremental compliance costs for the other vehicle classes because we do not believe those classes would use this technology and would, instead, use the hybrid technologies discussed below.

2-Mode Hybrids

GM, DaimlerChrysler, and BMW have formed a joint venture to develop a new HEV system based on HEV transmission technology originally developed by GM's Allison Transmission Division for heavy-duty vehicles like city buses. This technology 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 Toyota's Power Split design, 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 for heavy-duty applications and fuel economy at highway speeds. According to confidential manufacturer data, 2-mode hybrids could achieve incremental fuel consumption reductions of 25 to 40 percent. NHTSA estimates that 2-mode hybrids could achieve fuel reductions of 3.5 percent to 7 percent incremental to an Integrated Motor Assist (IMA)/ Integrated Starter-Alternator-Dampener (ISAD) Hybrid.

The 2002 NAS study did not consider this technology, while the NESCCAF study estimated the costs to range from $4,340 to $5,600, depending on vehicle class. These estimates are not incremental to an Integrated Motor Assist (IMA)/Integrated Starter-Alternator-Dampener (ISAD) Hybrid. To accurately project the cost of 2-mode hybrids when they were applied to midsize and large cars, we subtracted the estimated costs of an Integrated Motor Assist (IMA)/Integrated Starter-Alternator-Dampener (ISAD) Hybrid. We have used the NESCCAF estimates as the basis for our incremental compliance costs of $1,501 to $5,127 in 2006 dollars, incremental to an Integrated Motor Assist (IMA)/ Integrated Starter-Alternator-Dampener (ISAD) Hybrid or an ISG system depending on vehicle class.\62\ We have not estimated incremental compliance costs for small cars because we believe that this ISG or IMA/ISAD technology is a better fit for small cars.

\62\ GM's cost estimates are protected as confidential business information.

Power Split Hybrid

Toyota's Hybrid Synergy Drive system as used in the Prius is a completely different approach than Honda's IMA system and uses a ``Power Split'' device in place of a conventional transmission. The Power Split system replaces the vehicle's transmission with a single planetary gear and a motor/generator. A second, more powerful motor/generator is permanently connected to the vehicle's final drive and always turns with the wheels. The planetary gear splits the engine's torque between the first motor/generator and the drive motor. The first motor/generator uses its engine torque to either charge the battery or supply additional power to the drive motor. 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 completely independently of vehicle speed, much like a CVT.

The Power Split system allows for outstanding fuel economy in city driving. The vehicle also avoids the cost of a conventional transmission, replacing it with a much simpler single planetary and motor/generator. However, it is less efficient at highway speeds due to the requirement that the first motor/generator must be constantly spinning at a relatively high speed to maintain the correct ratio. Also, load capacity is limited to the first motor/generator's capacity to resist the reaction torque of the drive train.

A version of Toyota's Power Split system is also used in the Lexus RX400h and Toyota Highlander sport utility vehicles. This version has more powerful motor/generators to handle higher loads and also adds a third motor/generator on the rear axle of four-wheel-drive models. This provides the vehicle with four wheel drive capability and four wheel regenerative braking capability. Ford's eCVT system used in the hybrid Escape is another version of the Power Split system, but four-wheel-drive models use a conventional transfer case and drive shaft to power the rear wheels.

Other versions of this system are used in the Lexus GS450h and Lexus LS600h luxury sedans. These systems have modifications and additional hardware for sustained high-speed operation and/or all-wheel-drive capability. However, the Power Split system isn't planned for usage on full-size trucks and SUVs due to its limited ability to provide the torque needed by these vehicles. It's anticipated that full-size trucks and SUVs would use the 2-mode hybrid system. The 2002 NAS study didn't consider this technology, while the NESCCAF study estimated the incremental costs at to be $3,500 prior to any cost adjustment. Based on the NESCCAF study and fuel economy test data from EPA's certification database which shows these systems being capable of reducing fuel consumption by 25 to 35 percent, NHTSA estimates that Power Split hybrids can achieve incremental fuel consumption reductions of 25 to 35 percent over conventionally powered vehicles at an incremental cost of $3,700 to $3,850. Because NHTSA applies technologies incrementally to the technologies preceding them on our decision trees, the incremental fuel consumption reductions for Power Split hybrids are estimated to be 5 to 6.5 percent incremental to 2-Mode Hybrids (the technology that precedes Power Split hybrids on the decision tree), because the technologies applied prior to and including 2-Mode hybrids are estimated to have incremental fuel consumption reductions of 20 to 28.5 percent over conventionally powered vehicles. The technologies discussed below were not projected for use during the MY 2011 to 2015 timeframes because NHTSA isn't aware that any manufacturer is including these technologies in any vehicle for which we have production plans for nor has any manufacturer publicly stated that any of these technologies will definitively be included on future products. If NHTSA receives such information regarding one or more technologies, it will revisit this decision for the final rule. NHTSA is including its discussion of these technologies and their estimated costs and fuel consumption reductions as a reference for commenters and in anticipation of their possible inclusion in the final rule.

Variable Compression Ratio

A spark-ignited engine's specific power is limited by the engine's compression ratio, which is, in turn, currently limited by the engine's susceptibility to knock, particularly under high load conditions. Engines with variable compression ratio (VCR) improve fuel economy by the use of higher compression ratios at lower loads and lower compression ratios under higher loads. The NAS Report projected that VCR could incrementally reduce

fuel consumption by 2 to 6 percent over 4-valve VVT at an incremental cost of $218 to $510. NHTSA has no information which suggests that VCR will be included on any vehicles during the MY 2011-2015 timeframe, thus NHTSA does not use this technology in its analysis. Additionally, no updates to these estimates were sought.

Lean-Burn Gasoline Direct Injection Technology

One way to improve dramatically an engine's thermodynamic efficiency 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 NOX after-treatment, lean-burn GDI engines may be a possibility in North America. However, a key technical requirement for lean-burn GDI engines to meet EPA's Tier 2 NOX emissions levels is the availability of low-sulfur gasoline, which is projected to be unavailable during MY 2011-2015.

According to the NESCCAF report and confidential manufacturer data NHTSA estimates that lean-burn GDI engines could incrementally reduce fuel consumption from 9 to 16 percent at an incremental cost of $500 to $750 compared to a port-fueled (stoichiometric) engine. NHTSA did not project the use of this technology during the time frame covered by this proposal, due to large uncertainties surrounding the availability of low-sulfur gasoline. Nonetheless, we have estimated the incremental compliance cost for these systems at $750, independent of vehicle class, and incremental to a stoichiometric GDI engine.

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.

An HCCI engine has inherent advantages in its overall efficiency for several reasons. An extremely lean fuel/air charge increases thermodynamic efficiency. Shorter combustion times and higher EGR tolerance permit very high compression ratios (which also increase thermodynamic efficiency). Additionally, pumping losses are reduced because the engine can run unthrottled.

However, due to the nature of its combustion process, HCCI is difficult to control, requiring in-cylinder pressure sensors and very fast engine control logic to optimize combustion timing, especially considering the variable nature of operating conditions seen in a vehicle. To be used in a commercially acceptable vehicle application, an HCCI-equipped engine would most likely be ``dual-mode,'' in which HCCI operation is complemented with a traditional SI combustion process at idle and at higher loads and speeds.

Until recently, HCCI technology was considered to still be in the research phase. However, several manufacturers have made public statements about the viability of incorporating HCCI into production vehicles over the next 10 years. The NESCCAF study estimated the cost to range from $560 to $840, depending on vehicle class, including the costs for a stoichiometric GDI system with DVVL. We have based our estimated incremental compliance cost on the NESCCAF estimates and, after subtracting out the estimated incremental cost for a stoichiometric GDI system with DVVL, we estimate the incremental cost for HCCI to be from $263 to $685, depending on vehicle class. This estimated incremental compliance cost is incremental to a stoichiometric GDI engine.

According to the NESCCAF report and confidential manufacturer data, NHTSA estimates that gasoline HCCI/GDI dual-mode engines could incrementally reduce fuel consumption from 10 to 12 percent at an incremental cost of $233 to $606, compared to a comparable GDI engine.

Advanced CVT

Advanced CVTs have the ability to deliver higher torques than existing CVTs and have the potential for broader market penetration. These new designs incorporate toroidal friction elements or cone-and-ring assemblies with varying diameters. According to the NAS Report, advanced CVT could incrementally reduce fuel consumption by up to 2 percent at an incremental cost of $364 to $874. NHTSA has no information which suggests that VCR will be included on any vehicles during the MY 2011-2015 timeframe, thus NHTSA does not use this technology in its analysis. Additionally, no updates to these estimates were sought.

Plug-in Hybrids

Plug-In Hybrid Electric Vehicles (PHEVs) are very similar to hybrid electric vehicles, but with three significant functional differences. The first is the addition of a means to charge the battery pack from an outside source of electricity (usually the electric grid). Second, a PHEV would have a larger battery pack with more energy storage, and a greater capability to be discharged. Finally, a PHEV would have a control system that allows the battery pack to be significantly depleted during normal operation.

Deriving some of their propulsion energy from the electric grid provides several advantages for PHEVs. PHEVs offer a significant opportunity to replace petroleum used for transportation energy with domestically-produced electricity. The reduction in petroleum usage does, of course, depend on the amount of electric drive the vehicle is capable of under its duty cycle.

The fuel consumption reduction potential of PHEVs depends on many factors, the most important being the electrical capacity designed into the battery pack. To estimate the fuel consumption reduction potential of PHEVs, EPA has developed an in-house vehicle energy model (PEREGRIN) which is based on the PERE (Physical Emission Rate Estimator) physics-based model used as a fuel consumption input for EPA's MOVES mobile source emissions modelB.

EPA modeled the PHEV small car, large car, minivan and small trucks using parameters from a midsize car similar to today's hybrids and scaled to each vehicle's weight. The large truck PHEV was modeled separately assuming very little engine downsizing. Each PHEV was assumed to have enough battery capacity for a 20-mile-equivalent all-electric range and a power requirement to provide similar performance to a hybrid vehicle. A twenty mile range was selected because it offers a good compromise for vehicle performance, weight, battery packaging and cost.

To calculate the total energy use of a PHEV, a vehicle can be thought of as operating in two distinct modes, electric (EV) mode, and hybrid (HEV) mode. The energy consumed during EV operation can be accounted for and calculated in terms of gasoline-equivalent MPG by using 10CFR474, Electric and Hybrid Vehicle Research, Development, and Demonstration Program; Petroleum-Equivalent Fuel Economy Calculation. The EV mode fuel economy can then be combined with the HEV mode fuel economy using the Utility Factor calculation in SAE J1711 to determine a total MPG value for the vehicle. Calculating a total fuel consumption reduction based on model outputs, gasoline-equivalent calculations, and the Utility Factor calculations, results in a 28 percent fuel consumption reduction for small cars, large cars, minivans, and small trucks and a 31 percent fuel consumption reduction for large trucks.

The fuel consumption reduction potential of PHEVs will vary based on the electrical capacity designed into the battery pack. Assuming a 20-mile ``all-electric range'' design, a PHEV might incrementally reduce fuel consumption by 28 to 31 percent.\63\ Based on discussions with EPA, we have estimated the incremental cost of PHEVs to be from $4,500 to $10,200, depending on vehicle class.

\63\ This estimate is based on the EPA test cycle. We are unable to provide cost estimates for PHEV technology due to the great amount of uncertainty in deciding the appropriate battery chemistry to be used.

However, all indications suggest that any PHEVs that may be available within the time frame of this rulemaking will be concept vehicles and not production vehicles. Additionally, NHTSA is unaware of the existence of any batteries that are deemed acceptable for the performance characteristics necessary for a plug-in hybrid. Therefore, although we discuss them here, the model does not apply them.

NHTSA would like to note that if it receives new and/or updated information from manufacturers regarding the likelihood of PHEV production during the MY 2011 to 2015 timeframe, it will make every effort to include PHEVs as a technology in its final rule. To enable the possible inclusion of PHEVs as a technology, NHTSA would also have to configure the Volpe model to account for the estimated source(s) that would supply the electricity for electrical grid charging of the battery. Work has started on this effort, but has not yet been completed.

Tables III-1 through III-3 below summarize for each of the 10 classes of vehicles the cost and effectiveness assumptions used in this rulemaking as well as the year of availability of each technology. The agency seeks comments on our assumptions and the cost and effectiveness estimates provided.

Table III-1.--Technology Cost Estimates

Technologies	Vehicle technology incremental retail price equivalent per vehicle ($) by vehicle class									
	Subcompact car	Compact car	Midsize car	Large car	Small pickup	Small SUV	Minivan	Midsize SUV	Large pickup	Large SUV
Low friction lubricants--incremental to base engine	3	3	3	3	3	3	3	3	3	3
Engine friction reduction--incremental to base engine	0-84	0-84	0-126	0-126	0-126	0-126	0-126	0-126	0-168	0-168
Overhead Cam Branch	....	....	....	....	....	....	....	....	....	....
VVT--intake cam phasing	59	59	119	119	119	119	119	119	119	119

VVT--coupled cam phasing	59	59	119	119	119	119	119	119	119	119
VVT--dual cam phasing	89	89	209	209	209	209	209	209	209	209
Cylinder deactivation	n.a.	n.a.	203	203	203	203	203	203	229	229
Discrete VVLT	169	169	246	246	246	246	246	246	322	322
Continuous VVLT	254	254	466	466	466	466	466	466	508	508
Overhead Valve Branch	....	....	....	....	....	....	....	....	....	....
Cylinder deactivation	n.a.	n.a.	203	203	203	203	203	203	229	229
VVT--coupled cam phasing	59	59	59	59	59	59	59	59	59	59
Discrete VVLT	169	169	246	246	246	246	246	246	322	322
Continuous VVLT (includes conversion to Overhead Cam)	599	599	1262	1262	1262	1262	1262	1262	1380	1380
Camless valvetrain (electromagnetic)	336-673	336-673	336-673	336-673	336-673	336-673	336-673	336-673	336-673	336-673
GDI--stoichiometric	122-420	122-420	204-525	204-525	204-525	204-525	204-525	204-525	228-525	228-525
GDI--lean burn	750	750	750	750	750	750	750	750	750	750
Gasoline HCCI dual-mode	263	263	390	390	390	390	390	390	685	685
Turbocharge & downsize	690	690	120	120	120	120	120	120	810	810
Diesel--Lean NOX trap	1586	1586	....	....	....	....	....	....	....	....
Diesel--urea SCR	....	....	2051	2051	2411	2411	2126	2411	2261	2261
Aggressive shift logic	38	38	38	38	38	38	38	38	38	38
Early torque converter lockup	30	30	30	30	30	30	30	30	30	30
5-speed automatic	76-167	76-167	76-167	76-167	76-167	76-167	76-167	76-167	76-167	76-167
6-speed automatic	76-187	76-187	76-187	76-187	76-187	76-187	76-187	76-187	76-187	76-187
6-speed AMT	141	141	141	141	141	141	141	141	141	141
6-speed manual	107	107	107	107	107	107	107	107	107	107
CVT	100	100	139	139	n.a.	139	139	139	n.a.	n.a.
Stop-Start with 42 volt system	563	563	600	600	600	600	600	600	600	600
IMA/ISA/BSG (includes engine downsize)	1636	1636	2274	2274	n.a	n.a	n.a	n.a	n.a	n.a
2-Mode hybrid electric vehicle	n.a.	n.a.	4655	4655	4655	4655	4655	4655	6006	6006
Power-split hybrid electric vehicle (P-S HEV)	3700-3850	3700-3850	3700-3850	3700-3850	3700-3850	3700-3850	3700-3850	3700-3850	....	....
Plug-in hybrid electric vehicle (PHEV)	4500	4500	6750	6750	6750	6750	6750	6750	10200	10200
Improved high efficiency alternator & electrification of accessories (12 volt)	124-166	124-166	124-166	124-166	124-166	124-166	124-166	124-166	124-166	124-166
Electric power steering (12 or 42 volt)	118-197	118-197	118-197	118-197	118-197	118-197	118-197	118-197	118-197	118-197
Improved high efficiency alternator & electrification of accessories (42 volt)	124-166	124-166	124-166	124-166	124-166	124-166	124-166	124-166	124-166	124-166

Aero drag reduction (20% on cars, 10% on trucks)..	0-75	0-75	0-75	0-75	0-75	0-75	0-75	0-75	0-75	0-75
Low rolling resistance tires (10%)...............	6	6	6	6	6	6	6	6	....	....
Low drag brakes (ladder frame only)..............	....	....	....	....	87	87	....	87	87	87
Secondary axle disconnect (unibody only)..........	676	676	676	676	676	676	676	676	....	....
Front axle disconnect (ladder frame only).........	....	....	....	....	114	114	....	114	114	114
Weight reduction (1%)--above 5,000 lbs only.......	....	....	....	....	....	....	....	....	\1\	\1\
Weight reduction (2%)--incremental to 1%..........	....	....	....	....	....	....	....	....	\1\	\1\

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Weight reduction (3%)--incremental to 2%..........	....	....	....	....	....	....	....	....	\2\	\2\

\1\ 2/pound.
\2\ 3/pound.

Table III-2.--Technology Percent Effectiveness Estimates

Technologies	Vehicle technology incremental fuel consumption reduction (%) by vehicle class									
	Subcompact car	Compact car	Midsize car	Large car	Small pickup	Small SUV	Minivan	Midsize SUV	Large pickup	Large SUV
Low friction lubricants--incremental to base engine..	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Engine friction reduction--incremental to base engine..	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3
Overhead Cam Branch										
VVT--intake cam phasing..........................	2	2	1	1	1	1	1	1	2	2
VVT--coupled cam phasing.........................	1	1	3	3	2	2	1	1	2	2
VVT--dual cam phasing............................	1	1	3	3	1	1	1	1	2	2
Cylinder deactivation............................	n/a	n/a	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
Discrete VVLT....................................	3	3	1.5	1.5	1.5	1.5	0.5	0.5	1.5	1.5
Continuous VVLT..................................	4	4	3.5	3.5	2.5	2.5	1.5	1.5	2.5	2.5
Overhead Valve Branch										
Cylinder deactivation............................	n/a	n/a	6	6	6	6	6	6	6	6
VVT--coupled cam phasing.........................	3	3	2.5	2.5	1.5	1.5	0.5	0.5	2.5	2.5
Discrete VVLT....................................	1.5	1.5	1.5	1.5	1.5	1.5	0.5	0.5	1.5	1.5
Continuous VVLT (includes conversion to Overhead Cam)..	2.5	2.5	3.5	3.5	2.5	2.5	1.5	1.5	2.5	2.5

Camless valvetrain (electromagnetic)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
GDI--stoichiometric	1-2	1-2	1-2	1-2	1-2	1-2	1-2	1-2	1-2	1-2
GDI--lean burn	--	--	--	--	--	--	--	--	--	--
Gasoline HCCI dual-mode	10-12	10-12	10-12	10-12	10-12	10-12	10-12	10-12	10-12	10-12
Turbocharge & Downsize	5.0-7.5	5.0-7.5	5.0-7.5	5.0-7.5	5.0-7.5	5.0-7.5	5.0-7.5	5.0-7.5	5.0-7.5	5.0-7.5
Diesel--Lean NOx trap	11.5	11.5	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Diesel--urea SCR	n/a	n/a	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5
Aggressive shift logic	1-2	1-2	1-2	1-2	1-2	1-2	1-2	1-2	1-2	1-2
Early torque converter lockup	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
5-speed automatic	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
6-speed automatic	0.5-2.5	0.5-2.5	0.5-2.5	0.5-2.5	0.5-2.5	0.5-2.5	0.5-2.5	0.5-2.5	0.5-2.5	0.5-2.5
6-speed AMT	4.5-7.5	4.5-7.5	4.5-7.5	4.5-7.5	4.5-7.5	4.5-7.5	4.5-7.5	4.5-7.5	4.5-7.5	4.5-7.5
6-speed manual	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
CVT	3.5	3.5	3.5	3.5	n/a	3.5	3.5	3.5	n/a	n/a
Stop-Start with 42 volt system	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
IMA/ISA/BSG (includes engine downsize)	8.5	8.5	3.5	3.5	n/a	n/a	n/a	n/a	n/a	n/a
2-Mode hybrid electric vehicle	n/a	n/a	3.5	3.5	7	7	7	7	3.5	3.5
Power-split hybrid electric vehicle (P-S HEV)	5	5	6.5	6.5	6.5	6.5	6.5	6.5	n/a	n/a
Plug-in hybrid electric vehicle (PHEV)	28	28	28	28	28	28	28	28	31	31
Improved high efficiency alternator & electrification of accessories (12 volt)	1-2	1-2	1-2	1-2	1-2	1-2	1-2	1-2	1-2	1-2
Electric power steering (12 or 42 volt)	1.5	1.5	1.5-2	1.5-2	2	2	2	2	2	2
Improved high efficiency alternator & electrification of accessories (42 volt)	1-2	1-2	1-2	1-2	1-2	1-2	1-2	1-2	1-2	1-2
Aero drag reduction (20% on cars, 10% on trucks)	3	3	3	3	2	2	3	3	2	2
Low rolling resistance tires (10%)	1-2	1-2	1-2	1-2	1-2	1-2	1-2	1-2	n/a	n/a
Low drag brakes (ladder frame only)	n/a	n/a	n/a	n/a	1	1	n/a	n/a	1	1
Secondary axle disconnect (unibody only)	1	1	1	1	1	1	1	1	n/a	n/a
Front axle disconnect (ladder frame only)	n/a	n/a	n/a	n/a	1.5	1.5	n/a	n/a	1.5	1.5
Weight reduction (1%)--above 5,000 lbs only	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.7	0.7
Weight reduction (2%)--incremental to 1%	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.7	0.7
Weight reduction (3%)--incremental to 2%	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.7	0.7

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Table III-3.--Year of Availability

Technologies	Year of availability
Low friction lubricants--incremental to base engine.	Present.
Engine friction reduction--incremental to base engine.	Present.
Overhead Cam Branch	
VVT--intake cam phasing	Present.
VVT--coupled cam phasing	Present.
VVT--dual cam phasing	Present.
Cylinder deactivation	Present.
Discrete VVLT	Present.
Continuous VVLT	Present.
Overhead Valve Branch	
Cylinder deactivation	Present.
VVT--coupled cam phasing	Present.
Discrete VVLT	Present.
Continuous VVLT (includes conversion to Overhead Cam).	Present.
Camless valvetrain (electromagnetic)	2020.
GDI--stoichiometric	Present.
GDI--lean burn	2020.
Gasoline HCCI dual-mode	2016.
Turbocharging & Downsizing	2010.
Diesel--Lean NOX trap	2010.
Diesel--urea SCR	2010.
Aggressive shift logic	Present.
Early torque converter lockup	Present.
5-speed automatic	Present.
6-speed automatic	Present.
6-speed AMT	2010.
6-speed manual	Present.
CVT	Present.
Stop-Start with 42 volt system	2014.
IMA/ISA/BSG (includes engine downsize)	2014.
2-Mode hybrid electric vehicle	2014.
Power-split hybrid electric vehicle (P-S HEV).	2014.
Full-Series hydraulic hybrid	NA.
Plug-in hybrid electric vehicle (PHEV)	NA.
Full electric vehicle (EV)	NA.
Improved high efficiency alternator & electrification of accessories (12 volt).	Present.
Electric power steering (12 or 42 volt)	Present.
Improved high efficiency alternator & electrification of accessories (42 volt).	Present.
Aero drag reduction (20% on cars, 10% on trucks).	Present.
Low rolling resistance tires (10%)	Present.
Low drag brakes (ladder frame only)	Present.
Secondary axle disconnect (unibody only).	2012.
Front axle disconnect (ladder frame only)	Present.
Weight reduction (1%)--above 6,000 lbs only.	Present.
Weight reduction (2%)--incremental to 1%.	Present.
Weight reduction (3%)--incremental to 2%.	Present.

C. 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. This may occur because one or more technologies applied to the same vehicle partially address the same source or sources of engine 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 sometimes referred to 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).

The NAS committee which authored the 2002 Report was aware of technology synergies and considered criticisms as part of the peer-review process that its analysis was ``judgment-simplified,'' but concluded overall that its approach was ``sufficiently rigorous'' for purposes of the report.\64\ After examining its analysis again, the committee stated that ``* * * the path 1 and path 2 estimate average fuel consumption improvements * * * appear quite reasonable, although the uncertainty in the analysis grows as more technology features are considered.''\65\ In essence, as more technology features are considered, the features are more likely to overlap and result in synergies. Because NAS did not expect vehicle manufacturers to reach ``path 3'' in the timeframe considered, it did not concern itself deeply with the effect of technology synergies in its analysis.

\64\ NAS Report, p. 151.

\65\ Id.

NHTSA's rulemaking regarding CAFE standards for MY 2008-MY 2011 light trucks made significant use of NAS' ``path 2'' estimates of the effectiveness and cost of available technologies. In part because its analysis did not extend to the more aggressive ``path 3,'' the agency concluded that the NAS-based multiplicative approach it followed when aggregating these technologies was reasonable. In contrast, the agency's current proposal is based on an analysis that includes a broader range of technologies than was considered by NAS in 2001 and 2002. Also, the extent to which technologies are included in the current analysis is more consistent with NAS' prior ``path 3'' approach. Therefore, the agency's current analysis uses estimated ``synergies'' to address the uncertainties mentioned in the 2002 NAS report.

The Volpe model has been modified to estimate the interactions of technologies using estimates of incremental synergies associated with a number of technology pairs identified by NHTSA, Volpe Center, and EPA staff. The use of discrete technology pair incremental synergies is similar to that in DOE's National Energy Modeling System (NEMS).\66\ Inputs to the Volpe model incorporate NEMS-identified pairs, as well as additional pairs 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, Volpe Center, and EPA staff, new incremental synergy estimates for all pairs were obtained from a first-order ``lumped parameter'' analysis tool created by EPA.\67\ Results of this analysis were generally consistent with those of full-scale vehicle simulation modeling performed by Ricardo, Inc.\68\ NHTSA's analysis applies these incremental synergy values, obtained from the tool using baseline passenger car engine and vehicle inputs, to all vehicle classes.

\66\ 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), pp. 29-30.

\67\ This tool is a simple spreadsheet model that represents energy consumption in terns 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 and motor characteristics and other variables that are averaged over a driving cycle.

\68\ EPA contracted with Ricardo, Inc. (an independent consulting firm) to study the potential effectiveness of carbon dioxide-reducing (and thus, fuel economy-improving) vehicle technologies. The Ricardo study is available in the docket for this NPRM.

Incremental synergy values are specified in Volpe model input files in two ways: as part of the incremental effectiveness values table (same path technologies) and in a separate incremental synergies table (separate path technologies). In the case of same path technologies, each technology's incremental effectiveness value was obtained from the technical literature and manufacturers' submitted information, and then the sum of all

incremental synergies associated with that technology and each technology located higher on the same path was subtracted to determine the incremental effectiveness. For example, all engine technologies take into account incremental synergy factors of preceding engine technologies; 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 which lists technology pairings and incremental synergy factors associated with those pairings, most of which are between engine technologies and transmission 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. When the Volpe model applies incremental synergies, the fuel consumption improvement factors cannot be reduced below zero.

Incremental synergy values were calculated assuming the prior application (implying succession in some cases) of all technologies located higher along both paths than the pair considered. This is usually a true reflection of a given vehicle's equipment at any point in the model run and thus the method is expected to produce reasonable results in most cases.

NHTSA considered other methods for estimating interactions between technologies. For example, the agency has considered integrating detailed simulation of individual vehicles' performance into the Volpe model.\69\ However, while application of such simulation techniques could provide a useful source of information when developing inputs to the Volpe model, the agency believes that applying detailed simulation when analyzing the entire fleet of future vehicles is neither necessary nor feasible. NHTSA is charged with setting standards at the maximum feasible level. To understand the potential impacts of its standards, the agency analyzes entire fleets of vehicles expected to be produced in the future. Although some expected engineering characteristics of these vehicles are available, the level of detail needed for full vehicle simulation--a level of detail that would be important if NHTSA were actually designing vehicles--is not available.

\69\ In other words, this would mean having the Volpe model run a full vehicle simulation every time the Volpe model is evaluating the potential effect of applying a specific technology to a specific vehicle model.

As another possible alternative to using ``synergy'' factors, NHTSA has also considered modifying the Volpe model to accept as inputs different measures of efficiency for each engine, transmission, and vehicle model in the product plans. For instance, manufacturers could provide estimates of mechanical and drivetrain efficiencies. Mechanical efficiency (usually between 70 and 90 percent) gives an estimate of the amount of fuel consumed by engine friction and pumping losses. Drivetrain efficiency (usually between 80 and 90 percent) gives an estimate of the amount of fuel consumed by parasitic loads, gearbox friction, and torque converter losses. From these efficiencies along with other inputs such as compression ratio, aerodynamic drag, rolling resistance, and vehicle mass, the model could estimate the fuel consumption associated with each loss mechanism and enforce a maximum fuel consumption reduction for each vehicle model based on those estimates and the technologies applied. Like the use of incremental synergies, this method could help the model avoid double counting fuel consumption benefits when applying multiple technologies to the same vehicle model.\70\ The agency believes that this approach, like the use of ``synergy'' factors currently used by the Volpe model, could conceivably provide a means of addressing uncertainty in fuel consumption estimation within the context of CAFE analysis. However, the agency is not confident that model-by-model estimates of baseline fuel consumption partitioning would be available. Also, partitioned estimates of the effects of all the technologies considered in the analysis of this proposal were not available. If both of these concerns could be addressed, NHTSA believes it would be possible to implement partitioned accounting of fuel consumption. However, the agency is unsure whether and, if so, to what extent doing so would represent an improvement over our current approach of using incremental synergy factors.

\70\ This approach was proposed in a paper criticizing NAS' approach to synergies in the 2001-02 peer-review process for the NAS Report. See Patton, et al., ``Aggregating Technologies for Reduced Fuel Consumption: A Review of the Technical Content in the 2002 National Research Council Report on CAFE'', SAE 2002-01-0628, March 2002.

The agency solicits comments on its use of incremental synergy factors to address uncertainty in the estimation of the extent to which fuel consumption is reduced by applying technologies. For additional detail on the synergies used, please see Section V of this document. In particular, the agency solicits comment on (a) the values of the factors the agency has applied, (b) possible variations across the ten categories of vehicles the agency has considered, and (c) additional technology pairs that may involve such interactions. The proposal of any additional methodologies, such as prototyping and testing, full vehicle simulation, or partitioned accounting, should address information and resource requirements, particularly as related to the analysis of entire fleets of future vehicles expected to be produced through MY 2015. Synergies used for this analysis can be found in Section V of this document.

D. Technology Cost Learning Curve

In past rulemaking analyses, NHTSA did not explicitly account for the cost reductions a manufacturer may realize through learning achieved from experience in actually applying a given technology. NHTSA understood technology cost-estimates to reflect already the full learning costs of technology. EPA felt that for some of the newer, emerging technologies, cost estimates did not reflect the full impact of learning. NHTSA tentatively agreed, but is seeking comment on the impact of learning on cost and the production volumes where it occurs. NHTSA has modified its previous approach in this rulemaking for that reason. In this rulemaking we have included a learning factor for some of the 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.

NHTSA 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. Section V below describing the Volpe model contains additional information on learning curve functions.

Figure III-1 illustrates a learning curve for a vehicle technology with an

initial average unit cost of $100 and a learning rate of approximately 20 percent. In this hypothetical example, the initial production volume before cost reductions begin to be realized is set at 12,000 units and the production volume at the cost floor is set at roughly 50,000 units with a cost of $64.
[GRAPHIC] [TIFF OMITTED] TP02MY08.001

Most studies of the effect of the learning curve on production costs appear to assume that cost reductions begin only after some initial volume threshold has been reached, but not all of these studies specify what this threshold volume is. The rate at which costs decline beyond the initial threshold is usually expressed as the percent reduction in average unit cost that results from each successive doubling of cumulative production volume, sometimes referred to as the learning rate. Many estimates of learning experience curves do not specify a cumulative production volume beyond which cost reductions no longer occur, instead depending on the asymptotic behavior of the above expression of (CQ) for learning rates below 100 percent to establish a floor on costs.

For this analysis, NHTSA has applied learning curve cost reductions on a manufacturer-specific basis, and has 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 (car and truck volumes are treated separately for determining these sales volumes). The volumes chosen represent our best estimate for where learning would occur. As such, we believe that these estimates are better suited to this analysis than a more general approach of a single number for the learning curve factor, because each manufacturer would be implementing technologies at its own pace in this rule, rather than assuming that all manufacturers implement identical technology at the same time. NHTSA is aware that some of the cost estimates that it has relied upon were derived from suppliers and has added multipliers so that these costs are reflective of what manufacturers would pay for this technology. NHTSA seeks comments on the estimated level of price markups that manufacturers pay for technologies purchased from suppliers and whether different learning curves should be applied to those types of technologies. In addition, NHTSA seeks comments on how learning curves should be adjusted if a supplier supplies more than one manufacturer.

Ideally, we would know the development production cycle and maturity level for each technology so that we could calculate learning curves precisely. Without that knowledge, we have to use engineering judgment. After having produced 25,000 cars or trucks with a specific part or system, we believe that sufficient learning will have taken place such that costs will be lower by 20 percent for some technologies and 10 percent for others. After another 25,000 units, it is expected that, for some technologies, such as 6-speed AMTs, another cost reduction will have been realized.

For each of the technologies, we have considered whether we could project future cost reductions due to manufacturer learning. In making this determination, we considered whether or not the technology was in wide-spread use today or expected to be by the model year 2011-2012 time frame, in which case no future learning curve would apply because the technology would already be in wide-spread production by the automotive industry by that timeframe, e.g., on the order of multi-millions of units per year. (Examples of these include 5-speed automatic transmissions and intake-cam phasing variable valve timing.

These technologies have been in production for light-duty vehicles for more than 10 years.) In addition, we carefully considered the underlying source data for our cost estimates. If the source data specifically stated that manufacturer cost reduction from future learning would occur, we took that information into account in determining whether we would apply manufacturer learning in our cost projections. Thus, for many of the technologies, we have not applied any future cost reduction learning curve.

However, there are a number of technologies which are not yet in mass production for which we have applied a learning curve. As indicated in Table III-4 below, we have applied the learning curve beginning in MY 2011 to one set of technologies, and for a number of additional technologies we did not apply manufacturer learning until MY 2014. The distinction between MYs 2011 and 2014 is due to our source data for our cost estimates. For those technologies where we have applied manufacturer learning in MY 2011, the source of our cost estimate did not rely on manufacturer learning to develop the initial cost estimate we have used--therefore we apply the manufacturer

learning methodology beginning in MY 2011.

Table III.-4.--Learning Curve Application to Technologies

Technology	First year of application	Learning factor (percent)
Overhead Cam Branch Cylinder deactivation.....	2014	20
Continuous VVLT.............................	2014	20
Camless valvetrain (electromagnetic)..........	2011	20
GDI--lean burn...............................	2011	20
Gasoline HCCI dual-mode......................	2011	20
Turbocharging & downsizing...................	2014	20
Diesel--Lean NOX trap*.......................	2011	10
Diesel--urea SCR*............................	2011	10
6-speed AMT..................................	2011	20
Stop-Start with 42 volt system...............	2014	20
IMA/ISA/BSG (includes engine downsize)........	2014	20
2-Mode hybrid electric vehicle...............	2014	20
Power-split hybrid electric vehicle (P-S HEV).	2014	20
Plug-in hybrid electric vehicle (PHEV)........	2011	20
Improved high efficiency alternator & electrification of accessories (42 volt).....	2011	20
Secondary axle disconnect (unibody only)......	2011	20
Weight reduction (1%)--above 6,000 lbs only...	2011	20
Weight reduction (2%)--incremental to 1%......	2011	20
Weight reduction (3%)--incremental to 2%......	2011	20

* For diesel technologies, learning is only applied to the cost of the emission control equipment, not the cost for the entire diesel system.

The technologies for which we do not begin applying learning until 2014 all have the same reference source, the 2004 NESCCAF study, for which the sub-contractor was The Martec Group. In the work done for the 2004 NESCCAF report, Martec relied upon actual price quotes from Tier 1 automotive suppliers to develop automotive manufacturer cost estimates. Based on information presented by Martec to the National Academy of Sciences (NAS) Committee during their January 24, 2008, public meeting in Dearborn, Michigan,\71\ we understand that the Martec cost estimates incorporated some element of manufacturer learning. Martec stated that the Tier 1 suppliers were specifically requested to provide price quotes which would be valid for three years (2009-2011), and that for some components the Tier 1 supplier included cost reductions in years two and three which the supplier anticipated could occur, and which they anticipated would be necessary in order for their quote to be competitive with other suppliers. Therefore, for this analysis, we did not apply any learning curve to any of the Martec-sourced costs for the first three years of this proposal (2011-2013). However, the theory of manufacturer learning is that it is a continuous process, though the rate of improvement decreases as the number of units produced increases. While we were not able to gain access to the detailed submissions from Tier 1 suppliers which Martec relied upon for their estimates, we do believe that additional cost reductions will occur in the future for a number of the technologies for which we relied upon the Martec cost estimates for the reasons stated above in reference to the general learning curve effect. For those technologies we applied a learning curve beginning in 2014. Martec has recently submitted a study to the NAS Committee comparing the 2004 NESCCAF study with new updated cost information. Given that this study had just been completed, the agency could not take it into consideration for the NPRM. However, the agency will review the new study and consider its findings in time for the final rule.

\71\ ``Variable Costs of Fuel Economy Technologies'' Martec Group, Inc Report Presented to: Committee to Assess Technologies for Improving Light-Duty Vehicle Fuel Economy. Division on Engineering and Physical Systems, Board on Energy and Environmental Systems, the National Academy of Sciences, January 24, 2008.

Manufacturers' actual costs for applying these technologies to specific vehicle models are likely to include significant 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. 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 has applied an indirect cost multiplier of 1.5 to its estimate of the vehicle manufacturers' direct costs for producing or acquiring each fuel economy-improving technology to arrive at a consumer cost. This estimate was developed 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 same advanced technologies considered in the agency's analysis.\72\ Thus, its recommendation that a multiplier of 1.5 be applied to direct manufacturing costs to reflect manufacturers' increased indirect costs for deploying advanced fuel economy technologies appears to be appropriate for use in the current analysis. Historically, NHTSA has used almost the exact same multiplier, a multiplier of 1.51, as the markup from variable costs or direct manufacturing costs to consumer costs. This markup takes into account fixed costs, burden, manufacturer's profit, and dealer's profit. Table VII-2 of the PRIA shows the estimated incremental consumer costs for each vehicle type.\73\

\72\ Vyas, Anant, Dan Santini, and Roy Cuenca, Comparison of Indirect Cost Multipliers for Vehicle Manufacturing, Center for Transportation Research, Argonne National Laboratory, April 2000.

\73\ PRIA, VII-9.

E. Ensuring Sufficient Lead Time

In analyzing potential technological improvements to the product offerings for each manufacturer with a substantial share of the market, NHTSA added technologies based on our engineering judgment and expertise about possible adjustments to the detailed product plans submitted to NHTSA. Our decision whether and when to add a technology reflected our consideration of the practicability of applying a specific technology and the necessity for lead time in its application. NHTSA recognizes that vehicle manufacturers must have sufficient lead time to incorporate changes and new features into their vehicles and hence added technologies in a cost-minimizing fashion. That is, we generally added technologies that were most cost-effective and took into account the year of availability of the technologies.

NHTSA realizes that not all technologies will be available immediately or could be applied immediately and that there are different phase-in rates (how rapidly a technology is able to be applied across a manufacturer's fleet of vehicles) applicable to each technology as well as windows of opportunities when certain technologies could be applied (i.e., when a product is redesigned or refreshed).

a. Linking To Redesign and Refresh

In the automobile industry there are two terms that describe when changes to vehicles occur: redesign and refresh. In projecting the technologies that could be applied to specific vehicle models, NHTSA tied the application of the majority of the technologies to a vehicle's refresh/redesign cycle. 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, and often is characterized as the next generation of a vehicle. In contrast vehicle refresh usually only encompasses changes to a vehicle's appearance, and may include an upgraded powertrain and 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. Table III-5 below contains a complete list of the technologies that were applied and whether NHTSA allowed them to be applied during a redesign year, a refresh year or during any model year is shown in the table below.

Table III-5.--Technology Refresh and Redesign Application

Technology	Abbr.	Can be applied during redesign model year only	Can be applied during a redesign or refresh model year	Can be applied during any model year
Low Friction Lubricants	LUB	....	X	X
Engine Friction Reduction	EFR	....	X	....
Variable Valve Timing (ICP)	VVTI	....	X	....
Variable Valve Timing (CCP)	VVTC	....	X	....
Variable Valve Timing (DCP)	VVTD	....	X	....
Cylinder Deactivation	DISP	....	X	....
Variable Valve Lift & Timing (CVVL)	VVLTC	X	....	....
Variable Valve Lift & Timing (DVVL)	VVLTD	X	....	....
Cylinder Deactivation on OHV	DISPO	....		

X   ....
Variable Valve Timing (CCP) on OHV........ VVTO..................... ....
X   ....
Multivalve Overhead Cam with CVVL......... DOHC..................... X
....
Variable Valve Lift & Timing (DVVL) on OHV VVLTO.................... X
....
Camless Valve Actuation................... CVA...................... X
....
Stoichiometric GDI........................ SIDI..................... X
....
Lean Burn GDI............................. LBDI..................... X
....
Turbocharging and Downsizing.............. TURB..................... X
....
HCCI...................................... HCCI..................... X
....
Diesel with LNT........................... DSLL..................... X
....
Diesel with SCR........................... DSLS..................... X
....
5 Speed Automatic Transmission............ 5SP...................... ....
X   ....
Aggressive Shift Logic.................... ASL...................... ....
X   X
Early Torque Converter Lockup............. TORQ..................... ....
X   ....
6 Speed Automatic Transmission............ 6SP...................... ....
X   ....
Automatic Manual Transmission............. AMT...................... X
....
Continuously Variable Transmission........ CVT...................... X
....
6 Speed Manual............................ 6MAN..................... X
....
Improved Accessories...................... IACC..................... ....
....   X
Electronic Power Steering................. EPS...................... ....
X   ....
42-Volt Electrical System................. 42V...................... X
....
Low Rolling Resistance Tires.............. ROLL..................... ....
....   X
Low Drag Brakes........................... LDB...................... ....
....   X
Secondary Axle Disconnect--Unibody........ SAXU..................... ....
X   ....
Secondary Axle Disconnect--Ladder Frame... SAXL..................... ....
X   ....
Aero Drag Reduction....................... AERO..................... ....
X   ....
Material Substitution (1%)................ MS1...................... X
....
Material Substitution (2%)................ MS2...................... X
....
Material Substitution (5%)................ MS5...................... X
....
ISG with Idle-Off......................... ISGO..................... X
....
IMA/ISAD/BSG Hybrid (includes engine IHYB..................... X
....
downsizing).
2-Mode Hybrid............................. 2HYB..................... X
....

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Power Split Hybrid........................ PHYB..................... X

....

As can be seen in the above table, most technologies would only be applied by the Volpe model when a specific vehicle was due for a redesign or refresh. However, for a limited set of technologies, the model was not restricted to applying them during a refresh/redesign year and thus they were made available for application at any time.

These specific technologies are:

Low Friction Lubricants

Improved Accessories

Low Rolling Resistance Tires

Low Drag Brakes

All of these technologies 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 testing/calibration.

There is an additional technology whose application is not tied to refresh/redesign, which is Aggressive Shift Logic (ASL). ASL is accomplished through reprogramming the shift points for a transmission to be more like a manual transmission. Upgrading a transmission to utilize ASL can happen at refresh/redesign, but because it is not a hardware change, it can also occur at other points in a vehicle's design cycle. If a model that is scheduled for refresh/redesign has a transmission that is being upgraded to ASL, it is possible that all other vehicles that utilize the same transmission (which is usually produced at the same manufacturing plant) could be upgraded at the same time to incorporate ASL and that ASL could permeate other vehicle models in years other than a refresh/redesign year.

NHTSA based the redesign rates used in the Volpe Model on a combination of the manufacturers' confidential product plans and NHTSA's engineering judgment. In most instances, NHTSA has accepted the projected redesign periods from the companies who provided them through MY 2013. If companies did not provide product plan date, NHTSA used publicly available data about vehicle redesigns to establish the redesign rates for the vehicles produced by these companies.

NHTSA assumes that passenger cars will be redesigned every 5 years, based on the trend over the last 10-15 years for passenger cars to be redesigned every 5 years. These trends are reflected in the manufacturer production plans that NHTSA received in response to its request for product plan information and was confirmed by many automakers in meetings held with NHTSA to discuss various issues with manufacturers.

NHTSA believes that the vehicle design process has progressed and improved rapidly over the last decade and these improvements have resulted in the ability of manufacturers to shorten the design process and to introduce vehicles more frequently to respond to competitive market forces. 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.

Currently, light trucks are redesigned every 5 to 7 years, with some vehicles having longer redesign periods (e.g., full-size vans). In the most competitive SUV and crossover vehicle segments, the redesign cycle currently averages slightly above 5 years. It is expected that the light truck redesign schedule will be shortened in the future due to competitive market forces and in response to fuel economy and other regulatory requirements. It is expected that by MY 2014, almost all light trucks will be redesigned on a 5-year cycle. Thus, for almost all vehicles scheduled for a redesign in model year 2014 and later, NHTSA estimated that all vehicles would be redesigned on a 5-year cycle. Exceptions were made for high performance vehicles and other vehicles that traditionally had longer than average design cycles (e.g., 2-seater sports cars). For those vehicles, NHTSA attempted to preserve the historic redesign cycle rates.

b. Technology Phase-in Caps

In analyzing potential technological improvements to the product offerings for each manufacturer with a substantial share of the market, NHTSA added technologies based on our engineering judgment and expertise about possible adjustments to the detailed product plans submitted to NHTSA. Our decision whether and when to add a technology reflected our consideration of the practicability of applying a specific technology and the necessity for lead-time in its application.

NHTSA recognizes that vehicle manufacturers must have sufficient lead time to incorporate changes and new features into their vehicles and that these changes cannot occur all at once, but must be phased in over time. As discussed above, our analysis addresses these realities in part by timing the estimated application of most technologies to coincide with anticipated vehicle redesigns and/or freshenings. We have estimated that future vehicle redesigns can be implemented on a 5-year cycle with mid-cycle freshening, except where manufacturers have indicated plans for shorter redesign cycles.

However, the agency further recognizes that engineering, planning and financial constraints prohibit most technologies from being applied across an entire fleet of vehicles within a year. Thus, as for the analysis supporting its 2006 rulemaking regarding light truck CAFE, the agency is employing overall constraints on the rates at which each technology can penetrate a manufacturer's fleet. The Volpe model applies these ``phase-in caps'' by ceasing to add a given technology to a manufacturer's fleet in a specific model year once it has increased the corresponding penetration rate by at least amount of the cap. Having done so, the model proceeds to apply other technologies in lieu of the ``capped'' technology.

For its regulatory analysis in 2006, NHTSA applied phase-in caps expected to be consistent with NAS' indication in its 2002 report that even existing technologies would require 4 to 8 years to achieve widespread penetration of the fleet. The NAS report, which is believed to be the only peer-reviewed source which provides phase-in rates, was relied upon for establishing the phase-in caps that we used for all

technologies, except diesels and hybrids, for which the report didn't include that information. Most of the phase-in caps applied by the agency in 2006 ranged from 25 percent (4 year introduction) to 17 percent (approximately 6 years, the midpoint of the NAS estimate). The agency assumed shorter implementation rates for technologies that did not require changes to the manufacturing line. For other technologies (e.g., hybrid and diesel powertrains), the agency employed phase-in caps as low as 3 percent, to reflect the major redesign efforts and capital investments required to implement these technologies.

Considerable changes have occurred since NHTSA's 2006 analysis, and even more since the 2002 NAS report. Not only have fuel prices increased, but official forecasts of future fuel prices have increased, as well. This suggests a market environment in which consumers are more likely to demand fuel-saving technologies than previously anticipated, and it suggests a financial environment in which investors are more likely to invest in companies developing and producing such technologies. Indeed, some technologies have penetrated the marketplace more quickly than projected in 2006. Confidential product plan information submitted to NHTSA in 2007 and information from suppliers confirm that the rate of technology penetration has increased as compared to 2006.

Also, the statutory environment has changed since 2006. With the enactment of EISA, Congress has adopted the specific objectives of increasing new vehicle fuel economy to at least 35 mpg by 2020 and making ratable progress toward that objective in earlier model years. This reduces manufacturers' uncertainty about the general direction of future fuel economy standards in the United States. Moreover, developments in other regions (e.g., Europe) and countries (e.g., Canada and China) suggest that the generalized expectation that future vehicles will perform well with respect to energy efficiency is not unique to the United States. Discussions with manufacturers in late 2007 and early 2008 indicate that the industry is highly sensitive to all of these developments and has been anticipating the need to accelerate the rate of technology deployment in response to the passage of major energy legislation in the U.S.

Considering these developments, the agency revisited the phase-in caps it had applied in 2006 and determined that it would be appropriate to relax many of them. In our judgment, most of the engine technologies could penetrate the fleet in as quickly as five years--rather than in the six we previously estimated--as long as they are applied during redesign. Low friction lubricants are already widely used, and our expectation is that they can quickly penetrate the remainder of the fleet. Therefore, we relaxed the 25 percent (4-year) phase-in cap to 50 percent (2 years). Similarly, product plans indicate that transmissions with 5 or more forward gears will widely penetrate the fleet even without the current proposal. Also, given the technology cost and effectiveness estimates discussed above, the Volpe model frequently estimates that manufacturers will ``leapfrog'' past 5-speed transmissions to apply more advanced transmissions (e.g., 6-speed or AMT). We have therefore increased the phase-in cap for 5-speed transmissions from 25 percent (4 years) to 100 percent (1 year). However, in our judgment, phase-in caps of 17 percent (6 years) are currently still appropriate for most other transmission technologies.

Although NHTSA has applied phase-in caps of 25 percent (4 years) for most remaining technologies, we continue to anticipate that phase-in caps of 3 percent are appropriate for some advanced technologies, such as hybrids and diesels. Although engine, vehicle, and exhaust aftertreatment manufacturers have, more recently, expressed greater optimism than before regarding the outlook for light vehicle diesel engines, our expectation is that the phase-in cap that we have chosen is appropriate at this time. We also estimate that a 3 percent rate is appropriate for hybrid technologies, which are very complex, require significant engineering resources to implement, but are just now starting to penetrate the market.

Table III-6 below presents the phase-in caps applied in the current analysis, with rates from the analysis of the 2006 final rule provided for comparison. NHTSA requests comments on the phase-in caps shown here, and on whether slower or faster rates would be more appropriate and, if so, why.

Table III.--6. Phase-In Cap Application

Technology	2006 final rule	Current NPRM
Low Friction Lubricants	25	50
Engine Friction Reduction	17	20
Variable Valve Timing (ICP)	17	20
Variable Valve Timing (CCP)	17	20
Variable Valve Timing (DCP)	17	20
Cylinder Deactivation	17	20
Variable Valve Lift & Timing (CVVL)	17	20
Variable Valve Lift & Timing (DVVL)	17	20
Cylinder Deactivation on OHV	17	20
Variable Valve Timing (CCP) on OHV	17	20
Multivalve Overhead Cam with CVVL	17	20
Variable Valve Lift & Timing (DVVL) on OHV	17	20
Camless Valve Actuation	10	20
Stoichiometric GDI	3	20
Diesel following GDI-S (SIDI)	3	3
Lean Burn GDI	....	20
Turbocharging and Downsizing	17	20
Diesel following Turbo D/S	3	3
HCCI	....	13
Diesel following HCCI	3	3
5 Speed Automatic Transmission	17	100
Aggressive Shift Logic	17	25
Early Torque Converter Lockup	....	25
6 Speed Automatic Transmission	17	17

Automated Manual Transmission................	17	17
Continuously Variable Transmission...........	17	17
6 Speed Manual..............................	....	17
Improved Accessories........................	25	25
Electric Power Steering.....................	17	25
42-Volt Electrical System...................	17	25
Low Rolling Resistance Tires................	25	25
Low Drag Brakes.............................	17	25
Secondary Axle Disconnect--Unibody...........	17	17
Secondary Axle Disconnect--Ladder Frame.......	17	17
Aero Drag Reduction.........................	17	17
Material Substitution (1%)..................	17	17
Material Substitution (2%)..................	17	17
Material Substitution (5%)..................	17	17
ISG with Idle-Off...........................	5	3
IMA/ISAD/BSG Hybrid (includes engine downsizing)................................	5	3
2-Mode Hybrid...............................	5	3
Power Split Hybrid..........................	5	3
Plug-in Hybrid..............................	....	3

IV. Basis for Attribute-Based Structure for Setting Fuel Economy Standards

A. Why attribute-based instead of a single industry-wide average?

NHTSA 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. NHTSA welcomes Congress' affirmation through EISA of the value of setting attribute-based fuel economy standards, because we believe that an attribute-based structure is preferable to a single industry-wide average standard for the following 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 any 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 vehicles they sell. Therefore, fuel savings and 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.\74\ 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 and emissions targets.

\74\ The 2002 NAS Report, on which NHTSA relied in reforming the CAFE program for light trucks, 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 National Academy of Sciences, ``Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards,'' (``NAS Report'') National Academy Press, Washington, DC (2002), 5, finding 12. Available at http://www.nap.edu/openbook.php?record--id=10172page=R1 (last accessed April 20, 2008).

Third, attribute-based standards provide a more equitable regulatory framework for different vehicle manufacturers.\75\ 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.

\75\Id. at 4-5, finding 10.

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 achieved by the vehicles they sell, regardless of their size.

B. Which attribute is most effective?

Although NHTSA previously set the MY 2008-2011 light truck fuel economy standards based on vehicle footprint as the relevant attribute, the agency took a fresh look for purposes of this rulemaking. Although several attributes offer benefits, NHTSA has preliminarily concluded that a footprint-based function will again be the most effective and efficient for both passenger car and light truck standards. The discussion below explains our conclusion in favor of footprint, and also examines the relative benefits and drawbacks of the other attributes considered.

1. Footprint-Based Function

NHTSA is proposing to set fuel economy standards for manufacturers according to vehicle footprint, as light truck CAFE standards are currently set by NHTSA. A vehicle's ``footprint'' is the product of the average track width (the distance between the centerline of the tires \76\ ) and wheelbase (basically, the distance between the centers of the axles \77\ ). Each vehicle footprint value is assigned a mile per gallon target specific to that footprint value. Footprint-based

standards have a number of benefits, as described below.

\76\ The proposed definition for track width is the same as that used in NHTSA's April 2006 light truck CAFE rule, which is ``the lateral distance between the centerlines of the base tires at ground, including camber angle.'' 49 CFR 523.2, 71 FR 19450 (Apr. 14, 2006).

\77\ The proposed definition for wheelbase is also the same as that used in NHTSA's April 2006 light truck CAFE rule. Wheelbase is ``the longitudinal distance between front and rear wheel centerlines.'' Id.

First, NHTSA tentatively concludes that use of the footprint-attribute helps us achieve greater fuel economy/emissions reductions without having a potentially negative impact on safety. While past analytic work \78\ focused on the relationship between vehicle weight and safety, weight was understood to encompass a constellation of size-related factors, not just weight. More recent studies \79\ have begun to consider whether the relationship between vehicle size and safety differs. To the extent that reduction of mass has historically been associated with reductions in many other size attributes, and given the construct of the current fleet, we believe that the relationship between size or weight (on the one hand) and safety (on the other) has been similar.

\78\ See Kahane, Charles J., PhD, DOT HS 809 662, ``Vehicle

Weight, Fatality Risk and Crash Compatibility of Model Year 1991-99 Passenger Cars and Light Trucks,'' October 2003. Available at http://www.nhtsa.dot.gov/cars/rules/regrev/Evaluate/809662.html (last accessed April 20, 2008). See also Van Auken, R.M. and J.W. Zellner, ``An Assessment of the Effects of Vehicle Weight on Fatality Risk in Model Year 1985-98 Passenger Cars and 1985-97 Light Trucks,'' Dynamic Research, Inc., February 2002. Available at Docket No. NHTSA-2003-16318-2.

\79\ See Van Auken, R.M. and J.W. Zellner, Supplemental Results on the Independent Effects of Curb Weight, Wheelbase, and Track on Fatality Risk in 1985-1997 Model Year LTVs, Dynamic Research, Inc., May 2005. Available at Docket No. NHTSA-2003-16318-17.

Overall, use of vehicle footprint is ``weight-neutral'' and thus does not exacerbate the vehicle compatibility safety problem.\80\ A footprint-based system does not encourage manufacturers to add weight to move vehicles to a higher footprint category, because additional weight makes no difference to the required target. Nor would the system penalize manufacturers for making limited weight reductions. By using vehicle footprint in lieu of a weight-based metric, the standards would also facilitate the use of promising lightweight materials that, although perhaps not cost-effective in mass production today, may ultimately achieve wider use in the fleet, become less expensive, and enhance emissions reductions, vehicle safety, and fuel economy.\81\

\80\ The vehicle compatibility safety problem refers to the disparity in effects experienced by smaller lighter vehicles in crashes with larger heavier vehicles.

\81\ For example, the Aluminum Association indicated in the April 2006 light truck CAFE rulemaking that using aluminum to decrease a vehicle's weight by 10 percent could improve its fuel economy (and thus, reduce its CO_2 emissions) by 5-8 percent, without reducing performance in frontal barrier crash tests. See comments provided by the Aluminum Association, Inc., at Docket No. NHTSA-2003-16128-1120, pp. 5 and 12.

Finally, vehicle footprint is more difficult to modify than other attributes. It is more integral to a vehicle's design than either vehicle weight or shadow, and cannot easily be altered between model years in order to move a vehicle into a different category with a lower fuel economy target. Footprint is dictated by the vehicle platform, which is typically used for a multi-year model lifecycle. Short-term changes to a vehicle's platform would be expensive and difficult to accomplish without disrupting multi-year product planning. In some cases, several models share a common platform, thus adding to the cost, difficulty, and therefore unlikelihood of short-term changes.

Concurrent with the NPRM, NHTSA will develop a test procedure for measuring wheelbase and track width and for calculating footprint. This test procedure will be available on NHTSA's Web site. We note that the test procedure will be used to validate the corresponding wheelbase, track width, and footprint data provided to us by the manufacturers in their pre-model year reports but could include other CAFE-related enforcement activities in the future. We seek comment on the test procedure.

2. Functions Based on Other Attributes

Although NHTSA has concluded that footprint is the best attribute for CAFE standards, we considered a number of other attributes on which to base the standards, including, but not limited to, curb weight, engine displacement, interior volume, passenger capacity, towing capability, and cargo hauling capability. Below we have described the relative merits and drawbacks of the other attributes considered.

Curb weight: One of the benefits of choosing curb weight as the relevant attribute for the standards is that it correlates with fuel economy and emissions controls better than vehicle footprint. Additionally, because reductions in weight would lead to higher targets, weight-based standards prevent the systemic downweighting of vehicles and the associated detriment to safety. However, weight-based standards also discourage the down-weighting of vehicles through the use of lightweight materials that could improve fuel economy and safety and reduce emissions. Weight-based standards are also more susceptible to gaming and creep, because weight can be altered very easily compared to other attributes. Weight is also only rarely considered by consumers, in contrast to size (which is reflected in footprint and shadow), and can be raised considerably (thus decreasing fuel economy/increasing CO_2 emissions) without consumers being aware of the change.

Engine displacement: The primary benefit of choosing engine displacement as the relevant attribute for the standards is that it correlates well with fuel economy, since a larger engine consumes fuel at a faster rate. However, engine-displacement-based standards would be highly susceptible to gaming and creep, given that many vehicle manufacturers already offer identical models with different size engines. Additionally, engine-displacement-based standards would discourage the use of small turbo-charged engines, which have the potential to improve fuel economy without sacrificing the engine power that American consumers generally seek.

Interior volume: Standards based on interior volume would have virtually no correlation with fuel economy, so they were not extensively considered. Such standards would have the advantage of not encouraging downsizing, so they could have a positive impact on safety in that respect, but few other benefits were discerned.

Passenger capacity: Besides having virtually no correlation with fuel economy, passenger capacity has the disadvantage of being identical for a substantial portion of the light-duty vehicle population (i.e., many vehicles have five seats). Thus, using passenger capacity as the attribute on which to base fuel economy standards would essentially result in a single industry-wide average standard, which is precisely what Congress sought to avoid in requiring attribute-based standards.

Towing or cargo-hauling capability: In its light truck rulemaking for MYs 2008-2011, NHTSA sought comment on whether towing or cargo-hauling capability should be used as an attribute in addition to footprint--in other words, whether the footprint attribute should be modified in any way due to towing or cargo-hauling capability. The reason that NHTSA sought comment was that two vehicles with equal footprint would nevertheless achieve different fuel economies if one's towing or cargo-hauling capability was greater, because engineering a vehicle to provide that kind of power occurs at the expense of engineering for fuel economy. NHTSA posited that perhaps for vehicle manufacturers that have a product mix weighted toward vehicles with superior towing and/or cargo-hauling capabilities, a footprint-based Reformed CAFE standard might not provide a

fully equitable competitive environment. Based on comments to the final rule for the MY 2008-2011 light truck rulemaking, however, NHTSA concluded that the lack of an objective measure for tow rating and the potential for gaming of a system based on this attribute made towing or cargo-hauling capacity an inappropriate attribute at that time. NHTSA tentatively concludes that such is still the case.

In summary, then, NHTSA has tentatively decided that a footprint-based system will be optimal for this rulemaking. However, we seek comment on whether the proposed standards should be based on vehicle footprint alone, or whether other attributes such as the ones described above should be considered. If any commenters advocate one or more additional attributes, the agency requests those commenters to 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.

C. The Continuous Function

NHTSA considered this issue of how to set attribute-based functions in its 2006 light truck CAFE rulemaking, and examined the relative merits of both step functions and continuous functions. In the CAFE context, a step function would separate the vehicle models along the spectrum of attribute magnitudes into discrete groups, and each group would be assigned a fuel economy target (that end up looking like steps), so that the average of the groups would be the average fleet fuel economy. A continuous function, in contrast, would not separate the vehicles into a set of discrete categories. Each vehicle model produced by a manufacturer would have its own fuel economy target, based on its particular footprint. In other words, a continuous function is a mathematical function that defines attribute-based targets across the entire range of possible footprint values, and applies them through a harmonically weighted formula to derive regulatory obligations for fleet averages.

In proposing the current standards in this rulemaking, NHTSA relied on its experience in the last light truck rulemaking. In that rulemaking, NHTSA decided in favor of the continuous function for three main reasons.

First, under a step function, manufacturers who build vehicle models whose footprints fall near the upper boundary of a step have a considerable incentive to upsize the vehicle in order to receive the lower target of the next step. A continuous function reduces the incentive created by a step function to upsize a vehicle whose footprint is near a category boundary, because on an uninterrupted spectrum, upsizing slightly can never cause a drastic decrease in the stringency of the applicable target.

Second, the continuous function minimizes the incentive to downsize a vehicle as a way to meet the standards, because any downsizing results in higher targets being applicable.

And finally, the continuous function provides manufacturers with greater regulatory certainty, because there are no category boundaries that could be redefined in future rulemaking.

The considerations in favor of NHTSA's decision to base the MY 2008-11 light truck CAFE standards on a continuous function are also applicable to the current rulemaking, which would set footprint-based fuel economy standards for both light trucks and passenger cars. Thus, NHTSA has tentatively decided that a continuous function is the best choice for applying the footprint-based standards.

We note, however, that there are a variety of mathematical forms available to estimate the relationship between vehicle footprint and fuel economy that could be used as a continuous function. In the MY 2008-11 light truck CAFE rule, NHTSA considered a simple linear (straight-line) function, a quadratic (U-shaped) function, an exponential (curve that continuously becomes steeper or shallower) function, and an unconstrained logistic (S-shaped) function. Each of these relationships was estimated in gallons per mile (gpm) rather than in miles per gallon (mpg), because the relationship between fuel economy measured in mpg and fuel savings is not linear.\82\ NHTSA plotted the optimized fleets in terms of footprint versus gpm, and once a shape of a function was determined in terms of gpm, the agency then converted the functions to mpg for the purpose of evaluating the potential target values. See 71 FR 17600-17607 (Apr. 6, 2006) for a fuller discussion of the agency's process.

\82\ That is to say, an increase of one mpg in a vehicle with low fuel economy (e.g., 20 mpg to 21 mpg) results in higher fuel savings than if the change occurs in a vehicle with high fuel economy (e.g., 30 mpg to 31 mpg). Increasing fuel economy by equal increments of gallons per mile provides equal fuel savings regardless of the fuel economy of a vehicle. For example, increasing the fuel economy of a vehicle from 0.06 gpm to 0.05 gpm saves exactly the same amount of fuel as increasing the fuel economy of a vehicle from 0.03 gpm to 0.02 gpm.

Ultimately, NHTSA decided in the light truck CAFE rule that none of those four 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 \83\ provided a relatively good fit to the data points without creating problems associated with some or all of the other forms, i.e., excessively high targets for small vehicles, excessively low targets for large vehicles, or regions in which targets for large vehicles exceeded those for small vehicles. The constrained logistic function also limited the potential for the curve to be disproportionately influenced by a single vehicle model located at either end of the range (i.e., by outliers). Because most vehicle models are clustered in the middle of the footprint range, models toward either end have a greater influence on their target value, and thus on the overall shape of the curve that fits the data points. The constrained logistic function minimizes this problem.

\83\ A ``constrained'' logistic function is still S-shaped, like an unconstrained logistic function, but plateaus at the top and bottom rather than continuing to increase or decrease to infinity.

NHTSA's constrained logistic function in the light truck rule was defined by four parameters. Two parameters established the function's upper and lower bounds (asymptotes), respectively. A third parameter specified the footprint at which the function was halfway between the upper and lower bounds. The last parameter established the rate or ``steepness'' of the function's transition between the upper (at low footprint) and lower (at high footprint) boundaries.\84\

The resulting curve was an elongated reverse ``S'' shape, with fuel economy targets decreasing as footprint increased.

\84\ NHTSA determined the values of the parameters establishing the upper and lower asymptotes by calculating the sales-weighted harmonic average values of optimized fuel economy levels for light trucks with footprints below 43 square feet and above 65 square feet, respectively. Because these ranges respectively included the smallest and largest models represented at that time in the light truck fleet, the agency determined that these two segments of the light truck fleet were appropriate for establishing the upper and lower fuel economy bounds of a continuous function.

The remaining two parameters (i.e., the ``midpoint'' and ``curvature'' parameters) were estimated using production-weighted nonlinear least-squares regression to achieve the closest fit to data on footprint and optimized fuel economy for all light truck models expected to be produced during each of the model years 2008-2011. More precisely, these two parameters determine the range between the vehicle footprints where the upper and lower limits of fuel economy are reached, and the value of footprint for which the value of fuel economy is midway between its upper and lower bounds.

NHTSA has tentatively concluded that a constrained logistic function would continue to be appropriate for setting CAFE standards for both passenger cars and light trucks. We have reached that conclusion because the concerns that prevented NHTSA from choosing another mathematical function in the light truck CAFE rule continue to be relevant to the new standards. The description below of the Volpe model and how it works explains in much more detail how the constrained logistic function has been updated for purposes of this rulemaking. NHTSA seeks comment on whether another mathematical function might result in improved standards consistent with EPCA and EISA.

V. Volpe Model/Analysis/Generic Description of Function

A. The Volpe model

1. What is the Volpe model?

As it did for the development and analysis of the April 2006 light truck final rule, in developing this proposal NHTSA made significant use of a peer-reviewed modeling system developed by the Department of Transportation's Volpe National Transportation Systems Center (Volpe Center). The CAFE Compliance and Effects Modeling System (referred to herein as the Volpe model) serves two fundamental purposes: Identifying technologies each manufacturer could apply in order to comply with a specified set of CAFE standards, and calculating the costs and effects of manufacturers' application of technologies.

Before working with the Volpe Center to develop and apply this model, NHTSA had considered other options, including other modeling systems. NHTSA was unable to identify any other system that could operate at a sufficient level of detail with respect to manufacturers' future products, which involve thousands of unique vehicle models using hundreds of unique engines and hundreds of unique transmissions. NHTSA was also unable to identify any other system that could simulate a range of different possible reforms to CAFE standards. The Volpe model provides these and other capabilities, and helps NHTSA examine potential regulatory options.

2. How does the Volpe model apply technologies to manufacturers' future fleets?

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 proposed rule. 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 current proposal, the light vehicle (passenger car and light truck) market forecast included more than 3,000 vehicle models, more than 400 specific engines, and nearly 400 specific transmissions.\85\ This level of detail in the representation of the vehicle market is vital to an accurate analysis of manufacturer-specific costs and the analysis of reformed 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.

\85\ The market forecast is an input to the Volpe model developed by NHTSA using 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.

Examples of other models and analyses that NHTSA and Volpe Center staff have considered include DOE's NEMS, Oak Ridge National Laboratory's (ORNL) Transitional Alternative Fuels and Vehicles (TAFV) 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 power train/fuel combinations (e.g., methanol fuel-cell vehicle).\86\ Therefore, as currently structured, NEMS is unable to estimate manufacturer-specific implications of attribute-based CAFE standards.

\86\ U.S. Department of Energy, ``Transportation Sector Module of the National Energy Modeling System: Model Documentation 2007,'' DOE/EIA-M070, May 2007. Available at http://tonto.eia.doe.gov/FTPROOT/modeldoc/m070(2007).pdf (last accessed April 20, 2008). NEMS's Manufacturers Technology Choice Submodule (MTCS) is believed to have logical structures similar to those in Energy and Environmental Analysis, Inc.'s (EEA's) Fuel Economy Regulatory Analysis Model (FERAM). However, FERAM documentation and source code have not been made available to NHTSA or Volpe Center staff.

TAFV accounts for many power train/fuel combinations, having been originally designed to aid understanding of possible transitions to alternative fueled vehicles, but it 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.\87\ Thus, again, as currently structured, TAFV is unable to estimate manufacturer-specific implications of attribute-based CAFE standards.

\87\ Greene, David. ``TAFV Alternative Fuels and Vehicles Choice Model Documentation,'' ORNL//TM-2001//134, July 2001. Available at http://www-cta.ornl.gov/cta/Publications/Reports/ORNL--TM--2001--134.pdf (last accessed April 20, 2008).

CARB's analysis of light vehicle GHG emissions standards uses two levels of accounting. First, based on a report prepared for Northeast States Center for a Clean Air Future (NESCCAF), CARB represents the light-duty fleet in terms of 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. For each of these five vehicles, NESCCAF's report contains the results of full vehicle simulation given several pre-specified technology ``packages.''\88\ 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 regulatory

classes.\89\ Even for a flat standard such as considered by California, NHTSA would not base its analysis of manufacturer-level costs on this level of aggregation. Use of CARB's methods would not enable NHTSA to estimate manufacturer-specific implications of the attribute-based CAFE standards proposed today.\90\

\88\ Northeast States Center for a Clean Air Future (NESCCAF), Reducing Greenhouse Gases from Light-Duty Vehicles (2004). Available at http://bronze.nescaum.org/committees/mobile/rpt040923ghglightduty.pdf (last accessed April 20, 2008).

\89\ California Environmental Protection Agency, Air Resources Board, Staff Report: Initial Statement of Reasons (CARB ISOR) (2004), at 111-114. Available at http://www.arb.ca.gov/regact/grnhsgas/isor.pdf (last accessed April 20, 2008). We note that California has adopted these standards but is currently unable to enforce them, due to EPA's February 29, 2008, denial of California's request for waiver of federal preemption under Section 209 of the Clean Air Act. For information on EPA's decision, see http://www.epa.gov/otaq/ca-waiver.htm. (Last accessed April 20, 2008.) California filed a petition in the Ninth Circuit Court of Appeals

challenging EPA's denial of the waiver on January 2, 2008.
\90\ Although CARB's analysis covered a wider range of model years than does NHTSA's analysis, this does not lessen the importance of a detailed representation of manufacturers' fleets.

The Volpe model also uses several additional categories of data and estimates provided in various external input files:

One input file specifies the characteristics of fuel-saving technologies to be represented, and includes, for each technology, the first year in which the technology is expected to be ready for commercial application; upper and lower estimates of the effectiveness and cost (retail price equivalent) of the technology; coefficients defining the extent to which costs are expected to decline as a result of ``learning effects'' (discussed below); inclusion or exclusion of the technology on up to three technology ``paths''; and constraints (``phase-in caps'') on the annual rate at which manufacturers are estimated to be able to increase the technology's penetration rate. These technology characteristics and estimates are specified separately for each of the following categories of vehicles: Small sport/utility vehicles (SUVs), midsize SUVs, large SUVs, small pickups, large pickups, minivans, subcompact cars, compact cars, midsize cars, and large cars. In addition, the input file defining technology characteristics can (but need not) contain specified ``synergies'' between technologies--that is, differences in a given technology's effect on fuel consumption that result from the presence of other technologies.

Another input file specifies vehicular emission rates for the following pollutants: Carbon monoxide (CO), volatile organic compounds (VOCs), nitrogen oxides (NOX), particulate matter (PM), and sulfur dioxide (SO2). These rates are defined on a model year-by-model year and calendar year-by-calendar year basis, and are used to estimate changes in emissions that result from changes in vehicular travel (i.e., vehicle-miles traveled or VMT).

A third input file specifies a variety of economic and other data and estimates. The model can accommodate vehicle survival (i.e., percent of vehicles of a given vintage that remain in service) and mileage accumulation (i.e., annual travel by vehicles of a given vintage) rates extending as many years beyond the year of sale as for which estimates are available and use those for estimating VMT, fuel consumption, and emissions. The model can also accommodate forecasts of price and fuel taxation rates for up to seven fuels (e.g., gasoline, diesel) over a similar period. The model uses pump prices (i.e., including taxes) to estimate the value manufacturers expect vehicle purchasers to place on saved fuel, because they indicate the amount by which the manufacturer is expected to consider itself able to increase the retail price of the vehicle based on the purchaser's consideration of the vehicle's increased fuel economy. However, the model uses pretax fuel prices to estimate the monetized societal benefits of reduced fuel consumption, because fuel taxes represent transfers of resources from fuel buyers to government agencies rather than real resources that are consumed in the process of supplying or using fuel, so their value must be deducted from retail fuel prices to determine the value of fuel savings to the U.S. economy.

Other economic inputs include the rebound effect coefficient (i.e., the elasticity of VMT with respect to the per-mile cost of fuel); the discount rate; the ``payback period'' (i.e., the number of years manufacturers are estimated to assume vehicle purchasers consider when taking into account fuel savings); the ``gap'' between laboratory and actual fuel economy; the per-vehicle value of travel time (in dollars per hour); the economic costs (in dollars per gallon) of petroleum consumption; various external costs (all in dollars per mile) associated with changes in vehicle use; damage costs (all on a dollar per ton basis) for each of the above-mentioned criteria pollutants; and the rate at which noncompliance causes civil penalties. Section V below describes in much more detail how these inputs are included and used by the model.

The model also accommodates input data and estimates addressing the properties of different fuels. These include upstream carbon dioxide and criteria pollutant emission rates (i.e., U.S. emissions resulting from the production and distribution of each fuel), density (pounds/gallon), energy density (BTU/gallon), carbon content, shares of fuel savings leading to reduced domestic refining, and relative shares of different gasoline blends. These fuel properties and related estimates are used to calculate changes in domestic upstream emissions resulting from changes in fuel consumption.

Coefficients defining the probability distributions to apply when performing sensitivity analysis (i.e., Monte Carlo simulation) are also specified in this input file.\91\ These coefficients determine the likelihood that any given value will be selected when performing this type of analysis (e.g., the likelihood that a rebound effect of -0.1 will be tested). High and low fuel price forecasts are also specified in this input file for this purpose.

\91\ The sensitivity analysis and its usefulness are explained more fully below.

The final input file contains CAFE scenarios to be examined. The model accommodates a baseline (i.e., business-as-usual) scenario and different alternative scenarios. Effects of the alternative scenarios are calculated relative to results for the baseline scenario. Each scenario defines the coverage, structure, and stringency of CAFE standards for each of the covered model years.

With all of the above input data and estimates, the modeling system develops an estimate of a set of technologies each manufacturer could apply in response to each specified CAFE scenario. Because manufacturers have many choices regarding how to respond to CAFE standards, it is impossible to predict precisely how a given manufacturer would respond to a given set of standards. The modeling system begins with the ``initial state'' (i.e., business-as-usual) of each manufacturer's future vehicles, and accumulates the estimated costs of progressive additions of fuel-saving technologies. Within a set of specified constraints, the system adds technologies following a cost-minimizing approach, because this is what NHTSA expects a manufacturer would do in real life. At each step, the system evaluates the effective cost of applying available technologies to individual vehicle models, engines, or transmissions, and selects the application of technology that produces the lowest effective cost. The effective cost estimated to be considered by the manufacturer is calculated by adding the total incurred technology costs (in retail price equivalent or RPE), subtracting the reduction in civil

penalties owed for noncompliance with the CAFE standard, subtracting the estimated value \92\ of the reduction in fuel costs, and dividing the result by the number of affected vehicles.

\92\ The estimated value of the reduction in fuel costs represents the amount by which the manufacturer is expected to consider itself able to increase the retail price of the vehicle based on the purchaser's consideration of the vehicle's increased fuel economy. This calculation considers the change in the discounted outlays for fuel (and fuel taxes) during a ``payback period'' specified as an input to the model.

In representing manufacturer decision-making in response to a given CAFE standard, the modeling system accounts for the fact that historically some manufacturers have been unwilling to pay penalties and some have been willing to do so. Thus, the system applies technologies until any of the following conditions are met: the manufacturer no longer owes civil penalties for failing to meet the applicable standard, the manufacturer has exhausted technologies expected to be available in that model year, or the manufacturer is estimated to be willing to pay civil penalties, and doing so is estimated to be less expensive than continuing to add technologies. The system then progresses to the next model year (if included in the vehicle market and scenario input files), ``carrying over'' technologies where vehicle models are projected to be succeeded by other vehicle models.\93\

\93\ For example, if Honda is expected to produce the Civic in 2012 and 2013, a version of the Civic estimated to be produced in 2013 may carry over technologies from a version of the Civic produced in 2012 if the latter is identified as a ``predecessor'' of the former.

In the modeling system, this ``compliance simulation'' is constrained in several ways. First, technologies are defined as being applicable or not applicable to each of the ten vehicle categories listed above. The vehicle market forecast input file may also define some technologies as being already present or not applicable to specific vehicles, engines or transmissions. For example, a manufacturer may have indicated it plans to use low-drag brakes on some specific vehicle model, or NHTSA may expect that another manufacturer is not likely to apply a 7- or 8-speed transmission after it installs a 6-speed transmission on a vehicle. Second, some technologies are subject to specific ``engineering constraints.'' For example, secondary-axle disconnect can only be applied to vehicles with four-wheel (or all-wheel) drive. Third, some technologies (e.g., conversion from pushrod valve actuation to overhead cam actuation) are nearly always applied only when the vehicle is expected to be redesigned and others (e.g., cylinder deactivation) are applied only when the vehicle is expected to be refreshed or redesigned, so the model will only apply them at those particular points. Fourth, once the system applies a given technology to a percentage of a given manufacturers' fleet exceeding a specified phase-in cap, the system instead applies other technologies. The third and fourth of these constraints are intended to produce results consistent with manufacturers' product planning practices and with limitations on how quickly technologies can penetrate the fleet.

One important aspect of this compliance simulation is that it does not attempt to account for either CAFE credits or intentional over-compliance. In the real world, manufacturers may earn CAFE credits by selling flex-fueled vehicles (FFVs) and/or by exceeding CAFE standards, and may, within limitations, count those credits toward compliance in future or prior model years. However, EPCA and EISA do not allow NHTSA to consider these flexibilities in setting the standards. Therefore, the Volpe model does not attempt to account for these flexibilities.

Another possibility NHTSA and Volpe Center staff have considered, but do not yet know how to analyze, is the potential that manufacturers might ``pull ahead'' the implementation of some technologies in response to CAFE standards that they know will be steadily increasing over time. For example, if a manufacturer plans to redesign many vehicles in MY2011 and not in MY2013, but the standard for MY2013 is considerably higher than that for MY2011, the manufacturer might find it less expensive during MY2011-MY2013 (taken together) to apply more technology in MY2011 than is necessary for compliance with the MY2011 standard. Under some circumstances, doing so might make sense even without regard to the potential to earn and bank CAFE credits.

NHTSA and Volpe Center staff have discussed the potential to represent this type of response, but have thus far encountered two challenges. First, NHTSA is not certain that in determining the maximum feasible standard in a given model year, it would be appropriate to count on manufacturers overcomplying with standards in preceding model years. Second, considering other inter-model year dependencies (e.g., technologies that carry over between model years, phase-in caps that accumulate across model years, volume-based learning curves), Volpe Center staff currently anticipate that some iterative procedure would likely be necessary. Also, the agency wonders whether trying to represent this type of response would require make undue implicit assumptions regarding manufacturers' ability to predict future market conditions. Although NHTSA and Volpe Center staff will continue to explore the potential to represent inter-model year timing, it is not yet clear that it will be appropriate and feasible to do so in the near term.

The agency requests comment on the appropriateness under EPCA of considering (in the standard-setting context) this type of anticipatory application of technology. The agency further requests comment on appropriate methodologies for projecting and representing such decisions by manufacturers.

3. What effects does the Volpe model estimate?

Having completed this compliance simulation for all manufacturers and all model years, the system calculates the total cost of all applied technologies, as well as a variety of effects of changes in fuel economy. The system calculates year-by-year mileage accumulation, taking into account any increased driving estimated to result from the rebound effect. Based on the calculated mileage accumulation and on fuel economy and the estimated gap between laboratory and actual fuel economy, the system calculates year-by-year fuel consumption. Based on calculated mileage accumulation and fuel consumption, and on specified emission factors, the system calculates future full fuel-cycle domestic carbon dioxide and criteria pollutant emissions. The system calculates total discounted and undiscounted national societal costs of year-by-year fuel consumption, taking into account estimated future fuel prices (before taxes) and the estimated economic externalities of fuel consumption. Based on changes in year-by-year mileage accumulation, the system calculates changes in consumer surplus related to additional travel, as well as economic externalities related to additional congestion, accidents, and noise stemming from additional travel. The system calculates the value of time saved because increases in fuel economy produce increases in driving range, thereby reducing the frequency with which some vehicles require refueling. The system calculates the monetary value of damages resulting from criteria pollutants. Finally, the system accumulates all discounted and undiscounted societal benefits of each scenario as compared to the baseline

scenario. For each model year, the system compares total incurred technology costs to the total present value of societal benefits for each model year, calculating net societal benefits (i.e., discounted societal benefits minus total incurred technology costs) and the benefit-cost ratio (i.e., discounted societal benefits divided by total incurred technology costs).

One effect not currently estimated by the Volpe model is the market response to CAFE-induced changes in vehicle prices and fuel economy levels. NHTSA and Volpe Center staff have worked to try and develop and apply a market share model capable of estimating changes in sales of individual vehicle models. Doing so would allow estimation of the feedback between market shifts and CAFE requirements. For example, if the relative market share of vehicles with small footprints increases, the average required CAFE level under a footprint-based standard will also increase.

In an early experimental version of the Volpe model, Volpe Center staff included a market share model using a nested multinomial logit specification to calculate model-by-model changes in sales volumes. This allowed the Volpe model to calculate the resulting changes in manufacturers' required CAFE levels, and to seek iteratively a solution at which prices, fuel economy levels, sales volumes, and required CAFE levels converged to stable values. Although the market share model appeared to operate properly (and to converge rapidly), Volpe Center staff suspended its development because of three challenges:

First, Volpe Center staff were not successful in calibrating a logically consistent set of coefficients for the underlying multinomial logit model. The analysis, performed using information from a known (2002 model year) fleet, consistently yielded one or more coefficients that were either directionally incorrect (e.g., indicating that some attributes actually detract from value) or implausibly large (e.g., indicating that some attributes were of overwhelming value). Although Volpe Center staff tested many different specifications of the market share model, none produced results that appeared to merit further consideration.

Second, NHTSA and Volpe Center staff are not confident that baseline sales prices for individual vehicle models, which would be required by a market share model, can be reliably predicted. Although NHTSA requests that manufacturers include planned MSRPs in product plans submitted to NHTSA, MSRPs do not include the effect of various sales incentives that can change actual selling prices. The availability and dollar value of such incentives have been observed to vary considerably, but not necessarily predictably.

Finally, before applying a market share model, it would be necessary to estimate how manufacturers would allocate compliance costs among vehicle models. Although one obvious approach would be to assume that all costs would be passed through in the form of higher prices for those vehicle models with improved fuel economy, other approaches are perhaps equally plausible. For example, a manufacturer might shift compliance costs toward high-demand vehicles in order to compete better in certain market segments. Although the above-mentioned experimental version of the Volpe model included a ``cost allocation'' model that offered several different allocation options, NHTSA and Volpe Center staff never achieved confidence that these aspects of manufacturer decisions could be reasonably estimated.

NHTSA and Volpe Center staff are continuing to explore options for including these types of effects. At the same time, EPA has contracted with Resources for the Future (RFF) to develop a potential market share model. Depending on the extent to which these efforts are successful, the Volpe model could at some point be modified to include cost allocation and market share models. NHTSA seeks comments on possible methodologies for incorporating market responses to CAFE-induced changes in vehicle price and fuel economy in the Volpe model. In particular, NHTSA seeks comments addressing the concerns identified above regarding the formulation and calibration of a market share model, the estimation of future vehicle prices, and the estimation of manufacturers' decisions regarding the allocation of compliance costs.

4. How can the Volpe model be used to calibrate and evaluate potential CAFE standards?

The modeling system can also be applied in a more highly-automated mode whereby the optimal shape of an attribute-based CAFE standard may be estimated and its stringency may be set at a level that produces a specified total technology cost or average required CAFE level among a specified set of manufacturers, or that is estimated to maximize net societal benefits. The first step in this operating mode involves identifying manufacturer-by-manufacturer CAFE levels at which societal benefits are estimated to be maximized. The second step involves combining the resultant fleets and statistically fitting a constrained logistic curve of the following form:

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Here, TARGET is the fuel economy target (in mpg) applicable to vehicles of a given footprint (FOOTPRINT, in square feet), LIMITLOWER and LIMITUPPER are the function's lower and upper asymptotes (also in mpg), e is approximately equal to 2.718,\94\ MIDPOINT 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 WIDTH 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 V-1 below shows an example of a logistic target function, where LIMITLOWER = 20 mpg, LIMITUPPER = 30 mpg, MIDPOINT = 40 square feet, and WIDTH = 5 square feet:

\94\ The number e is one of the most important numbers in mathematics and statistics. The function has a hockey stick appearance when plotted. The value of e itself is a never ending number whose first 8 digits equal 2.7182818. NHTSA uses it here because it occurs in many natural processes and tends to fit data well. In the last light truck rulemaking, NHTSA examined several functional forms that did not rely on e, but they were judged not to provide as good a fit for the data. We are using the same conclusion here.

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The lower asymptote is determined by calculating the average fuel economy of the largest vehicles in the ``optimized'' fleet discussed above, where the percentage of the fleet to consider is specified externally. Similarly, the upper asymptote is determined by calculating the average fuel economy of the smallest vehicles in the same fleet. Initial values of the other two coefficients of the logistic function are determined through a standard statistical technique (nonlinear least-square regression), except as discussed in sections V and VI below regarding the adjusting of the original curve for the passenger car function.

Following this initial calibration of the target function, the system adjusts the lower and upper asymptotes uniformly (on a gallon per mile basis) until one of the following externally specified conditions is met: the average CAFE level required of the included manufacturers approximately equals an externally specified goal; net societal benefits (i.e., total benefits minus total costs) are maximized, or total benefits are as close as observed (among evaluated stringency levels) to total costs. Due to rounding of fuel economy and CAFE levels, the first condition can only be satisfied on an approximate basis.

The modeling system provides another type of higher-level automation--the ability to perform uncertainty analysis, also referred to as Monte Carlo simulation. For some input parameters, such as technology costs, values can be tested over a specified continuous probability distribution. For others, such as fuel prices, discrete scenarios (e.g., high, low, and reference cases), each with a specified probability, can be tested. The system performs sensitivity analysis by randomly selecting values for parameters to be varied, performing the compliance simulation and effects calculations, repeating these results many times and recording results for external analysis. This operating mode enables the examination of the uncertainty of high-level results (e.g., total costs, fuel savings, or net societal benefits), as well as their sensitivity to variations in the model's input parameters.

5. How has the Volpe model been updated since the April 2006 light truck CAFE final rule?

Several changes were made to the Volpe model between the analysis reported in the April 2006 light truck final rule and the analysis of the current NPRM. As discussed above, the set of technologies represented was updated, the logical sequence for progressing

through these technologies was changed, methods to account for ``synergies'' (i.e., interactions) between technologies and technology cost reductions associated with a manufacturer's ``learning'' were added, the effective cost calculation used in the technology application algorithm was modified, and the procedure for calibrating a reformed standard was changed, as was the procedure for estimating the optimal stringency of a reformed standard.

As discussed in Section III above, the set of technologies considered by the agency has evolved since the previous light truck CAFE rulemaking. The set of technologies now included in the Volpe model is shown below in Table V-1, with codes used by the model to refer to each technology.

Table V-1.--Revised Technology Set for Volpe Model

Technology	Code (for Model)

Low Friction Lubricants....................	LUB
Engine Friction Reduction..................	EFR
Variable Valve Timing (Intake Cam Phasing)..	VVTI
Variable Valve Timing (Coupled Cam Phasing).	VVTC
Variable Valve Timing (Dual Cam Phasing)....	VVTD
Cylinder Deactivation......................	DISP
Variable Valve Lift & Timing (Continuous VVL).	VVLTC
Variable Valve Lift & Timing (Discrete VVL).	VVLTD
Cylinder Deactivation on Overhead Valve (OHV).	DISPO
Variable Valve Timing (CCP) on OHV..........	VVTO
Multivalve Overhead Cam with CVVL...........	DOHC
Variable Valve Lift & Timing (DVVL) on OHV..	VVLTO
Camless Valve Actuation....................	CVA
Stoichiometric Gasoline Direct Injection (GDI).	SIDI
Lean Burn GDI..............................	LBDI
Turbocharging and Downsizing................	TURB
Homogeneous Charge Compression Ignition.....	HCCI
Diesel with Lean NOX Trap (LNT).............	DSLL
Diesel with Selective Catalytic Reduction (SCR).	DSLS
5 Speed Automatic Transmission..............	5SP
Aggressive Shift Logic.....................	ASL
Early Torque Converter Lockup...............	TORQ
6 Speed Automatic Transmission..............	6SP
Automatic Manual Transmission...............	AMT
Continuously Variable Transmission..........	CVT
6 Speed Manual.............................	6MAN
Improved Accessories.......................	IACC
Electronic Power Steering..................	EPS
42-Volt Electrical System..................	42V
Low Rolling Resistance Tires................	ROLL
Low Drag Brakes............................	LDB
Secondary Axle Disconnect--Unibody..........	SAXU
Secondary Axle Disconnect--Ladder Frame.....	SAXL
Aero Drag Reduction........................	AERO
Material Substitution (1%)..................	MS1
Material Substitution (2%)..................	MS2
Material Substitution (5%)..................	MS5
Integrated Starter/Generator (ISG) with Idle-Off.	ISGO
IMA/ISAD/BSG Hybrid (includes engine downsizing).	IHYB
2-Mode Hybrid..............................	2HYB
Power Split Hybrid.........................	PHYB
Full Diesel Hybrid.........................	DHYB

The logical sequence for progressing between these technologies has also been changed. As in the previous version of the Volpe model, technologies are assigned to groups (e.g., engine technologies) and the model follows a cost-minimizing approach to selecting technologies. However, the model now includes some ``branch points'' at which it selects from two or more technologies within the same group. This enables a more detailed representation of some technologies that have multiple variants (e.g., variable valve timing) and, as relevant to the applicability of different technologies, more specific differentiation between technologies that have already been applied to vehicles (e.g., single versus dual overhead cam engines). This revised logical sequencing is expected to produce results that are more realistic in terms of the application of technologies to different vehicle models. For example, in this analysis OHV engines and OHC engines were considered separately, and the model was generally not allowed to apply multivalve OHC technology to OHV engines (except where continuous variable valve timing and lift is applied to OHV engines, in which case the model assumes conversion to DOHC valvetrain).

Figure V-2 below shows the resultant ``decision tree'' for the group of engine technologies. As an example of the ``branching'' mentioned above, having applied cylinder deactivation and coupled cam phasing to an overhead valve engine, the Volpe model selects either discrete valve lift or an engine redesign to multivalve overhead cam with continuous variable valve lift. Figure V-3 shows the decision tree for transmission technologies, and Figure V-4 shows the decision trees for other technologies.

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Each time the model applies a technology to a vehicle in the fleet, it considers the next available technology on every available path. An available technology is one that is not included in the base vehicle, has not been applied by the model, and is not disqualified due to the vehicle's characteristics (discussed below). For a given path, the next available technology is the first available item (if no technologies on the path have yet been applied) or the first available item following the most recently applied technology on that path. An available path is any path that includes available technologies.

The engine and transmission paths contain several forks where the model may choose among two or more same-path items along with items from other paths. At some of these forks, conditions on the connecting arrows require the model to follow a particular branch. These conditions are based on previously applied technologies or vehicle characteristics. For example, ladder frame vehicles must follow the left branch of the transmission technology path, while unibody vehicles can follow either the right or left branch. The consequence is that the model considers both aggressive shift logic (ASL) and CVT for unibody vehicles, but only ASL for ladder frame vehicles. Conditions along the engine technologies path are based on valvetrain design (OHV, OHC, SOHC, and DOHC).

Other conditions require the model to discontinue considering technologies along a given path. For example, 2-Mode Hybrid and Power Split Hybrid drivetrains can be applied only to vehicles equipped with automatic transmissions. If the model has already chosen a manual transmission and IMA/ISAD/BSG Hybrid drivetrain (or if the base vehicle is equipped with these), the hybrid path becomes unavailable and the model must choose subsequent technologies from other paths.

a. Technology Synergies

In some cases, the change in fuel economy achieved by applying a given technology depends on what other technologies are already present. The Volpe model has been modified to provide the ability to represent such ``synergies'' between technologies, as discussed above. These effects are specified in one of the model's input files. As shown below in Table V-2, which uses technology codes listed in Table V-1 above, most of the synergies represented in the analysis of this proposal are negative. In other words, most of the interactions are such that a given technology has a smaller effect on fuel economy if some other technologies have already been applied. The inclusion of such effects in the model is

expected to produce more realistic estimates of the benefit of applying various technologies.

Table V-2.--``Synergies'' from Technology Input File for Volpe Model

[In percent]

Technology A	Technology B	SUV-Small	SUV-Mid	SUV-Large	Minivan	Pickup-Small
Synergies		Synergy values by vehicle class. Positive values are synergies, negative values are dissynergies.				
VVTI	5SP	-0.50	-0.50	-0.50	-0.50	-0.50
VVTI	ISGO	-0.50	-0.50	-0.50	-0.50	-0.50
VVTC	5SP	-0.50	-0.50	-0.50	-0.50	-0.50
VVTC	CVT	-0.50	-0.50	-0.50	-0.50	-0.50
VVTC	ASL	-0.50	-0.50	-0.50	-0.50	-0.50
DISP	5SP	-1.00	-1.00	-1.00	-1.00	-1.00
DISP	CVT	-1.00	-1.00	-1.00	-1.00	-1.00
DISP	ASL	-0.50	-0.50	-0.50	-0.50	-0.50
DISP	ISGO	-0.50	-0.50	-0.50	-0.50	-0.50
VVLTC	5SP	-0.50	-0.50	-0.50	-0.50	-0.50
VVLTC	CVT	-0.50	-0.50	-0.50	-0.50	-0.50
VVLTC	ASL	-0.50	-0.50	-0.50	-0.50	-0.50
VVLTC	6MAN	-0.50	-0.50	-0.50	-0.50	-0.50
VVLTD	CVT	-0.50	-0.50	-0.50	-0.50	-0.50
VVLTD	6SP	-0.50	-0.50	-0.50	-0.50	-0.50
DISPO	5SP	-1.50	-1.50	-1.50	-1.50	-1.50
DISPO	CVT	-1.00	-1.00	-1.00	-1.00	-1.00
DISPO	ASL	-0.50	-0.50	-0.50	-0.50	-0.50
DISPO	6SP	-0.50	-0.50	-0.50	-0.50	-0.50
DISPO	ISGO	-1.00	-1.00	-1.00	-1.00	-1.00
VVTO	CVT	-0.50	-0.50	-0.50	-0.50	-0.50
VVTO	6MAN	0.50	0.50	0.50	0.50	0.50
DOHC	5SP	-1.00	-1.00	-1.00	-1.00	-1.00
DOHC	CVT	-1.00	-1.00	-1.00	-1.00	-1.00
DOHC	ASL	-0.50	-0.50	-0.50	-0.50	-0.50

DOHC	6SP	-0.50	-0.50	-0.50	-0.50	-0.50
DOHC	6MAN	-0.50	-0.50	-0.50	-0.50	-0.50
DOHC	ISGO	0.50	0.50	0.50	0.50	0.50
VVLTO	5SP	-0.50	-0.50	-0.50	-0.50	-0.50
VVLTO	CVT	-0.50	-0.50	-0.50	-0.50	-0.50
VVLTO	6SP	-0.50	-0.50	-0.50	-0.50	-0.50

[In percent]

Synergies		Synergy values by vehicle class. Positive values are synergies, negative values are dissynergies.				
Technology A	Technology B	SUV-Small	SUV-Mid	SUV-Large	Minivan	Pickup-Small
CVA	5SP	-0.50	-0.50	-0.50	-0.50	-0.50
CVA	CVT	-1.00	-1.00	-1.00	-1.00	-1.00
CVA	ASL	-0.50	-0.50	-0.50	-0.50	-0.50
CVA	6SP	-0.50	-0.50	-0.50	-0.50	-0.50
CVA	6MAN	0.50	0.50	0.50	0.50	0.50
HCCI	CVT	-0.50	-0.50	-0.50	-0.50	-0.50
HCCI	6SP	-0.50	-0.50	-0.50	-0.50	-0.50
TURB	5SP	-1.00	-1.00	-1.00	-1.00	-1.00
TURB	CVT	-1.00	-1.00	-1.00	-1.00	-1.00
TURB	ASL	-0.50	-0.50	-0.50	-0.50	-0.50
TURB	6SP	-0.50	-0.50	-0.50	-0.50	-0.50
TURB	6MAN	-0.50	-0.50	-0.50	-0.50	-0.50
E25	5SP	0.50	0.50	0.50	0.50	0.50
E25	6MAN	0.50	0.50	0.50	0.50	0.50
E25	ISGO	-0.50	-0.50	-0.50	-0.50	-0.50
ISGO	IACC	-0.50	-0.50	-0.50	-0.50	-0.50
ISGO	EPS	-1.00	-1.00	-1.00	-1.00	-1.00
ISGO	42V	-1.00	-1.00	-1.00	-1.00	-1.00
DSLT	5SP	0.50	0.50	0.50	0.50	0.50

DSLT........................	CVT............	0.50	0.50	0.50	0.50	0.50
DSLT........................	ISGO...........	0.50	0.50	0.50	0.50	0.50
DSLT........................	ASL............	0.50	0.50	0.50	0.50	0.50
DSLH........................	5SP............	0.50	0.50	0.50	0.50	0.50
DSLH........................	CVT............	-0.50	-0.50	-0.50	-0.50	-0.50
DSLH........................	6SP............	-0.50	-0.50	-0.50	-0.50	-0.50

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[[pp. 24401-24450]] Average Fuel Economy Standards, Passenger Cars and Light Trucks; Model Years 2011-2015

[[Continued from page 24400]]

DSLH........................	6MAN...........	0.50	0.50	0.50	0.50	0.50
DSLH........................	ISGO...........	0.50	0.50	0.50	0.50	0.50
DSLS........................	5SP............	-0.50	-0.50	-0.50	-0.50	-0.50
DSLS........................	CVT............	-2.50	-2.50	-2.50	-2.50	-2.50
DSLS........................	6SP............	-1.00	-1.00	-1.00	-1.00	-1.00
DSLS........................	6MAN...........	-0.50	-0.50	-0.50	-0.50	-0.50
DSLS........................	ISGO...........	0.50	0.50	0.50	0.50	0.50

[In percent]

Synergies		Synergy values by vehicle class. Positive values are synergies, negative values are dissynergies.				
Technology A	Technology B	Pickup-Large	Subcompact	Compact	Midsize	Large
VVTI........................	5SP............	-0.50	-0.50	-0.50	-0.50	-0.50
VVTI........................	ISGO...........	-0.50	-0.50	-0.50	-0.50	-0.50
VVTC........................	5SP............	-0.50	-0.50	-0.50	-0.50	-0.50
VVTC........................	CVT............	-0.50	-0.50	-0.50	-0.50	-0.50
VVTC........................	ASL............	-0.50	-0.50			

Technology A	Technology B	Pickup-Large	Subcompact	Compact	Midsize	Large
				-0.50	-0.50	-0.50
DISP........................	5SP............	-1.00	-1.00	-1.00	-1.00	-1.00
DISP........................	CVT............	-1.00	-1.00	-1.00	-1.00	-1.00
DISP........................	ASL............	-0.50	-0.50	-0.50	-0.50	-0.50
DISP........................	ISGO...........	-0.50	-0.50	-0.50	-0.50	-0.50
VVLTC.......................	5SP............	-0.50	-0.50	-0.50	-0.50	-0.50
VVLTC.......................	CVT............	-0.50	-0.50	-0.50	-0.50	-0.50
VVLTC.......................	ASL............	-0.50	-0.50	-0.50	-0.50	-0.50
VVLTC.......................	6MAN...........	-0.50	-0.50	-0.50	-0.50	-0.50
VVLTD.......................	CVT............	-0.50	-0.50	-0.50	-0.50	-0.50
VVLTD.......................	6SP............	-0.50	-0.50	-0.50	-0.50	-0.50
DISPO.......................	5SP............	-1.50	-1.50	-1.50	-1.50	-1.50
DISPO.......................	CVT............	-1.00	-1.00	-1.00	-1.00	-1.00
DISPO.......................	ASL............	-0.50	-0.50	-0.50	-0.50	-0.50
DISPO.......................	6SP............	-0.50	-0.50	-0.50	-0.50	-0.50
DISPO.......................	ISGO...........	-1.00	-1.00	-1.00	-1.00	-1.00
VVTO........................	CVT............	-0.50	-0.50	-0.50	-0.50	-0.50
VVTO........................	6MAN...........	0.50	0.50	0.50	0.50	0.50
DOHC........................	5SP............	-1.00	-1.00	-1.00	-1.00	-1.00
DOHC........................	CVT............	-1.00	-1.00	-1.00	-1.00	-1.00
DOHC........................	ASL............	-0.50	-0.50	-0.50	-0.50	-0.50
DOHC........................	6SP............	-0.50	-0.50	-0.50	-0.50	-0.50
DOHC........................	6MAN...........	-0.50	-0.50	-0.50	-0.50	-0.50
DOHC........................	ISGO...........	0.50	0.50	0.50	0.50	0.50
VVLTO.......................	5SP............	-0.50	-0.50	-0.50	-0.50	-0.50
VVLTO.......................	CVT............	-0.50	-0.50	-0.50	-0.50	-0.50
VVLTO.......................	6SP............	-0.50	-0.50	-0.50	-0.50	-0.50

[In percent]

Synergies		Synergy values by vehicle class. Positive values are synergies, negative values are dissynergies.				
Technology A	Technology B	Pickup-Large	Subcompact	Compact	Midsize	Large

CVA........................	5SP............	-0.50	-0.50	-0.50	-0.50	-0.50
CVA........................	CVT............	-1.00	-1.00	-1.00	-1.00	-1.00
CVA........................	ASL............	-0.50	-0.50	-0.50	-0.50	-0.50
CVA........................	6SP............	-0.50	-0.50	-0.50	-0.50	-0.50
CVA........................	6MAN...........	0.50	0.50	0.50	0.50	0.50
HCCI.......................	CVT............	-0.50	-0.50	-0.50	-0.50	-0.50
HCCI.......................	6SP............	-0.50	-0.50	-0.50	-0.50	-0.50
TURB.......................	5SP............	-1.00	-1.00	-1.00	-1.00	-1.00
TURB.......................	CVT............	-1.00	-1.00	-1.00	-1.00	-1.00
TURB.......................	ASL............	-0.50	-0.50	-0.50	-0.50	-0.50
TURB.......................	6SP............	-0.50	-0.50	-0.50	-0.50	-0.50
TURB.......................	6MAN...........	-0.50	-0.50	-0.50	-0.50	-0.50
E25........................	5SP............	0.50	0.50	0.50	0.50	0.50
E25........................	6MAN...........	0.50	0.50	0.50	0.50	0.50

E25........................	ISGO...........	-0.50	-0.50	-0.50	-0.50	-0.50
ISGO.......................	IACC...........	-0.50	-0.50	-0.50	-0.50	-0.50
ISGO.......................	EPS............	-1.00	-1.00	-1.00	-1.00	-1.00
ISGO.......................	42V............	-1.00	-1.00	-1.00	-1.00	-1.00
DSLT.......................	5SP............	0.50	0.50	0.50	0.50	0.50
DSLT.......................	CVT............	0.50	0.50	0.50	0.50	0.50
DSLT.......................	ISGO...........	0.50	0.50	0.50	0.50	0.50
DSLT.......................	ASL............	0.50	0.00	0.00	0.50	0.50
DSLH.......................	5SP............	0.50	0.50	0.50	0.50	0.50
DSLH.......................	CVT............	-0.50	-0.50	-0.50	-0.50	-0.50
DSLH.......................	6SP............	-0.50	-0.50	-0.50	-0.50	-0.50
DSLH.......................	6MAN...........	0.50	0.50	0.50	0.50	0.50
DSLH.......................	ISGO...........	0.50	0.50	0.50	0.50	0.50
DSLS.......................	5SP............	-0.50	-0.50	-0.50	-0.50	-0.50
DSLS.......................	CVT............	-2.50	-2.50	-2.50	-2.50	-2.50
DSLS.......................	6SP............	-1.00	-1.00	-1.00	-1.00	-1.00
DSLS.......................	6MAN...........	-0.50	-0.50	-0.50	-0.50	-0.50
DSLS.......................	ISGO...........	0.50	0.50			

0.50 0.50 0.50

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b. Technology learning curves

The Volpe model has also been modified to provide the ability to account for cost reductions a manufacturer may realize through learning achieved from experience in actually applying a given technology. Thus, for some of the technologies, we have included a learning factor. Stated another way, the ``learning curve'' describes the reduction in unit production costs as a function of accumulated production volume and small redesigns that reduce costs.

As explained above, a typical learning curve can be described by three parameters: (1) The initial production volume before cost reductions begin to be realized; (2) the rate at which cost reductions occur with increases in cumulative production beyond this initial volume (usually referred to as the ``learning rate''); and (3) the production volume after which costs reach a ``floor,'' and further cost reductions no longer occur. Over the region where costs decline with accumulating production volume, an experience curve can be expressed as C(Q) = aQ¯\b\, where a is a constant coefficient, Q represents cumulative production, and b is a coefficient corresponding to the assumed learning rate. In turn, the learning rate L, which is usually expressed as the percent by which average unit cost declines with a doubling of cumulative production, and is related to the value of the coefficient b by L = 100*(1 - 2-\b\).\95\

\95\ See, e.g., Robert H. Williams, ``Toward Cost Buydown via Learning-by-Doing for Environmental Energy Technologies,'' paper presented at Workshop on Learning-by-Doing in Energy Technologies, Resources for the Future, Washington, DC, June 17-18, 2003, pp. 1-2. Another common but equivalent formulation of the relationship between L and b is (1-L) = 2\-b\, where (1-L) is referred to as the progress ratio; see Richard P. Rumelt, ``Note on Strategic Cost Dynamics,'' POL 2001-1.1, Anderson School of Business, University of California, Los Angeles, California, 2001, pp. 4-5.

The new learning curves are described in greater detail above in Section III. We seek comment on the assumptions used to develop the new proposed learning curves.

c. Calibration of reformed CAFE standards

The procedure used by the Volpe model to develop (i.e., calibrate) the initial shape of a reformed standard was also modified. In the version of the model used to analyze NHTSA's April 2006 light truck final rule, the asymptotes for the constrained logistic function defining fuel economy targets were assigned based on the set of vehicles that would have been assigned to the lowest and highest bins defined in that rule's 2005 NPRM. The Volpe model has been modified to accept specified percentages (in terms of either models or sales) of the fleet to include when assigning asymptotes.

The procedure used by the Volpe model to estimate the ``optimized'' stringency of a reformed standard was also modified. In the version of the model used to analyze the 2006 light truck final rule, the shape of the function (i.e., the constrained logistic function) defining fuel economy targets was recalibrated every model year and then shifted up and down to estimate the stringency at which marginal costs begin to exceed marginal benefits or, equivalently, the point at which net societal benefits are maximized. However, analysis conducted by the agency to prepare for the current rulemaking revealed several opportunities to refine the procedure described above before applying it to an action that spans several model years. The first refinement is a method for gradually transforming the shape of the continuous function between model years and guarding against erratic fluctuations in the shape (though not necessarily the stringency) of the continuous function. The second is the implementation of several anti-backsliding measures that prevents the average required CAFE level from falling between model years and prevents the continuous function for a given model from crossing or falling below that of the preceding model year. The third, applied to passenger cars only, is an option to specify a fixed relationship between the function's midpoint and width coefficients. These refinements are discussed in greater detail in Section V.B below.

6. What manufacturer information does the Volpe model use?

For purposes of determining and analyzing CAFE standards, NHTSA has historically made significant use of detailed product plan information provided to the agency by individual manufacturers, supplementing this information where appropriate with information from other sources, such as data submitted to the agency in relation to CAFE compliance. Such information is considered confidential business

information (CBI) under federal law. Although NHTSA shares the information with other agencies (Volpe, EPA, and DOE) involved in CAFE activities, neither NHTSA nor any other agency may release the information to the public.

Consistent with this practice, the Volpe model uses detailed representations of (i.e., model-by-model, linked to specific engines and transmissions) the fleets manufacturers are expected to produce for sale in the U.S. In preparation for today's action, the agency issued in the spring of 2006 a request that manufacturers provide updated product plans for passenger cars and light trucks.

NHTSA received product plan information from Chrysler, Ford, GM, Honda, Nissan, Mitsubishi, Porsche and Toyota. The agency did not receive any product plan information from BMW, Ferrari, Hyundai, Mercedes or VW.

Chrysler, Ford, GM, Honda, Nissan, Mitsubishi, Porsche and Toyota provided information covering multiple model years. However, only Chrysler and Mitsubishi provided us with product plans that showed differing production quantities, vehicle introductions, vehicle redesigns/refreshes changes, without any carryover production quantities, from MY 2007 to MY 2015. The agency incorporated their product plan information as part of the input file to the model without the need to project or carryover any vehicle production data.

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 we started to carry 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 we started to carry 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 us to carry them forward.

Product plan information was provided until MY 2008 for Porsche, thus the first year that we started to carry over production quantities for Porsche was MY 2009.

For Hyundai, given that it is one of the largest 7 manufacturers, the agency used the mid-year 2007 data contained in the agency's CAFE database to establish the baseline models and production quantities for their vehicles. For the other manufacturers, because of the time constraint the agency was under to meet the statutory deadline, we used the 2005 information from our database, which is the latest information used in the current analysis. To the extent possible, because, the CAFE database does not capture all of the product plan data that we request from companies, we supplemented the CAFE database information with information on public Web sites, from commercial information sources and for Hyundai, from the MY 2008-2011 light truck rule.

In all cases, manufacturers' respective sales volumes were normalized to produce passenger car and light truck fleets that reflected manufacturers' MY2006 market shares and to reflect passenger car and light truck fleets of projected aggregate volume consistent with forecasts in the EIA's 2007 Annual Energy Outlook. The agency requests comment on whether alternative methods should be used to estimate manufacturers' market shares and the overall sizes of the future passenger car and light truck fleets.

In a companion notice, the agency is requesting updated product plan information from all companies, and as in previous fuel economy rulemakings, we will be using those plans for the final rule. These plans will impact the standards for the final rule. To that end, the agency is requesting that these plans be as detailed and as accurate as possible.

7. What economic information does the Volpe model use?

NHTSA's preliminary analysis of alternative CAFE standards for the model years covered by this proposed rulemaking relies on a range of information, economic estimates, and input parameters. This section describes this information and each assumption and specific parameter values, and discusses the rationale for tentatively choosing each one. Like the product plan information, 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 and as discussed below, the price of gasoline and discount rate used for discounting future benefits have the greatest influence over the level of the standards. The agency seeks comment on the economic assumptions presented below. On the first question, based on the comparisons of the side cases to the base case that Jim did on Friday, the order of impact for the economic assumptions is: (1) Technology cost and effectiveness; (2) fuel prices; (3) discount rate; (4) oil import externalities; (5) rebound effect; (6) criteria air pollutant damage costs; (7) carbon costs. This reflects the base case assumptions, and could change slightly if we used different assumptions to start, but 1st through 3rd should stay the same.

For the reader's reference, Table V-3 below summarizes the values used to calculate the impacts of each scenario:

Table V-3.--Economic Values for Benefits Computations (2006$)

Rebound Effect (VMT Elasticity w/respect to Fuel Cost per Mile)	-0.15
Discount Rate Applied to Future Benefits	7%
Payback Period (years)	5.0
``Gap'' between Test and On-Road mpg	20%
Value of Travel Time per Vehicle ($/hour)	$24.00
Economic Costs of Oil Imports ($/gallon)	
``Monopsony'' Component	$0.176
Price Shock Component	$0.109
Military Security Component	$--
Total Economic Costs ($/gallon)	$0.285
Total Economic Costs ($/BBL)	$11.97
External Costs from Additional Automobile Use Due to ``Rebound'' Effect ($/vehicle-mile)	
Congestion	$0.047
Accidents	$0.025
Noise	$0.001
External Costs from Additional Light Truck Use Due to ``Rebound'' Effect ($/vehicle-mile)	
Congestion	$0.052
Accidents	$0.023
Noise	$0.001
Emission Damage Costs	
Carbon Monoxide ($/ton)	$--
Volatile Organic Compounds ($/ton)	$1,700
Nitrogen Oxides ($/ton)	$3,900
Particulate Matter ($/ton)	$164,000
Sulfur Dioxide ($/ton)	$16,000

Carbon Dioxide ($/metric ton).........................	$7.00
Annual Increase in CO_2 Damage Cost..............	2.4%

a. Costs of Fuel Economy Technologies

We developed detailed estimates of the costs of applying fuel economy-improving technologies to vehicle models for use in analyzing the impacts of alternative standards considered in this rulemaking. The estimates were based on those reported by the 2002 NAS Report analyzing costs for increasing fuel economy, but were modified 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, the agency also developed varying cost estimates for applying certain fuel economy technologies to vehicles of different sizes and body styles. We may adjust these cost estimates based on comments received to this NPRM.

The technology cost estimates used in this 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 have been fully realized. However, NHTSA recognizes 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. 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 applies an indirect cost multiplier of 1.5 to the estimate of the vehicle manufacturers' direct costs for producing or acquiring each fuel economy-improving/CO2 emission-reducing technology. Historically, NHTSA has used an almost identical multiplier, 1.51, for the markup from variable costs or direct manufacturing costs to consumer costs. This markup takes into account fixed costs, burden, manufacturer's profit, and dealers' profit. NHTSA's methodology for determining this markup was recently peer reviewed.\96\

\96\ See Docket No. NHTSA-2007-27454, Item 4.

This estimate 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/low CO2 emissions by employing many of the same advanced technologies considered in our analysis.\97\ Thus, we believe that its recommendation that a multiplier of 1.5 be applied 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.

\97\ 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 April 20, 2008).

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b. Potential Opportunity Costs of Improved Fuel Economy

An important concern is whether achieving the fuel economy improvements required by alternative CAFE standards would require manufacturers to compromise the performance, carrying capacity, safety, or comfort of their vehicle models. If it did so, the resulting sacrifice in the value of these attributes to consumers would represent an additional cost of achieving the required improvements in fuel economy, and thus of manufacturers' compliance with 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 manufacturing costs that would be necessary to maintain the product plan levels of performance, comfort, capacity, or safety of any light-duty vehicle model to which those technologies are applied. In doing so, we primarily followed the precedent established by the 2002 NAS Report, although we updated its assumptions as necessary for the purposes of the current rulemaking. The NAS study estimated ``constant performance and utility'' costs for fuel economy technologies, and NHTSA has used these as the basis for their further efforts to develop the technology costs employed in analyzing manufacturer's costs for complying with alternative light truck standards.

NHTSA acknowledges 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, we believe that our tentative cost estimates for fuel economy/ CO_2 emission-reduction technologies should be generally sufficient to prevent significant reductions in consumer welfare provided by vehicle models to which manufacturers apply those technologies. Nevertheless, we seek comments on alternative ways to deal with these issues.

c. The On-Road Fuel Economy ``Gap''

Actual fuel economy levels achieved by light-duty vehicles in on-road driving fall somewhat short of their levels measured under the laboratory-like test conditions used by EPA to establish its published fuel economy ratings for different models. In analyzing the fuel savings from alternative CAFE standards, NHTSA has previously adjusted the actual fuel economy performance of each light truck model downward from its rated value to reflect the expected size of this on-road fuel

economy ``gap.'' On December 27, 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.\98\

\98\ 71 FR 77871 (Dec. 27, 2006).

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*.80). NHTSA has employed EPA's revised estimate of this on-road fuel economy gap in its analysis of the fuel savings resulting from alternative CAFE standards proposed in this rulemaking.

d. Fuel Prices and the Value of Saving Fuel

Projected future fuel prices are a critical input into the preliminary 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) for this analysis. Specifically, we used the AEO 2008 Early Release forecasts of inflation-adjusted (constant-dollar) retail gasoline and diesel fuel prices, which represent the EIA's most up-to-date estimate of the most likely course of future prices for petroleum products.\99\ Federal government agencies generally use EIA's projections in their assessments of future energy-related policies.

\99\ 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 April 20, 2008). EIA says that it will release the complete version of AEO 2008--including the High and Low Price and other side cases--at the end of April. The agency will use those figures for the final rule.

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 is $2.36 per gallon, rising gradually to $2.51 by the year 2030 (these values include federal, state and local taxes). However, valuing fuel savings over the 36-year maximum lifetime of light trucks assumed in this analysis requires fuel price forecasts that extend through 2050, the last year during which a significant number of MY 2015 vehicles will remain in service.\100\ To obtain fuel price forecasts for the years 2031 through 2050, the agency assumes that retail fuel prices forecast in the Reference Case for 2030 will remain constant (in 2006 dollars) through 2050.

\100\ 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. In the case of light-duty trucks, for example, this age has typically been 36 years for recent model years.

The value of fuel savings resulting from improved fuel economy/reduced CO_2 emissions to buyers of light-duty vehicles 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 $0.53. State fuel taxes are weighted by sales. 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, 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 as a whole.

In estimating the economy-wide or ``social'' value of fuel savings of increasing CAFE/reducing CO_2 emissions levels, NHTSA assumes that current fuel taxes will remain constant in real or inflation-adjusted terms over the lifetimes of the vehicles proposed to be regulated. In effect, this assumes that the average value per gallon of taxes on gasoline and diesel fuel levied by all levels of government will rise at the rate of inflation over that period. This value is deducted from each future year's forecast of retail gasoline and diesel prices reported in AEO 2008 to determine the social value of each gallon of fuel saved during that year as a result of improved fuel economy/reduced CO_2 emissions. Subtracting fuel taxes results 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 can be found in the PRIA. EIA includes ``High Price Case'' and ``Low Price Case'' in AEO analyses that reflect uncertainties regarding future levels of oil production, but those cases are not meant to be probabilistic, and simply illustrate the range of uncertainty that exists. Because AEO 2008 Early Release included only a Reference Case of forecast of fuel prices and did not include the High and Low Price cases, the agency 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 reported in AEO 2007.\101\ These alternative scenarios project 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 our assumption that fuel taxes will remain constant in real or inflation-adjusted terms over this period, these forecasts imply social values of saving fuel ranging from $1.47 to $2.79 per gallon during 2020, and from $1.56 to $3.23 per gallon in 2030.

\101\ Energy Information Administration, Annual Energy Outlook 2007, High Price Case, Table 12, http://www.eia.doe.gov/oiaf/aeo/pdf/aeohptab_12.pdf (last accessed April 20, 2008) and Energy Information Administration, Annual Energy Outlook 2007 Low Price Case, Table 12, http://www.eia.doe.gov/oiaf/aeo/pdf/aeolptab_12.pdf (last accessed April 20, 2008).

EIA is widely-recognized as an impartial and authoritative source of analysis and forecasts of U.S. energy production, consumption, and prices. The agency has published annual forecasts of energy prices and consumption levels for the U.S. economy since 1982 in its Annual Energy Outlook (AEO). These forecasts have been widely 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 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 AEO reported 91 separate forecasts of world oil prices for the years 1995-2005, of which 33 have subsequently proven too high while the

remaining 58 have underestimated actual prices. The average absolute error (i.e., regardless of its direction) 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 AEO have significantly underestimated petroleum prices during those years for which actual prices are now available.

However, NHTSA does 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 differ from the Reference Case forecast presented in EIA's Annual Energy Outlook 2008 Revised Early Release. This is particularly the case because this forecast has been 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 previously in AEO 2007. NHTSA also notes that retail gasoline prices across the U.S. have averaged $2.94 per gallon (expressed in 2005 dollars) for the first three months of 2008, slightly below EIA's recently revised forecast that gasoline prices will average $2.98 per gallon (also in 2005 dollars) throughout 2008.

Comparing different forecasts of world oil prices also shows that EIA's Reference Case forecast reported in Annual Energy Outlook 2007 (AEO 2007) was actually the highest of all six publicly-available forecasts of world oil prices over the 2010-30 time horizon.\102\ Because world petroleum prices are the primary determinant of retail prices for refined petroleum products such as transportation fuels, this suggests that the Reference Case forecast of U.S. fuel prices reported in AEO 2007 is likely to be the highest of those projected by major forecasting services. Further, as indicated above, EIA's most recent fuel price forecasts have been revised significantly upward from those previously projected in AEO 2007.

\102\ See http://www.eia.doe.gov/oiaf/archive/aeo07/pdf/forecast.pdf, Table 19, p. 106.

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e. Consumer Valuation of Fuel Economy and Payback Period

In estimating the value of fuel economy improvements that would result from alternative CAFE standards to potential vehicle buyers, NHTSA assumes 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. The five-year figure represents the current average term of consumer loans to finance the purchase of new vehicles. We recognize 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. However, NHTSA believes that five years represents a reasonable estimate of the average period over which buyers who finance their purchases of new vehicle receive--and thus must recognize--the monetary value of future fuel savings resulting from higher fuel economy.

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 above. It is then deducted from the technology costs incurred by its 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 its total sales for future model years.

However, it is important to recognize that NHTSA 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'' we assume for their buyers. This is discussed directly below in section f on ``Vehicle survival and use assumptions.'' As indicated previously, the maximum vehicle lifetimes used to analyze the effects of alternative fuel economy standards are estimated to be 25 years for automobiles and 36 years for light trucks.

f. Vehicle Survival and Use Assumptions

NHTSA's preliminary analysis of fuel/CO2 emissions savings and related benefits from adopting alternative standards for MY 2011-2015 passenger cars and light trucks is based on estimates of the resulting changes in fuel use over their entire lifetimes in the U.S. vehicle fleet. The first step in estimating lifetime fuel consumption by vehicles produced during a model year is to calculate the number that is expected to remain in service during each future year after they are produced and sold.\103\ This number is calculated by multiplying the number of vehicles 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.''

\103\ 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 1 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 than 2% 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, 8-11 (January 2006). Available at http://www-nrd.nhtsa.dot.gov/pdf/nrd-30/NCSA/Rpts/2006/809952.pdf (last accessed April 20, 2008).

The agency relies on projections of the number of passenger cars and light trucks that will be produced during future years reported by the EIA in its AEO Reference Case forecast.\104\ It uses updated values of age-specific survival rates for cars and light trucks 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.\105\

\104\ The most recent edition is Energy Information Administration, Annual Energy Outlook 2008: Early Release. Available at http://www.eia.doe.gov/oiaf/aeo/index.html (last accessed April 20, 2008).

\105\ Lu, S., NHTSA, Regulatory Analysis and Evaluation Division, ``Vehicle Survivability and Travel Mileage Schedules,'' DOT HS 809 952, 8-11 (January 2006). Available at http://www-nrd.nhtsa.dot.gov/pdf/nrd-30/NCSA/Rpts/2006/809952.pdf (last accessed April 20, 2008). These updated survival rates suggest that the expected lifetimes of recent-model passenger cars and light trucks are 13.8 and 14.5 years.

The next step in estimating fuel use is 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) is multiplied by the average number of miles they are expected to be driven at the age they will have reached in that year. The agency estimated the average number of miles driven annually by cars and light trucks of each age using data from the Federal Highway Administration's 2001 National Household Transportation Survey (NHTS).\106\

\106\ For a description of the Survey, see http://nhts.ornl.gov/quickStart.shtml (last accessed April 20, 2008).

Finally, fuel consumption during each year of a model year's lifetime is estimated by dividing the total number of miles its surviving vehicles are driven by the fuel economy they are expected to achieve under each alternative CAFE standard. Each model year's total lifetime fuel consumption is the sum of 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 maximum life spans. In turn, the savings in a model year's lifetime fuel use that will result from each alternative CAFE standard is the difference between its lifetime fuel use at the fuel economy level it attains under the Baseline alternative, and its lifetime fuel use at the higher fuel economy level it is projected to achieve under that alternative standard.

To illustrate these calculations, the most recent edition of the AEO projections that 8.52 million light trucks will be produced during 2012, and the agency's updated survival rates show that slightly more than half of these --50.1 percent, or 4.27 million--are projected to remain in service during the year 2027, when they will have reached an age of 14 years. At that age, light trucks achieving the fuel economy level required under the Baseline alternative are driven an average of about 10,400 miles, so model year 2012 light trucks will be driven a total of 44.4 billion miles (= 4.27 million surviving vehicles x 10,400 miles per vehicle) during 2027. Summing the results of similar calculations for each year of their 36-year maximum lifetime, model year 2012 light trucks will be driven a total of 1,502 billion miles under the Baseline alternative. Under that alternative, they are projected to achieve a test fuel economy level of 23.8 mpg, which corresponds to actual on-road fuel economy of 19.0 mpg (= 23.8 mpg x 80 percent). Thus their lifetime fuel use under the Baseline alternative is projected to be 79.0 billion gallons (= 1,502 billion miles divided by 19.0 miles per gallon).

g. Growth in Total Vehicle Use

By assuming that the annual number of miles driven by cars and light trucks at any age will remain constant over the future, NHTSA's procedure for estimating the number of miles driven by cars and light trucks over their lifetimes in effect assumes that all future growth in total vehicle-miles driven stems from increases in the number of vehicles in service, rather than from increases in the average number of miles they are driven each year. 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 determine the validity of these assumptions, the agency conducted a detailed analysis of the causes of recent growth in 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.\107\ During that time, the total number of passenger cars registered for in the U.S. grew by about 0.3 percent annually, almost exclusively as a result of increasing sales of new cars.\108\ Thus growth in the average number of miles automobiles are driven each year accounted for the remaining 1.2 percent (= 1.5 percent--0.3 percent) annual growth in total automobile use.\109\

\107\ Calculated from data reported in FHWA, Highway Statistics, Summary to 1995, Table vm201at http://www.fhwa.dot.gov/ohim/summary95/vm201a.xlw, (last accessed April 20, 2008).and annual editions 1996-2005, Table VM-1 at http://www.fhwa.dot.gov/policy/ohpi/hss/hsspubs.htm (last accessed April 20, 2008).

\108\ A slight increase in the fraction of new passenger cars remaining in service beyond age 10 has accounted for a small share of growth in the U.S. automobile fleet. The fraction of new automobiles remaining in service to various ages was computed from R.L. Polk vehicle registration data for 1977 through 2005 by the agency's Center for Statistical Analysis.

\109\ See supra note [2 above here]

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 automobile use, however, nearly all growth in light truck use over these two decades was attributable to rapid increases in the number of light trucks in use.\110\ In turn, growth in the size of the nation's light truck fleet has resulted almost exclusively from rising sales of new light trucks, since the fraction of new light trucks remaining in service to various ages has remained stable or even declined slightly over the past two decades.\111\

\110\ FHWA data show that growth in total miles driven by ``Two-axle, four-tire trucks,'' a category that includes most or all light trucks used as passenger vehicles, averaged 5.1% annually from 1985 through 2005. However, the number of miles light trucks are driven each year averaged 11,114 during 2005, almost unchanged from the average figure of 11,016 miles during 1985. Id.

\111\ Unpublished analysis of R.L. Polk vehicle registration data conducted by NHTSA Center for Statistical Analysis, 2005.

On the basis of this analysis, the agency tentatively concludes 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 years. However, the assumption that average annual use of passenger cars will remain fixed over the future appears to ignore an important source of recent growth in their total use, the gradual increase in the average number of miles they are driven. To the extent that this factor continues to represent a significant source of growth in future passenger car use, the agency's analysis is likely to underestimate the reductions in fuel use and related environmental impacts resulting from stricter CAFE standards for passenger cars.\112\ The agency plans to account explicitly for potential future growth in average annual use of both cars and light trucks in the analysis accompanying its Final Rule establishing CAFE standards for model years 2011-15.

\112\ Assuming that average annual miles driven per automobile will continue to increase over the future would increase the agency's estimates of total lifetime mileage for MY 2011-18 passenger cars. Their estimated lifetime fuel use would also increase under each alternative standard considered in this analysis, but in inverse relation to their fuel economy. Thus lifetime fuel use will 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. Taking account of this factor would thus increase the agency's estimates of fuel savings for those alternatives, and omitting it will cause the agency's analysis to underestimate those fuel savings.

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h. Accounting for the Rebound Effect of Higher Fuel Economy

The rebound effect refers to the tendency for owners to increase the number of miles they drive a vehicle in response to an increase in its fuel economy, as would result from more stringent fuel economy standards. The rebound effect occurs because an increase in a vehicle's fuel economy reduces its owner's fuel cost for driving each mile, which is typically the largest

single component of the cost of operating a vehicle. Even with the vehicle's higher fuel economy, this additional driving uses some fuel, so the rebound effect will reduce the net fuel savings that result when the 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 average fuel cost per mile driven decreases in response to a change in the marginal cost of driving an extra mile, due either an increase in fuel economy or a reduction in the price of fuel.

The magnitude of the rebound effect is one of the determinants of the actual fuel savings that are likely to result from adopting stricter standards, and thus an important parameter affecting NHTSA's evaluation of alternative standards for future model years. The rebound effect can be measured directly by estimating the elasticity of vehicle use with respect to fuel economy itself, or indirectly by the elasticity of vehicle use with respect to fuel cost per mile driven.\113\ When expressed as a positive percentage, either of these parameters gives the fraction of fuel savings that would otherwise result from adopting stricter standards, but is offset by the increase in fuel consumption that results when vehicles with increased fuel economy are driven more.

\113\ Fuel cost per mile is equal to the price of fuel in dollars per gallon divided by fuel economy in miles per gallon, so this figure declines when a vehicle's fuel economy increases.

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.\114\ The most common approach to estimating its magnitude has been to analyze statistically 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 fleet-wide average fuel economy and its effect of fuel cost per mile driven. 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.\115\

\114\ Some studies estimate that the long-run rebound effect is significantly larger than the immediate response to increased fuel efficiency. Although their estimates of the adjustment period required for the rebound effect to reach its long-run magnitude vary, this long-run effect is most appropriate for evaluating the fuel savings and emissions reductions resulting from stricter standards that would apply to future model years.

\115\ In effect, these studies treat U.S. states as a data ``panel'' by applying appropriate estimation procedures to data consisting of each year's average values of these variables for the separate states.

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 the absolute levels of fuel costs, personal income, or household vehicle ownership. Most studies using aggregate annual data for the U.S. assume a constant rebound effect, although some of these studies test whether the effect can vary as changes in retail fuel prices or average fuel economy alter fuel cost per mile driven. Many studies using household survey data estimate significantly different rebound effects for households owning varying numbers of vehicles, although they arrive at differing conclusions about whether the rebound effect is larger among households that own more vehicles. One recent study using state-level data concludes that the rebound effect varies directly in response to changes in personal income and the degree of urbanization of U.S. cities, as well as fuel costs.

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 alternative standards, NHTSA reviewed 22 studies of the rebound effect conducted from 1983 through 2005. We then conducted a detailed analysis of the 66 separate estimates of the long-run rebound effect reported in these studies, which is summarized in the table below.\116\ As the table indicates, these 66 estimates of the long-run rebound effect range from as low as 7 percent to as high as 75 percent, with a mean value of 23 percent.

\116\ In some cases, NHTSA derived estimates of the overall rebound effect from more detailed results reported in the studies. For example, where studies estimated different rebound effects for households owning different numbers of vehicles but did not report an overall value, we computed a weighted average of the reported values using the distribution of households among vehicle ownership categories.

Limiting the sample to 50 estimates reported in the 17 published studies of the rebound effect yields the same range but a slightly higher mean (24 percent), while focusing on the authors' preferred estimates from published studies narrows this range and lowers its average only slightly. The median estimate of the rebound effect in all three samples, which is generally regarded as a more reliable indicator of their central tendency than the average because it is less influenced by unusually small and large estimates, is 22 percent. As Table V-4 indicates, approximately two-thirds of all estimates reviewed, of all published estimates, and of authors' preferred estimates fall in the range of 10-30 percent.

Table V-4.--Summary of Rebound Effect Estimates

Category of estimates	Number of studies	Number of estimates	Range Low	Range High	Distribution Median	Distribution Mean	Distribution 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 2006 values of vehicle use, fuel prices, fleet fuel efficiency, household income, and household vehicle ownership.

The type of data used and authors' assumption about whether the rebound effect varies over time have important effects on its estimated magnitude. 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 23 estimates based on household survey data is more than twice as large (31 percent), and the median of 9 estimates based on pooled state data matches that of the entire sample (22 percent). The 37 estimates assuming a constant rebound effect produce a median of 20 percent, while the 29 originally reported estimates of a variable rebound effect have a slightly higher median value (23 percent).

In selecting a single value for the rebound effect to use in analyzing alternative standards for future model years, NHTSA tentatively attaches greater significance to studies that allow the rebound effect to vary in response to changes in the various factors that have been found to affect its magnitude. However, it is also important to update authors' originally-reported estimates of variable rebound effects to reflect current conditions. Recalculating the 29 original estimates of variable rebound effects to reflect current (2006) values for retail fuel prices, average fuel economy, personal income, and household vehicle ownership reduces their median estimate to 16 percent.\117\ NHTSA also tentatively attaches greater significance to the recent study by Small and Van Dender (2005), which finds that the rebound effect tends to decline as average fuel economy, personal income, and suburbanization of U.S. cities increase, but--in accordance with previous studies--rises with increasing fuel prices.\118\

\117\ 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 average fuel cost per mile driven. While their estimate for the entire interval (1966-2001) they analyze is 22 percent, updating this estimate using 2006 values of these variables reduces the rebound effect to approximately 10 percent. Similarly, updating Greene's 1992 original estimate of a 15 percent rebound effect to reflect 2006 fuel prices and average fuel economy reduces it to 6 percent. See David L. Greene, ``Vehicle Use and Fuel Economy: How Big is the Rebound Effect?'' The Energy Journal, 13:1 (1992), 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), 119-137; and David L. Greene, James R. Kahn, and Robert C. Gibson, ``Fuel Economy Rebound Effect for Household Vehicles,'' The Energy Journal, 20:3 (1999), 1-21.

\118\ In the most recent light truck CAFE rulemaking, NHTSA chose not to preference the Small and Van Dender study over other published estimates of the value of the rebound effect, stating that since it ``remains an unpublished working paper that has not been subjected to formal peer review, ``the agency does not yet consider the estimates it provides to have the same credibility as the published and widely-cited estimates it relied upon.'' See 71 FR 17633 (Apr. 6, 2006). The study has subsequently been published and peer-reviewed, so NHTSA is now prepared to ``consider it in developing its own estimate of the rebound effect for use in subsequent CAFE rulemakings.''

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--particularly the Small and Van Dender study--NHTSA has selected a rebound effect of 15 percent to evaluate the fuel savings and other effects of alternative standards for the time period covered by this rulemaking. However, we do 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 these variables. A range extending from 10 percent to at least 20 percent--and perhaps as high as 25 percent--appears to be appropriate for the required analysis of the uncertainty surrounding these estimates. While the agency selected 15 percent, it also ran sensitivity analyses at 10 and 20 percent. The results are shown in the PRIA.

i. Benefits From Increased Vehicle Use

The increase in vehicle use from the rebound effect provides additional benefits to their owners, who may make more frequent trips or travel farther to reach more desirable destinations. This additional travel provides benefits to drivers and their passengers by improving their access to social and economic opportunities away from home. As evidenced by their decisions to make more frequent or longer trips when improved fuel economy reduces their costs for driving, the benefits from this additional travel exceed the costs drivers and passengers incur in making more frequent or longer trips.

The amount by which the 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 the increased consumer surplus provided by added driving using the conventional approximation, which is one half of the product of the decline in vehicle operating costs per vehicle-mile and the resulting increase in the annual number of miles driven. The magnitude of these benefits represents a small fraction of the total benefits from the alternative fuel economy standards considered.

j. Added Costs From Congestion, Crashes and Noise

Although it provides some benefits to drivers, increased vehicle use associated with the rebound effect also contributes to increased traffic congestion, motor vehicle accidents, and highway noise. Depending on how the additional travel is distributed over the day and on where it takes place, additional vehicle use can contribute to traffic congestion and delays by increasing traffic volumes on facilities that are already heavily traveled during peak periods. These added delays impose higher costs on drivers and other vehicle occupants in the form of increased travel time and operating expenses. Because drivers do not take these added costs into account in deciding when and where to travel, they must be accounted for separately as a cost of the added driving associated with the rebound effect.

Increased vehicle use due to the rebound effect may also increase the costs associated with traffic accidents. Drivers may take account of the potential costs they (and their passengers) face from the possibility of being involved in an accident when they decide to make additional trips. However, they probably do not consider all of the potential costs they impose on occupants of other vehicles and on pedestrians when accidents occur, so any increase in these ``external'' accident costs must be considered as another cost of additional rebound-effect driving. Like increased delay costs, any increase in these external accident costs caused by added driving is likely to depend on the traffic conditions under which it takes place, since accidents are more frequent in heavier traffic (although their severity may be reduced by the slower speeds at which heavier traffic typically moves).

Finally, added vehicle use from the rebound effect may also increase traffic noise. Noise generated by vehicles

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. Because these effects are unlikely to be taken into account by the drivers whose vehicles contribute to traffic noise, they represent additional externalities associated with motor vehicle use. Although there is considerable uncertainty in measuring their value, any increase in the economic costs of traffic noise resulting from added vehicle use must be included together with other increased external costs from the rebound effect.

NHTSA relies on estimates of congestion, accident, and noise costs caused by automobiles and light trucks developed by the Federal Highway Administration to estimate the increased external costs caused by added driving due to the rebound effect.\119\ These estimates are intended to measure the increases in costs from added congestion, property damages and injuries in traffic accidents, and noise levels caused by automobiles and light trucks that are borne by persons other than their drivers (or ``marginal'' external costs). Updated to 2006 dollars, FHWA's ``Middle'' estimates for marginal congestion, accident, and noise costs caused by automobile use amount to 5.2 cents, 2.3 cents, and 0.1 cents per vehicle-mile (for a total of 7.6 cents per mile), while those for pickup trucks and vans are 4.7 cents, 2.5 cents, and 0.1 cents per vehicle-mile (for a total of 7.3 cents per mile).\120\, \121\ 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.

\119\ 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 April 20, 2008).

\120\ See Federal Highway Administration, 1997 Federal Highway Cost Allocation Study, http://www.fhwa.dot.gov/policy/hcas/final/index.htm, Tables V-22, V-23, and V-24 (last accessed April 20, 2008).

\121\ The Federal Highway Administration's estimates of these costs agree closely with some other recent estimates. For example, recent published research conducted by Resources for the Future (RFF) estimates marginal congestion and external accident costs for increased light-duty vehicle use in the U.S. to be 3.5 and 3.0 cents per vehicle-mile in year-2002 dollars. See Ian W.H. Parry and Kenneth A. Small, ``Does Britain or the U.S. Have the Right Gasoline Tax?'' Discussion Paper 02-12, Resources for the Future, 19 and Table 1 (March 2002). Available at http://www.rff.org/rff/Documents/RFF-DP-02-12.pdf (last accessed April 20, 2008).

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k. Petroleum Consumption and Import Externalities

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.\122\ 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 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 itself.

\122\ 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: North-Holland, pp. 1167-1218.

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 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.\123\ 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.''

\123\ 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 ($231 million minus $200 million) 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.

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 prices, so that the world oil market does not behave completely competitively.\124\ 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 petroleum continues to exert some influence on world oil prices, although this influence appears to be limited.\125\

\124\ For a summary 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, 17. Available at http://pzl1.ed.ornl.gov/ORNL6851.pdf (last accessed April 20, 2008).

\125\ Id. 18-19.

The second component of external economic costs imposed by U.S. petroleum imports 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 levels, 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 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.

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 these 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 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 believes 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, 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 Reserve 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 2005-07 and 2008-11, 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.\126\ 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.\127\ 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).\128\

\126\ 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. Available at http://pzl1.ed.ornl.gov/ORNL6851.pdf (last accessed April 20, 2008).

\127\ Leiby, Paul N. ``Estimating the Energy Security Benefits of Reduced U.S. Oil Imports,'' Oak Ridge National Laboratory, ORNL/TM-2007/028, Revised July 23, 2007. Available at http://pzl1.ed.ornl.gov/energysecurity.html (click on link below ``Oil Imports Costs and Benefits'') (last accessed April 20, 2008).

\128\ 72 FR 23899 (May 1, 2007).

The updated ORNL study was subjected to a detailed peer review by experts selected by EPA, and its estimates of the value of oil import externalities were subsequently revised to reflect their comments and recommendations.\129\ 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 world oil price, as well as reduce its estimate of the sensitivity of U.S. gross domestic product (GDP) to potential sudden increases in world oil prices.

\129\ Peer Review Report Summary: Estimating the Energy Security Benefits of Reduced U.S. Oil Imports, ICF, Inc., September 2007.

After making the revisions recommended by peer reviewers, ORNL's updated estimates of the monopsony cost associated with U.S. oil imports range from $5.22 to $9.68 per barrel, with a most likely estimate of $7.41 per barrel. 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 $0.124 to $0.230 per gallon, with the actual value most likely to be $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 $4.54 to $5.84 per barrel, although its

most likely estimate of $4.59 per barrel is very close to the lower end of this range. According to these estimates, each gallon of fuel saved will reduce the expected costs disruptions to the U.S. economy by $0.108 to $0.139, with the actual value most likely to be $0.109 per gallon.

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 $0.232 to $0.370 per gallon, with a most likely estimate of $0.286 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 employs this midpoint estimate in its analysis of the benefits from fuel savings projected to result from alternative CAFE standards for model years 2011-15. It also analyzes the effect on these benefits estimates from variation in this value over the range from $0.232 to $0.370 per gallon of fuel saved.

NHTSA's analysis of benefits from alternative CAFE standards does 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. This view concurs with that of 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 the alternative increases in CAFE standards considered for model years 2011-15.

l. Air Pollutant Emissions

(i) Impacts on Criteria Air Pollutant Emissions

While reductions in domestic fuel refining and distribution that result from lower fuel consumption will reduce U.S. emissions of criteria pollutants, additional vehicle use associated with the rebound effect from higher fuel economy will increase emissions of these 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 (emissions per gallon refined of fuel or mile driven) in fuel refining and vehicle use 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 VOC), nitrogen oxides (NOX), fine particulate matter (PM2.5), and sulfur oxides (SOX).

The increase in emissions of these pollutants from additional vehicle use due to the rebound effect is estimated 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.\130\ 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.

\130\ U.S. Environmental Protection Agency, MOBILE6 Vehicle Emission Modeling Software, available at http://www.epa.gov/otaq/m6.htm#m60 (last accessed April 20, 2008).

Based on analysis of changes in U.S. gasoline imports and domestic gasoline consumption forecast in AEO's 2008 Early Release, NHTSA tentatively estimates that 50 percent of fuel savings resulting from higher CAFE standards will result in reduced imports of refined gasoline, while the remaining 50 percent will reduce domestic fuel refining.\131\ The reduction in domestic refining is assumed to leave its sources of crude petroleum unchanged from the mix of 90 percent imports and 10 percent domestic production projected by AEO.

\131\ Estimates of the response of gasoline imports and domestic refining to fuel savings from stricter standards are variable and highly uncertain, but our preliminary analysis indicates 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.

NHTSA proposes to estimate reductions in criteria pollutant emissions from gasoline refining and distribution using emission rates obtained from Argonne National Laboratories' Greenhouse Gases and Regulated Emissions in Transportation (GREET) model.\132\ 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.\133\ We tentatively assume 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 are 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 activities would be occurring. Similarly, reduced domestic fuel refining using domestically-produced crude oil is tentatively assumed to reduce emissions during all phases of gasoline production and distribution.\134\

\132\ Argonne National Laboratories, The Greenhouse Gas and Regulated Emissions from Transportation (GREET) Model, Version 1.8, June 2007, available at http://www.transportation.anl.gov/software/GREET/index.html (last accessed April 20, 2008).

\133\ Emissions that occur during vehicle refueling at retail gasoline stations (primarily evaporative emissions of volatile organic compounds, or VOCs) are already accounted for in the ``tailpipe'' emission factors used to estimate the emissions generated by increased 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.

\134\ In effect, this assumes that the distances crude oil travels to U.S. refineries are approximately the same regardless of whether it 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 gasoline stations.

The net changes in emissions of each criteria pollutant are 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 is converted to an economic value using estimates of the economic costs per ton emitted (which result primarily from damages to human health) developed by EPA and submitted to the federal Office of Management and Budget 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.

(ii) Reductions in CO2 Emissions

Fuel savings from stricter CAFE standards also result in lower emissions of carbon dioxide (CO_2), the main greenhouse gas emitted as a result of refining, distribution, and use of transportation fuels.\135\ Lower fuel consumption reduces carbon dioxide emissions directly, because the primary source of transportation-related CO2 emissions is fuel combustion in internal combustion engines. NHTSA tentatively estimates 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.\136\

\135\ For purposes of this rulemaking, NHTSA estimated emissions of vehicular CO2 emissions, but did not estimate vehicular emissions of methane, nitrous oxide, and hydroflourocarbons. Methane and nitrous oxide account for less than 3 percent of the tailpipe GHG emissions from passenger cars and light trucks, and CO2 emissions accounted for the remaining 97 percent. Of the total (including non-tailpipe) GHG emissions from passenger cars and light trucks, tailpipe CO2 represents about 93.1 percent, tailpipe methane and nitrous oxide represent about 2.4 percent, and hydroflourocarbons (i.e., air conditioner leaks) represent about 4.5 percent. Calculated from U.S CO2. EPA, Inventory of U.S> Greenhouse Gas Emissions and Sinks 1990-2006, EPA430-R-08-05, April 15, 2008. Available at http://www.epa.gov/climatechange/emissions/downloads/08_CR.pdf, Table 215. (Last accessed April 20, 2008.)

\136\ 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, p. 3.16.

Reduced fuel consumption also reduces carbon dioxide emissions that result from the use of carbon-based energy sources during fuel production and distribution.\137\ NHTSA currently estimates the reductions in CO2 emissions during each phase of fuel production and distribution using CO2 emission rates obtained from the GREET model, using the previous assumptions about how fuel savings are reflected in reductions in each phase. The total reduction in CO2 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.

\137\ NHTSA did not, for purposes of this proposed rulemaking, attempt to estimate changes in ``upstream'' emissions of greenhouse gases (GHGs) other than CO2. This was because carbon dioxide from final combustion itself accounts for nearly 97 percent of the total CO2-equivalent emissions from petroleum production and use, even with other GHGs that result from those activities (principally methane and nitrous oxide) weighted by their higher global warming potentials (GWPs) relative to CO2. Calculated from U.S. EPA, Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2006, EPA430-R-08-05, April 15, 2008. Available at http://epa.gov/climatechange/emissions/downloads/08_CR.pdf, Tables 3-3, 3-39, and 3-41. (Last accessed April 20, 2008.)

NHTSA has not attempted to estimate changes in emissions of other greenhouse gases, in particular methane, nitrous oxide, and hydrofluorocarbons. The agency invites comment on the importance and potential implications of doing so under NEPA.

(iii) Economic value of reductions in CO2 emissions

NHTSA has taken the economic benefits of reducing CO2 emission into account in this rulemaking, both in developing proposed CAFE standards and in assessing the economic benefits of each alternative that was considered. As noted above, the Ninth Circuit found in CBD that NHTSA had been arbitrary and capricious in deciding not to monetize the benefit of reducing CO_2 emissions, saying 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.

To this end, NHTSA reviewed published estimates of the ``social cost of carbon emissions'' (SCC). 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.\138\ It is typically estimated as the net present value of the impact over some time period (100 years or longer) of one additional ton of carbon emitted into the atmosphere. Because accumulated concentrations of greenhouse gases in the atmosphere and the projected impacts on global climate are increasing over time, the economic damages resulting from each additional ton of CO_2 emissions in future years are believed to be greater as a result. 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.

\138\ Carbon itself accounts for 12/44, or about 27%, 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 dollars per ton of carbon, and must be divided by 3.67 to determine their equivalent value per ton of carbon dioxide emissions.

There is 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 include the sensitivity of global temperatures and other climate attributes to increasing atmospheric concentrations of greenhouse gases, discount rates applied to future economic damages from climate change, whether damages sustained by developing regions of the globe 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.\139\

\139\ 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, 2007: Perspectives on climate change and sustainability. 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, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, pp. 821-824.

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 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, 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. The Working Group II's contribution to the Fourth Assessment Report of the United Nations Intergovernmental Panel on Climate Change (IPCC)\140\ notes that:

\140\ Climate Change 2007--Impacts, Adaptation and Vulnerability, Contribution of Working Group II to the Fourth Assessment Report of the IPCC, 17. Available at http://www.ipcc-wg2.org (last accessed).

The large ranges of SCC are due in the large part to differences in assumptions regarding climate sensitivity, response lags, the treatment of risk and equity, economic and non-economic impacts, the

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inclusion of potentially catastrophic losses, and discount rates.

Although the IPCC does not recommend a single estimate of the SCC, it does cite the Tol (2005) study on four separate occasions (pages 17, 65, 813, 822) as the only available survey of the peer-reviewed literature that has itself been subjected to peer review. Tol developed a probability function using the SCC estimates of the peer reviewed literature and found estimates 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 one hundred and three 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 uncertain but is unlikely that the marginal damage costs of carbon dioxide emissions exceed $50 per [metric] ton carbon [about $14 per metric ton of CO2].'' \141\ He also concluded that the costs may be less than $14.

\141\ Tol, Richard. The marginal damage costs of carbon dioxide emissions: an assessment of the uncertainties. Energy Policy 33 (2005) 2064-2074, 2072. The summary SCC estimates reported by Tol are assumed to be denominated in U.S. dollars of the year of publication, 2005.

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 chances 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 contrast, the other estimates of costs and benefits of increasing fuel economy 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.\142\ 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.

\142\ The reduction in payments from U.S. oil purchasers to domestic petroleum producers is not included as a benefit, since it represents a transfer that occurs entirely within the U.S. economy.

In order to be consistent with NHTSA's use of exclusively domestic costs and benefits in prior CAFE rulemakings, the appropriate value to be placed on changes climate damages caused by carbon emissions should be one that reflects the change in damages to the United States alone. Accordingly, NHTSA notes 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 United States.

Although no estimates of benefits to the U.S. itself that are likely to result from reducing CO_2 emissions are currently available, NHTSA expects that if such values were developed, the agency would employ those rather than global benefit estimates in its analysis. NHTSA also anticipates that if such values 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, the agency has elected to use the IPCC 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.\143\ This corresponds to approximately $12 per metric ton of CO_2 when expressed in 2006 dollars. This estimate is based on the 2005 Tol study.\144\ The Tol 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 the IPCC estimate includes the worldwide costs of potential damages from carbon dioxide emissions, NHTSA has elected to employ it as an upper bound on the estimated value of the reduction in U.S. domestic damage costs that is likely to result from lower CO_2 emissions.\145\

\143\ The estimate of $43 per ton of carbon emissions is reported by Tol (p. 2070) as the mean of the ``best'' estimates reported in peer-reviewed studies (see fn. 144). It thus differs from the mean of all estimates reported in the peer-reviewed studies surveyed by Tol. The $43 per ton value is also attributed to Tol by IPCC Working Group II (2007), p. 822.

\144\ Tol's more recent (2007) and inclusive survey has been published online with peer-review comments. The agency has elected not to rely on the estimates it reports, but will consider doing so in its analysis of the final rule if the survey has been published, and will also consider any other newly-published evidence.

\145\ For purposes of comparison, we note that in the rulemaking to establish CAFE standards for MY 2008-11 light trucks, NRDC recommended a value of $10 to $25 per ton of CO_2 emissions reduced by fuel savings and both Environmental Defense and Union of Concerned Scientists recommended a value of $50 per ton of carbon (equivalent to about $14 per ton of CO_2 emissions).

The IPCC Working Group II Fourth Assessment Report (2007, p. 822) further suggests that the SCC of carbon is growing at an annual 2.4 percent growth rate, based on estimated increases in damages from future emissions reported in published studies. NHTSA has also elected to apply this growth rate to Tol's original 2005 estimate. Thus by 2011, the agency estimates 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 agrees with the IPCC Working Group II (2007) report 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'' (pp. 9). Although this finding suggests that the global value of economic benefits from reducing carbon dioxide emissions is unlikely to be zero, 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 this proposal, 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 CAFE 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 per metric ton) and lower ($0 per metric ton) bounds of this range.

NHTSA seeks comment on its tentative conclusions for the value of

the SCC, the use of a domestic versus 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 greenhouse gases other than CO_2, and any other aspects of developing a reliable SCC value for purposes of establishing CAFE standards.

m. The Value of Increased Driving Range

Improving vehicles' fuel economy may also 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 thus provides some additional benefits to their owners. (Alternatively, if manufacturers respond to improved fuel economy by reducing the size of fuel tanks to maintain a constant driving range, the resulting cost saving will presumably be reflected in lower vehicle sales prices.)

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 required 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.\146\ As an 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 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) to 400 miles (= 16 gallons x 25 mpg). Assuming that it is driven 12,000 miles/year, this reduces the number of times it needs to be refueled each year 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.

\146\ 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 October 20, 2007); update available at http://ostpxweb.dot.gov/policy/Data/VOTrevision1--2-11-03.pdf (last accessed October 20, 2007).

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 $24.00 (in 2006 dollars).\147\ 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 10/

60 x 1.3 x $24.00). This calculation is repeated for each future calendar year that vehicles of each model year affected by the alternative CAFE standards proposed in this rule would remain in service. Like fuel savings and other benefits, however, the value of this benefit declines over a model year's lifetime, because a smaller number of vehicles originally produced during that model year remain in service each year, and those remaining in service are driven fewer miles.

n. Discounting Future Benefits and Costs

\147\ The hourly wage rate during 2006 is estimated to be $24.00. Personal travel (94.4 percent of urban travel) is valued at 50 percent of the hourly wage rate. Business travel (5.6 percent or urban travel) is valued at 100 percent of the hourly wage rate. For intercity travel, personal travel (87 percent) is valued at 70 percent of the wage rate, while business travel (13 percent) is valued at 100 percent of the wage rate. The resulting values of travel time are $12.67 for urban travel and $17.66 for intercity travel, and must be multiplied by vehicle occupancy (1.6) to obtain the estimate value of time per vehicle hour.

Discounting future fuel savings and other benefits is intended to account for the reduction in their value to society when they are deferred until some future date rather than received immediately. The discount rate expresses the percent decline in the value of these benefits--as viewed from today's perspective--for each year they are deferred into the future. NHTSA uses a rate of 7 percent per year to discount the value of future fuel savings and other benefits to analyze the potential impacts of alternative CAFE standards. However, the agency also performed an alternative analysis of benefits from alternative increases in CAFE standards using a 3 percent discount rate, and seeks comment on whether the standards should be set using a 3 percent rate instead of a 7 percent rate.

There are several reasons that NHTSA relies primarily on 7 percent as the appropriate rate for discounting future benefits from increased CAFE standards. First, OMB Circular A-4 indicates that this rate reflects the economy-wide opportunity cost of capital.\148\ It also states that this ``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.''\149\ We believe that a substantial portion of the cost of this regulation may come at the expense of other investments the auto manufacturers might otherwise make. Several large manufacturers are resource-constrained with respect to their engineering and product-development capabilities. As a result, other uses of these resources will be foregone while they are required to be applied to technologies that improve fuel economy.

\148\ Office of Management and Budget, Circular A-4, ``Regulatory Analysis,'' September 17, 2003, 33. Available at http://www.whitehouse.gov/omb/circulars/a004/a-4.pdf (last accessed Feb. 14, 2008).

\149\ Id.

Second, 7 percent also appears to be an appropriate rate to the extent that the costs of the regulation come at the expense of consumption as opposed to investment. NHTSA believes that financing rates on vehicle loans represent an appropriate discount rate, because they reflect the opportunity costs faced by consumers when buying vehicles with greater fuel economy and a higher purchase price. Most new and used vehicle purchases are financed, and because most of the benefits from higher fuel economy standards accrue to vehicle purchasers in the form of fuel savings, the appropriate discount rate is the interest rate buyers pay on loans to finance their vehicle purchases.\150\

\150\ Some empirical evidence also demonstrates that used car purchasers are willing to pay higher prices for greater fuel economy; see, e.g., James A. Kahn, ``Gasoline Price Expectations and the Used Automobile Market: A Rational Expectations Asset Price Approach,'' Quarterly Journal of Economics, Vol. 101 (May 1986), 323-339.

According to the Federal Reserve, the interest rate on new car loans made through commercial banks has closely tracked the rate on 10-year treasury notes, but exceeded it by about 3 percent.\151\ The official Administration forecast is that real (or inflation-adjusted) interest rates on 10-year treasury notes will average about 3 percent through 2016, implying that 6 percent is a reasonable forecast for the real interest rate on new car loans.\152\ In turn, the interest rate on used car loans

made through automobile financing companies has closely tracked the rate on new car loans made through commercial banks, but exceeded it by about 3 percent.\153\ (We consider rates on loans that finance used car purchases, because some of the fuel savings resulting from improved fuel economy accrue to used car buyers.) Given the 6 percent estimate for new car loans, a reasonable forecast for used car loans is thus 9 percent.

\151\ See Federal Reserve Bank, Statistical Release H.15, Selected Interest Rates (Weekly) (click on ``Historical Data,'' then ``Treasury constant maturities,'' then ``10-year, monthly''), available at http://www.federalreserve.gov/Releases/H15/data/Monthly/H15_TCMNOM_Y10.txt (last accessed February 13, 2008); and Federal Reserve Bank, Statistical Release G.19, Consumer Credit, (click on ``Historical Data,'' then ``Terms of Credit'') available at http://www.federalreserve.gov/releases/g19/hist/cc_hist_tc.html (last accessed February 13, 2008).

\152\ See The White House, Joint Press Release of the Council of Economic Advisors, the Department of the Treasury, and the Office of Management and Budget, November 29, 2007, available at http://www.whitehouse.gov/news/releases/2007/11/20071129-4.html (last accessed February 13, 2008).

\153\ See supra [2 above here] and Federal Reserve Bank, Statistical Release G.20, Finance Companies, (click on ``Historical Data,'' then ``Terms of Credit'') available at http://www.federalreserve.gov/releases/g20/hist/fc_hist_tc.html (last accessed February 13, 2008).

Because the benefits of fuel economy accrue to both new and used car owners, a discount rate between 6 percent and 9 percent is thus appropriate for evaluating future benefits resulting from more stringent fuel economy standards. Assuming that new car buyers discount fuel savings at 6 percent for 5 years (the average duration of a new car loan) \154\ and that used car buyers discount fuel savings at 9 percent for 5 years (the average duration of a used car loan), \155\ the single constant discount rate that yields equivalent present value fuel savings is very close to 7 percent.

\154\ Id.

\155\ Id.

However, NHTSA also seeks comment on whether a discount rate of 3 percent would be more appropriate for this proposed rulemaking. OMB Circular A-4 also states that when 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 appropriate. The alternative discount rate that is most appropriate in this case is the social rate of time preference, which refers to the rate at which society discounts future consumption to determine its value at the present time. The rate that savers are willing to accept to defer consumption into the future when there is no risk that borrowers will fail to pay them back offers one possible measure of the social rate of time preference. As noted above, the real rate of return on long-term government debt, which has averaged around 3 percent over the last 30 years, provides a reasonable estimate of this value.

In the context of CAFE standards for motor vehicles, the appropriate discount rate depends on one's view of how the costs and benefits of more stringent standards are distributed between vehicle manufacturers and consumers. Given that the discount rate plays a significant role in determining the level of the standards under a ``social optimization'' context, NHTSA conducted an analysis of what the standards and associated costs and benefits would be if the future benefits were discounted at 3 percent. The results of this analysis can be found in the PRIA. We estimated that following the same methods and criteria discussed below, but applying a 3 percent discount rate rather than a 7 percent discount rate, would suggest standards reaching about 33.6 mpg (average required fuel economy among both passenger cars and light trucks) in MY2015, 2 mpg higher than the 31.6 mpg average resulting from the standards we are proposing based on a 7 percent discount rate. The more stringent standards during MY2011-MY2015 would reduce CO2 emissions by 672 million metric tons (mmt), or 29 percent more than the 521 mmt achieved by the proposed standards. On the other hand, we estimated that standards increasing at this pace would require about $85b in technology outlays during MY2011-MY2015, or 89 percent more than the $45b in technology outlays associated with the standards proposed today.

Thus, although our proposed standards are based on a 7 percent discount rate, NHTSA seeks comment on whether it should set standards based on discount rate assumptions of 3 percent, instead of 7 percent.

o. Accounting for Uncertainty in Benefits and Costs

In analyzing the uncertainty surrounding its estimates of benefits and costs from alternative CAFE standards, NHTSA has considered alternative estimates of those assumptions and parameters likely to have the largest effect. 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 uncertainty analysis is presented in the section of this document discussing each variable.

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.

B. How Has NHTSA Used the Volpe Model To Select the Proposed Standards?

1. Establishing a Continuous Function Standard

NHTSA's analysis supporting determination of the proposed continuous function standard builds on the analysis that supported the determination of the standards in NHTSA's 2006 light truck final rule. That process involved three steps.\156\

\156\ See 71 FR 17596-97 (Apr. 6, 2006) for a more complete discussion of this process.

In ``phase one,'' NHTSA added fuel saving technologies to each manufacturer's fleet, model by model, for a model year until the net benefit from doing so reached its maximum value (i.e., until the incremental cost of improving its fuel economy further just equals the incremental value of fuel savings and other benefits from doing so). This was done for each of the seven largest manufacturers. Data points representing each vehicle's size and ``optimized'' fuel economy from the light truck fleets of those manufacturers were then combined into a single data set.

In ``phase two,'' a preliminary continuous function was statistically fitted through these data points, subject to constraints at the upper and lower ends of the footprint range.

Once a preliminary continuous function was statistically fitted to the data for a model year, ``phase three'' was performed. In that phase, the level of the function was adjusted to maximize net benefits, that is, the preliminary continuous function was raised or lowered until industry-wide (limited to the seven largest manufacturers) benefits were maximized.

For NHTSA's 2006 light truck rulemaking, the optimization procedure was applied in its entirety only for MY 2011. The levels of the functions for MYs 2008-2010 were set at levels producing incremental costs approximately equivalent to those produced by the alternative Unreformed

CAFE standards promulgated for those model years in the same rulemaking.

Analysis conducted by NHTSA to prepare for the current proposed rulemaking revealed several opportunities to refine the procedure described above before applying it to this action, which spans several model years. The resultant procedure is described below.

2. Calibration of Initial Continuous Function Standards

For the optimized standards, the first step in the current procedure involves all three phases described above. Separately, for each of the seven largest manufacturers, the agency determined the level of additional technology that would maximize net benefits. The agency then combined the resultant fleets and used standard statistical analysis procedures to specify a continuous function (i.e., a function without abrupt changes) with asymptotes \157\ set at the average fuel economy levels of the smallest and largest vehicles in this ``optimized'' fleet.\158\

\157\ Some functions are not bounded. For example, a line that is not flat will increase in one direction without limit and will, in the other direction, decrease without limit. The continuous function applied by the agency is of a form with upper and lower boundaries. Even as vehicle footprint declines or increases, the function's value (in mpg or grams/mile) will never exceed or fall below a specific value. These upper and lower limits are called asymptotes.

\158\ Consistent with EPCA, the passenger car and light truck fleets were analyzed separately. For passenger cars, the agency determined the asymptotes of the continuous function by calculating the average fuel economy of the smallest 8 percent and the largest 5 percent of the fleet. For light trucks, the agency considered the smallest 11 percent and the largest 10 percent of the fleet. These cohorts were determined by identifying gaps in the distribution of vehicles according to footprint.

In the 2006 light truck final rule, NHTSA created an attribute-based fuel economy standard based upon a continuous function using a logistic curve. The 2006 rulemaking, and its antecedent advanced notice of proposed rulemaking, contain an extended discussion of alternative approaches, including a bin-based system and different potential curves. As discussed below, that final rule explains NHTSA's decision to promulgate a standard based on a logistic (``S shaped'') curve with constrained asymptotes (upper and lower limits).

Although we did not explicitly discuss it in the MY 2008-2011 light truck rulemaking, NHTSA now wishes to explain that any continuous function with lower asymptotes, as was promulgated in the last rulemaking and is proposed in this rulemaking, provides an absolute lower fuel economy level which guards against manufacturers having an unlimited economic incentive to upsize their vehicles in order to lower their fuel economy requirement. As vehicle footprint continues to increase, decreases in the corresponding fuel economy target become progressively smaller, such that the target approaches but never reaches the value of the lower asymptote. Because the required level of CAFE is the harmonic average of targets applicable to a manufacturer's vehicle models, the value of the standard can approach but will never fall to the value of this lower asymptote, no matter how far the manufacturer's product mix shifts toward larger vehicles. This will limit any loss of fuel savings due to manufacturer decisions to upsize their vehicles.

In a perfect world, NHTSA would develop the continuous functions for setting passenger car and light truck standards by letting the vehicle attribute (footprint) completely control the shape of the curves used for the functions in a way that provides the clearest observed relationship between this attribute and its fuel economy. But, NHTSA must balance many real world practical and public policy aspects in order to ensure that the standards are achieving the purpose set forth by EPCA and EISA. In developing the Agency's last light truck rule, the curve used to fit the data (attribute versus fuel economy) was a sales-weighted least-squares logistic curve. During this rulemaking, as NHTSA continued to look for ways to improve its standard setting methodology, consideration was given to other methods that could be used to develop the continuous functions. One such method that NHTSA explored and is using in this proposal is unweighted analysis of the data using the Mean Absolute Deviation (MAD) statistical procedure. Unweighted regression involves counting each vehicle model once, rather than as many times as vehicles included in that model are to be produced. MAD involves weighting deviations from predicted values based on their absolute rather than squared magnitude. As discussed below, NHTSA has tentatively concluded that, compared to sales-weighted least-squares analysis, unweighted MAD is better suited to data with wide disparities in weight (i.e., sales volumes) and with many outliers.

In establishing footprint-based CAFE standards, the agency does not have the sole objective of seeking to reflect a clear engineering relationship between footprint and fuel economy. Attributes other than footprint would be more closely correlated with fuel economy. The agency's objective is to make CAFE regulations more consistent with public policy goals, in particular (1) a rebalancing of requirements such that full-line manufacturers are not disproportionately burdened and (2) the establishment of an incentive that discourages manufacturers from responding to CAFE standards in ways that could compromise occupant protection and highway safety. While it is helpful that the attribute--in this case footprint--has an observed relationship to fuel economy, it is not necessary that this relationship be isolated from accompanying relationships (e.g., between weight and fuel economy) that can be better related to estimable physical processes. Similarly, it is more important that the functional form for the attribute-based standard yield desirable outcomes than that it singly seek a clear foundation in estimable physical processes.

In general, public policy considerations and available vehicle data combine to suggest that the fuel economy standard should be generally downward sloping (on a fuel economy basis) with respect to NHTSA's chosen attribute, vehicle footprint. The arguments that favor an attribute-based system (maintaining consumer choice, protecting safety, more equitable distribution of costs, reducing the cost of regulation) all argue for a downward sloping curve. Larger vehicles should, in principle, have higher drag, weigh more, and therefore have greater inertia than otherwise identical smaller vehicles. Hence, all other factors remaining equal, larger vehicles should have lower fuel economy than smaller vehicles. Therefore, the selection of vehicle footprint as the reference attribute should produce downward sloping curves. Also, the tendency of larger vehicles to have lower fuel economy than smaller vehicles should provide some disincentive to shift to larger vehicles rather than adding technology; although doing so would tend to reduce the required CAFE level, it would also tend to reduce the achieved CAFE level.

However, vehicle data, by itself, does not necessarily define what functional form that the curve ought to take. In the 2006 light truck rulemaking, NHTSA considered linear, quadratic, exponential, unconstrained logistic, and constrained logistic functions as possible alternatives. For light trucks, the various approaches produced broadly similar standards through the most commonly used vehicle sizes, but drastically different standards at the high and low ends of the range.

Linear functions produced very high fuel economy standards for the

smallest vehicles, and low standards for the largest vehicles.

The quadratic function generated a minimum at about 75 square feet, and then perversely turned upward for vehicles with larger footprints. The standard for very small vehicles was unreasonably high.

The exponential and unconstrained logistic functions produced unreasonably high standards for small vehicles, but flattened out for larger vehicles.

The constrained logistic function provided a broadly linear downward-sloping through the most commonly used vehicle sizes, along with basically flat standards for very large and very small vehicles.

On this basis, NHTSA believed that, while the data did not dictate a particular functional form, public policy considerations made the constrained logistic function particularly attractive. The considerations include:

A relatively flat standard for larger vehicles acts as a de facto `backstop' for the standard in the event that future market conditions encourage manufacturers to build very large vehicles. Nothing prevents manufacturers from building larger vehicles. With a logistic curve, however, vehicles upsizing beyond some limit face a flat standard that is increasingly difficult to meet.

A constrained logistic curve doesn't impose unachievable fuel economy standards on vehicles that have unusually small footprints, thus continuing to keep manufacturing fuel-efficient small vehicles available as a compliance option.

A curve fitted without upper and lower constraints could reach very high fuel economy levels for small vehicles and very low fuel economy vehicles for large vehicles. While such a curve might produce similar required CAFE levels for the industry as a whole, it could have a particular adverse impact on manufacturers that specialize in very small vehicles, for example, two-seater sports cars. By the same token, it could require little or nothing of manufacturers specializing in very large vehicles.

The transition from the `flat' portions of the curve to the `slope' portions of the curve is smooth and gradual, reducing the incentive for manufacturers to achieve compliance through marginal changes in vehicle size.

The inflection points are set by the data and can potentially vary from year to year, rather than being chosen by NHTSA.

On the other hand, a constrained logistic curve shares with other functional forms a risk of an excessively steep or excessively flat slope. The slope of the compliance curve may be considered as `too steep' for public policy purposes when manufacturers can achieve appreciable reductions in compliance costs by marginally increasing the size of a vehicle's footprint--e.g., the cost of compliance from upsizing is lower than other cost-effective compliance methods open to manufacturers.

A slope is `too flat' for public policy purposes when it negates the advantages of an attribute-based system: Where the standard doesn't meaningfully vary with respect to changes in the underlying attribute, it cannot be said to be an attribute-based system within the meaning of the statute.

NHTSA chose footprint as the best attribute for an attribute-based standard in part because we believed changing a vehicle's footprint would involve significant costs for manufacturers, probably requiring a redesign of the vehicle.

While ``too steep'' or ``too flat'' inevitably cannot be defined with precision, they need to be kept in mind.

For the proposed standards, the agency defined the continuous function using the following formula:

[GRAPHIC] [TIFF OMITTED] TP02MY08.007

Where:

T = the fuel economy target (in mpg)
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 \159\

\159\ That is, the midpoint.

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d = the parameter (in square feet) defining the rate at which the value of targets decline from the largest to smallest values
e = 2.718\160\

\160\ For the purpose of the Reformed CAFE standard, we are carrying e out to only three decimal places.

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x = footprint (in square feet, rounded to the nearest tenth) of the vehicle model

NHTSA invites comment regarding the relative importance of the curve as a means of (1) providing a basis for describing the observed relationship between footprint and fuel economy, (2) providing a basis for describing a theoretical physical relationship (assuming one can be defined) between footprint and fuel economy, and (3) providing socially desirable incentives to manufacturers. The agency further invites comment on functional forms that would be consistent with each of these purposes.

As for analysis of the light truck rule promulgated in 2006, NHTSA constrained this function by determining the maximum and minimum targets (a and b) and then holding those targets constant while using statistical techniques to fit the other two coefficients (c and d) in this equation.

In the current analysis for passenger cars, the upper and lower asymptotes are based on the smallest three percent and largest four percent, respectively, of the fleet. These reflect footprint values defining distinct cohorts outside the bulk of the fleet, and correspond to footprint values of less than 39.5 square feet (i.e., up to the approximate size of a Honda Fit) and greater than 52.5 square feet (i.e., at least as great as the approximate size of a Toyota Avalon), respectively:

[GRAPHIC] [TIFF OMITTED] TP02MY08.008

For light trucks, the upper asymptote (i.e., the highest mpg value of the continuous function defining fuel economy targets) is based on the smallest (in terms of footprint) eleven percent of the fleet, and the lower asymptote is based on the largest six percent of the fleet. These cohorts correspond to footprint values of less than 44.5 square feet (i.e., up to the approximate size of a Honda CR-V) and greater than 72.5 square feet (i.e., comprised primarily of extended vans and long-bed pickup trucks), respectively:

[[Page 24420]]

[GRAPHIC] [TIFF OMITTED] TP02MY08.009

NHTSA invites comment on the identification of vehicle cohorts for purposes of establishing upper and lower limits (asymptotes) bounding the attribute-based standard. After updating its baseline market forecast in consideration of new product plan information from manufacturers, the agency plans to reevaluate these cohorts for both passenger cars and light trucks before promulgating a final rule, and notes that changes in approach could lead to changes in stringency.

Given the above asymptotes, fitting the above functional form to the ``optimized'' passenger car fleet resulted in the following initial continuous functions:

[[Page 24421]]

[GRAPHIC] [TIFF OMITTED] TP02MY08.010

For each model year, NHTSA then raised or lowered the resultant continuous function until net benefits were maximized for the seven largest manufacturers (in total). Without subsequent recalibrations discussed below, this produced the following continuous functions for passenger cars:

[[Page 24422]]

[GRAPHIC] [TIFF OMITTED] TP02MY08.011

The agency followed the same procedures for setting light truck standards and doing so resulted in the following continuous functions:

[[Page 24423]]

[GRAPHIC] [TIFF OMITTED] TP02MY08.012

In fitting the continuous function, NHTSA considered a range of statistical estimation techniques. In the 2006 light truck rulemaking, NHTSA estimated the parameters of the logistic function using fuel consumption (measured in gallons per mile) for each vehicle produced in a particular model year, weighted by sales.

For this rulemaking, we observed that estimated fuel consumption functions for passenger cars were significantly affected by several outliers--a small number of popular vehicles that had significantly higher fuel economy than the fleet as a whole and, even more so, than vehicles of similar footprint. For passenger cars, the function, as estimated by weighted ordinary least squares, was exceptionally steep within the range considered. This observation, in turn, led NHTSA to consider alternative approaches to statistically fitting the continuous function.

Among the options considered by NHTSA were the following: dropping the outlying vehicles from the estimation process, weighted and unweighted ordinary least squares, and weighted and unweighted mean absolute deviation (MAD). MAD is a statistical procedure that has been demonstrated to produce more efficient parameter estimates in the presence of significant outliers.\161\ As examples, the following two charts show the MY2015 passenger car and light truck fleets after the application of technologies to each manufacturer's fleet. These charts reveal numerous outliers for the passenger car fleet and, to a lesser extent, the light truck fleet:

\161\ In the case of a dataset not drawn from a sample with a Gaussian, or normal, distribution, there is often a need to employ robust estimation methods rather than rely on least-squares approach to curve fitting. The least-squares approach has, as an underlying assumption, that the data are drawn from a normal distribution, and hence fits a curve using a sum-of-squares method to minimize errors. This approach will, in a sample drawn from a non-normal distribution, give excessive weight to outliers by making their presence felt in proportion to the square of their distance from the fitted curve, and, hence, distort the resulting fit. With outliers in the sample, the typical solution is to use a robust method such as a minimum absolute deviation, rather than a squared term, to estimate the fit (see, e.g., ``AI Access: Your Access to Data Modeling,'' at http://www.aiaccess.net/English/Glossaries/GlosMod/e_gm_O_Pa.htm#Outlier). The effect on the estimation is to let the presence of each observation be felt more uniformly, resulting in a curve more representative of the data (see, e.g., Peter Kennedy, A Guide to Econometrics, 3rd edition, 1992, MIT Press, Cambridge, MA).

[[Page 24424]]

[GRAPHIC] [TIFF OMITTED] TP02MY08.013

[[Page 24425]]

[GRAPHIC] [TIFF OMITTED] TP02MY08.014

NHTSA requests comment on the best method for statistically fitting the continuous function.

There are good theoretical arguments for using an unweighted (rather than weighted) analysis. Although the purpose of the attribute-based standard is to discourage downsizing (because of safety implications) and more equitably distribute compliance burdens among manufacturers, we strive to develop the curves based on the observed physical relationship between vehicle size (i.e., footprint) and fuel economy. The curve developed using unweighted sales data better reflects this relationship.

However, the process by which we select the stringency (as distinct from the form) of the standard must consider sales volumes because the standards are based on sales-weighted average performance. Therefore, even if we use unweighted analysis develop the form of the standard, we would continue to evaluate the standard's stringency (and, therefore, its costs and benefits) based on sales-weighted average calculations done on a manufacturer-by-manufacturer basis.

There is already precedent for using unweighted data to produce curves that are descriptive of engineering relationships. In NHTSA's Preliminary Regulatory Impact Analysis for FMVSS 216 roof crush standards, a series of force-versus-deflection curves were produced for individual vehicle models and then averaged together. In that case, the agency was seeking observed relationships that reflect engineering possibilities, rather than a profile of the existing sales fleet.

In terms of relative emphasis on different vehicle models, the distinction between unweighted and weighted analysis is profound in the light vehicle market, in part because of the way ``models'' are defined for purposes of CAFE. The highest-selling passenger car model represents 356,000 units, and the lowest-selling model represents only 5 units. As a group, the five lowest-selling models represent only 305 units. Thus, weighted analysis places more than 1,000 times the emphasis on the highest-selling model than on the five lowest-selling models, and more than 70,000 times the emphasis than on the single lowest-selling model. The following histograms show the broader distributions of models and sales with respect to model-level sales (first for passenger cars, then for light trucks):

[[Page 24426]]

[GRAPHIC] [TIFF OMITTED] TP02MY08.015

[GRAPHIC] [TIFF OMITTED] TP02MY08.016

For purposes of setting the stringency of the corporate average fuel economy standard, this is vital because enforcement is based on the sales-weighted average. However, for purposes of developing a curve intended to represent fuel economy levels achieved at a given footprint, weighted analysis effectively ignores many models.

On the other hand, unweighted estimation is depending on the definition of a ``model''. Manufacturers will sometimes offer substantially similar vehicles with different badges (i.e., Ford Taurus/Mercury Sable) as two different models. The distinction between differing ``options packages'' on a single model and two distinct models is inevitably a bit blurry. When estimating fuel economy standards using a sales-weighted regression, this distinction is not material, since the estimation process will produce substantially the same results independently of the number of distribution of those sales into larger or smaller numbers of models. In unweighted estimation, however, dividing a particular vehicle family into a larger number of distinct models give that family some extra influence in the analysis. Nonetheless, considering that such parsing less than does sales weighting. NHTSA has tentatively concluded that unweighted estimation remains preferable to sales-weighted estimation, but invites comment on whether and, if so how substantially similar vehicles should be combined for purposes of fitting an attribute-based function when using unweighted estimation.

The following charts show, for MY2015 passenger cars and light trucks, how the use of sales-weighted least-squares estimation compares to the proposed approach, which uses unweighted mean absolute deviation. For passenger cars, the curve resulting from proposed approach is somewhat shallower than the curve resulting from sales-weighted least squares estimation. For light trucks, the curve resulting from proposed approach is somewhat steeper:

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[GRAPHIC] [TIFF OMITTED] TP02MY08.017

NHTSA invites comment on the relative merits of unweighted and weighted estimation, as well as on the other curve fitting options (e.g., the use of mean absolute deviation) raised here. The agency plans to reevaluate curve fitting approaches for both passenger cars and light trucks before promulgating a final rule, and notes that changes in approach could lead to changes in stringency and impacts on different manufacturers.

[GRAPHIC] [TIFF OMITTED] TP02MY08.018

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3. Adjustments To Address Policy Considerations

NHTSA believes that the resultant curve characteristics discussed above are empirically correct in that they correspond to the footprint and fuel economy values of the fleet obtained by adding fuel saving technologies to each manufacturer's fleet until the net benefit from doing so reached its maximum value.

However, there are three issues (described above) which may tend to reduce the effectiveness of fuel economy regulation over time. These concerns are:

- Curve crossings;
- Excessive steepness of the passenger car curve;
- Risk of upsizing.

In this rule, NHTSA proposes a solution to the curve crossing issue, requests comment on various methods of reducing the steepness of the passenger car, and examines the potential for upsizing generally under the provisions of this proposed rule.

a. Curve Crossings

For both passenger cars and light trucks, NHTSA observed some curve crossings from one model year to the next (i.e., for the same footprint, some targets fell below the levels attained in the previous model year), as revealed in the above charts. The upper limit of the MY 2012 passenger car curve falls slightly (about 0.1 mpg) below the MY 2011 value. For light trucks, the lower asymptote in MY 2012 is 0.9 mpg below the lower asymptote in MY 2011. This was not observed during the last round of light truck rulemaking because reformed CAFE was fully implemented only in MY 2011. During the transition period (MYs 2008-2010), the standards were set at levels equivalent in cost to unreformed CAFE. However, for this rulemaking, because the projected fleet composition changes between model years and the fuel economy target function is optimized in every model year, the initial continuous functions do not change monotonically (i.e., in only one direction--increasing) from year to

year at every footprint value. Given the availability of lead time and the importance of improving fuel economy, NHTSA has decided that, in the setting of the standards, we should ensure that the fuel economy targets do not fall from one year to the next at any footprint value.

To address the year-to-year fluctuations in the functions, which may lead to these curve crossings, NHTSA recalibrated each continuous function to prevent it from crossing the continuous function from any previous model year. In doing so, the agency attempted to avoid continuous functions that would artificially encourage the product mix to approximate that of earlier years. Instead, the agency recalibrated by gradually shifting the initial continuous functions for each model year toward the initial continuous function determined above for the product mix for MY 2015. For both passenger cars and light trucks, the agency adjusted each of the four coefficients in the formula determining the continuous function such that regular steps were taken year by year between the values determined above for MY 2011 and those for MY 2015. For example, the inflection point (the coefficient determining the footprint at which the target falls halfway between its minimum and maximum values) defining the light truck target function was increased by 0.034 square feet annually from 51.9 square feet in MY 2011 to 52.1 square feet in MY 2015.

NHTSA also recalibrated the continuous function for each model year by adding, as needed, anti-backsliding constraints that prevent the function from either (a) yielding an industry wide average level of CAFE lower than that for the preceding model year, (b) for a given footprint, having targets that fall below the level of previous year, and (c) having an asymptote lower than that of the preceding model year. The ``decision tree'' for determining for each model year the need for each of these constraints is summarized below in Figure V 16.

[GRAPHIC] [TIFF OMITTED] TP02MY08.019

The industry-wide average CAFE is prevented from decreasing between model years in order to prevent standards from falling below the level that was determined to be achievable for the model year before. To allow the industry-wide CAFE level to fall between successive model years would be to promulgate a standard that, notwithstanding maximizing net benefits, falls below what the agency has determined to be feasible in previous years. In a model year in which simple maximization of net benefits would have caused this to occur, NHTSA shifted the resultant curve upward (without changing the curve's shape) in order to produce an industry-wide CAFE equal to that of the preceding model year.

Application of the decision tree shown above results in the following target functions for passenger cars and light trucks, respectively. These target functions are identical to those shown below

in Section VI, which discusses the standards proposed today by NHTSA:
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[GRAPHIC] [TIFF OMITTED] TP02MY08.020

[GRAPHIC] [TIFF OMITTED] TP02MY08.021

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b. Steep Curves for Pasenger Cars

NHTSA has developed a set of attribute-based curves for passenger cars for this proposal consistent with the methodology used in the 2008-2011 light duty truck rule. However, unlike the relatively gradually sloped curve related fuel economy to footprint for trucks, our analysis for cars when utilizing a constained logistic curve produces a comparatively steep ``S''-shaped curve for passenger cars. This occurs primarily because--unlike trucks--current passenger car sales include vehicles with a wide range of fuel economy spanning a relatively narrow footprint range. Consequently, there is a relatively steep curve applied to the middle range of footprint values with a more rapid change of slope in the tails to flatten curve and thus satisfy the constrained logistic functional form.

In this rule, NHTSA is proposing a relatively ``steep'' curve. The agency has considered and experimented with several methods of reducing the steepness of the passenger car curve. However, each of these approaches has created challenges that may potentially be worse than the problem they are trying to cure. The Agency is questioning whether the steep slope portion of the curve could potentially motivate vehicle manufacturers to reduce their compliance obligation under the standard by slightly increasing its footprint when they redesign their vehicles. We do not know the extent to which this is a real problem, but the agency has considered this possibility and has worked to minimize steepness of the slope while maintaining the scientific integrity behind our methodology.

However, any attempt to ``fix'' the steepness of the passenger car curve appears to come at a price: First, flattening the curve by any particular method will move the curve away from the actual vehicle data. Second, flatter curves are generally place greater compliance burdens on full-line manufacturers than comparatively stringent (in terms of average require CAFE) standards. Furthermore, NHTSA believes that this could increase the overall costs required to achieve a given amount of fuel savings and societal

benefits, and it increases the risk that NHTSA would need to return to a ``least capable manufacturer'' approach in order to ensure economic practicability. Doing so would likely reduce stringency, and reduce fuel savings. In deciding on a particular approach, NHTSA must balance the certainty of high costs and lost fuel savings through a less ``efficient'' standard against the risk that the steepness of the curve might stimulate manufacturers to evade the standard over time by redesigning their vehicles over time.

In proposing the steep curve for this rule, NHTSA has tentatively decided that the cures that we have identified come at too high a price, i.e., lost stringency or undesirable side effects. However, NHTSA requests comment on these and other potential solutions to reduce the steepness of the proposed car curves for passenger cars.

Some of the approaches considered or tested by NHTSA include:

Linear standards. When the fuel consumption of vehicles with added technologies is plotted against footprint, we note a roughly linear relationship over the existing range of footprint values. Hence, a simple alternative to the current constrained logistic function would be to estimate a linear form of the curve with the sales data. However, NHTSA is concerned that such an approach may result in very low fuel economy standards for the largest footprint vehicles, very high fuel economy standards for the smallest vehicles, and loss of the inherent backstop properties of the constrained logistic function.

In addition, the slope of a line estimated through a ``cloud'' of data may be very sensitive to the exact characteristics of vehicles with the largest and smallest footprints. It may turn out that small changes in vehicle characteristics in the tails could shift the slope of a linear estimate. Further, it may be impossible to materially adjust the slope of a linear standard in future years without accepting curve crossing. The following two charts compare linear regression results for MY2015 to the curves proposed today by NHTSA. The result for passenger cars illustrates the concern regarding behavior at large and small footprints. Over the range of footprints in which light trucks are expected to be offered in MY2015, the result for light trucks shows less difference from the proposed curve.

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[GRAPHIC] [TIFF OMITTED] TP02MY08.023

Constrained linear standards. Another possible approach would be to retain the flattened tails proposed today but reduce the steepness of the middle portion by allowing it to directly reflect a linear relationship. This approach could be likened to a simplification or linearization of the constrained logistic function. The same minima and maxima would be used to bound the vertical extent of the linear form. The following two charts suggest that, at least for the MY2015 passenger car and light truck fleets considered today, a constrained linear standard would, compared to the standard proposed today, likely result in a similar distribution of compliance burdens among manufacturers (because the stringency at each footprint would be similar):

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[GRAPHIC] [TIFF OMITTED] TP02MY08.024

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However, the agency remains concerned that the slope could exhibit greater year-to-year variation than the proposed logistic form (although further analysis would be required in order to address this concern). Also, as discussed in the preamble to the 2006 Federal Register notice regarding light truck CAFE standards, the agency remains concerned that the upper and lower ``kinks'' in the function could offer unexpected incentives for manufacturers to redesign vehicles with footprints close to the kink-point.

Dual Attribute Approaches. A third possible solution would be to use additional attribute-based information to spread out the distribution of passenger cars across the x-axis. In effect, this approach uses a second attribute to normalize the footprint-fuel economy relationship. This second attribute might be horsepower, weight, or horsepower-to-weight.

In analyzing the expected passenger car market, NHTSA observes that the ratio of engine horsepower to vehicle weight generally increases with increasing footprint. Higher power-to-weight ratios tend to imply lower fuel economy, as the engine is typically larger and operating less efficiently under driving conditions applicable to certification. Thus, the fuel consumption versus footprint curves for passenger cars reflect this relationship. For trucks, there does not appear to be a relationship between footprint and the power-to-weight ratio. For passenger cars, then, adjusting fuel consumption values to normalize for differences in power-to-weight ratio may produce a flatter curve providing less of an upsizing incentive for middle footprint values.

NHTSA has experimented with normalizing footprint by horsepower-to-weight ratio. The result was a nearly flat standard with respect to footprint across the most popular size ranges. This did not appear to deliver the benefits of an attribute-based system. In addition, it involves significant downward adjustments to the fuel economy of hybrid electric vehicles (such as the Toyota Prius), for which the engine is not the sole source of motive power. Also, it involves significant upward adjustments to the fuel economy of

vehicles with high power-to-weight ratios (such as the Chevrolet Corvette). Some of these upward and downward adjustments are large enough to suggest radical changes in the nature of the original vehicles. Furthermore, insofar as such normalization implies that NHTSA should adopt a two-attributed standard (e.g., in which the target depends on footprint and power-to-weight ratio), it may be challenging and time consuming to come up with a sufficiently precise vehicle-by-vehicle definition of horsepower or horsepower-to-weight to be used for regulatory purposes.

[GRAPHIC] [TIFF OMITTED] TP02MY08.026

Shape Based on Combined Fleet. A fourth possible solution would be to combine the passenger car and light truck fleet to determine the shape of the constrained logistic curve, and then determine the stringency (i.e., height) of that curve separately for each fleet. On one hand, this approach would base the curve's shape on the widest available range of information. On the other, the resultant initial shape for each fleet would be based on vehicles from the other fleet. For example, the initial shape applied to passenger cars would be based, in part, on large SUVs and pickup trucks, and the initial shape applied to light trucks would be based, in part, on subcompact cars. Stringency would still be determined separately for passenger cars and light trucks. NHTSA invites comments on the consistency of this approach with the requirement in EPCA to establish separate standards for passenger cars and light trucks.

NHTSA performed a preliminary analysis of this approach. Considering the very wide range of fuel consumption levels in the combined fleet, NHTSA developed the asymptotes based on the average fuel consumption of all passenger cars and light trucks, respectively, rather than on the smallest passenger cars and the largest light trucks. The resultant MY2015 curve, shown below, is similar in curvature to the proposed curve for passenger cars

and notably steeper than the proposed curve for light trucks.

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[GRAPHIC] [TIFF OMITTED] TP02MY08.027

[GRAPHIC] [TIFF OMITTED] TP02MY08.028

Ignoring Outliers. A fifth possible solution would be to ignore outliers (data points that are unique and skew the curve). Lacking an objective means of classifying specific vehicle models as outliers that should be excluded from the analysis, NHTSA explored the possibility of excluding all hybrid electric vehicles (HEVs). The Japanese government also excluded HEVs for purposes of developing Japan's light vehicle efficiency standards. However, doing so yields initial curves of shapes similar to those proposed, but displaced slightly in the direction of

lower fuel consumption. The similarity of the shapes of these curves suggests that optimization against the full fleet (with HEVs) would produce standards whose stringency is similar to that of those proposed today.
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[GRAPHIC] [TIFF OMITTED] TP02MY08.029

[[Page 24442]]

[GRAPHIC] [TIFF OMITTED] TP02MY08.030

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NHTSA invites comments on the importance of addressing the relative steepness of the proposed curves for passenger cars, and on the feasibility of, technical basis for, and implications of any options for doing so. The agency plans to reevaluate standards for both passenger cars and light trucks before promulgating a final rule, and notes that changes in approach--including measures to address the steepness of the passenger car curves--could lead to changes in stringency as well as different impacts on different manufacturers.

c. Risk of Upsizing

The steepness of the proposed curve for passenger cars presents a localized risk that manufacturers will respond in ways that compromise expected fuel savings. That is, although the constrained logistic curve has a steep region, that region does not cover a wide range of footprints. However, any attribute-based system involves the broader risk that manufacturers will shift toward vehicles with the lowest fuel economy targets to the extent that upsizing can be accomplished sufficiently cheaply and without so much weight increase as to nullify the effect of a lower target. As mentioned above, the constrained logistic curve proposed by NHTSA provides an absolute floor. That is, even if manufacturers discontinue all but the very largest known passenger cars and light trucks, they would still be required to meet CAFE standards no lower than the lower asymptote (on an mpg basis) of the constrained logistic curve. Also, for domestic passenger cars, EISA establishes a floor or ``backstop'' equal to 92 percent of the average required CAFE level for passenger cars. This backstop is discussed below in Section VI.

It is difficult to assess the risk that manufacturers may shift the mix of vehicles enough to approach the EISA floor for domestic passenger cars, or to approach the lower asymptotes for light trucks or imported passenger cars. However, considering the footprint distribution of vehicles (as indicated by the various histograms and scatter plots shown above in this section) expected to be covered by the proposed rule,

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NHTSA anticipates that manufacturers would not be able to approach these reductions in stringency without dramatically altering product mix. The agency doubts that manufacturers could do so unless consumer preferences for larger vehicles also shift dramatically.

NHTSA also notes that under attribute-based CAFE standards such as the agency is proposing today, shifts in consumer preferences could cause manufacturers' required CAFE levels and, therefore, achieved fuel savings (and perhaps costs) to increase. For example, if changes in fuel prices combine with demographic and/or other factors to cause market preferences to shift significantly toward vehicles with smaller footprints, manufacturers shifting (relative to current estimates) in that direction will face higher required CAFE levels than the agency has estimated.

VI. Proposed Fuel Economy Standards

A. Standards for Passenger Cars and Light Trucks

For both passenger cars and light trucks, the agency is proposing CAFE standards estimated, as for the previously-promulgated reformed MY 2008-2011 light truck standards, to maximize net benefits to society. However, as discussed in Section V, the agency considered and analyzed modified approaches to calibrating the continuous function and fitting the data in order to address characteristics of the data (vehicles with outlying fuel economy, footprint, and or sales), and to address the issues of backsliding, steepness of the curve, and curve crossings from one model year to the next. While the agency is proposing the curves below, we continue to be concerned about the steepness of the passenger car curve and about gaming potential and are seeking comments on different approaches to address the steepness, as discussed in Section V. The proposed curves below and their respective shapes are calibrated using unweighted mean absolute deviation (MAD) regression and determined through a gradual transformation of curves to guard against erratic fluctuations and through a series of anti-backsliding measures that prevents the average required CAFE level from falling between model years and prevents the continuous function for a given model from crossing or falling below that of the preceding model year. These refinements are discussed in greater detail in Section V of the notice.

1. Proposed Passenger Car Standards MY 2011-2015

We have tentatively determined that the proposed standards for MY 2011-2015 passenger cars would result in required fuel economy levels that are technologically feasible, economically practicable, and set by taking into account both the effect of other motor vehicle standards of the Government on fuel economy and the need of the United States to conserve energy. Values for the parameters defining the target functions defining these proposed standards for cars are as follows:

Parameter	Model year 2011	2012	2013	2014	2015
a	38.2	40.0	40.8	41.2	41.7
b	25.9	27.4	28.7	29.9	31.2
c	45.9	45.8	45.7	45.6	45.5
d	1.6	1.5	1.5	1.4	1.4

Where, per the adjusted continuous function formula above in Section V:

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:

Based on the product plan information provided by manufacturers in response to the February 2007 request for information and the incorporation of publicly available supplemental data and information, NHTSA has estimated the required average fuel economy levels under the proposed adjusted standards for MYs 2011-2015 as follows:

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[GRAPHIC] [TIFF OMITTED] TP02MY08.031

Table VI-1.--Required CAFE Levels (mpg) for Passenger Cars

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	33.3	35.0	36.0	36.8	37.7
Chrysler	28.7	29.3	32.2	32.6	33.6
Ferrari	30.4	32.0	33.1	33.9	34.9
Ford	31.0	32.7	33.7	34.5	35.5
Fuji (Subaru)	36.9	38.7	39.6	40.1	40.8
General Motors	30.0	31.7	32.8	33.7	34.7
Honda	32.1	33.8	34.8	35.5	36.4
Hyundai	33.4	35.1	36.0	36.7	37.5
Lotus	38.1	40.0	40.8	41.2	41.7
Maserati	28.9	30.6	31.8	32.8	34.0
Mercedes	31.7	33.3	34.4	35.3	36.2
Mitsubishi	33.0	35.1	35.9	37.0	37.9
Nissan	31.2	33.2	34.2	35.0	35.9
Porsche	37.6	39.4	40.3	40.7	41.3
Suzuki	37.3	39.2	40.1	40.6	41.2
Toyota	30.1	31.5	32.7	33.6	34.6
Volkswagen	35.4	37.2	38.2	38.8	39.5
Total/Average	31.2	32.8	34.0	34.8	35.7

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2. Proposed Standards for Light Trucks MY 2011-2015

NHTSA is proposing light truck fuel economy standards for MYs 2011 through 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 purpose of this rulemaking. These assumptions differ from those used by the agency in setting the MY 2008-2011 light truck standards in early 2006, and result in an increase in the projected overall average fuel economy for MY 2011. The agency used the most up-to-date EIA projections for available gasoline prices. These projections are, on average, at approximately $0.25 per gallon higher than the projections used in the last light truck rulemaking. Other differences in assumptions include more current product plan information (i.e., spring 2007 product plans reflecting persistently higher fuel prices, instead of the fall 2005 plans used in the 2006 final rule), an updated technology list and updated costs estimates and penetration rates for technologies, and updated values for externalities such as energy security and placing a value of carbon dioxide emission reductions.

NHTSA is proposing ``optimized'' standards for MY 2011-2015 light trucks, the process for establishing which is described at length above, but which may be briefly described as maximizing net social benefits plus anti-backsliding measures. We have tentatively determined that the proposed light truck standards for MYs 2011-2015 represent the maximum feasible fuel economy level for that approach. In reaching this tentative conclusion, we have balanced the express statutory factors and other relevant considerations, such as safety and effects on employment, and we will also consider our NEPA analysis in the agency's final action.

The proposed 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 V Values for the parameters defining the target functions defining these proposed standards for light trucks are as follows:

Parameter	Model year 2011	2012	2013	2014	2015
A	30.9	32.7	34.1	34.1	34.3
B	21.5	22.8	23.8	24.3	24.8
C	51.9	52.0	52.0	52.1	52.1
D	3.8	3.8	3.8	3.9	3.9

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:

[GRAPHIC] [TIFF OMITTED] TP02MY08.032

Based on the product plans provided by manufacturers in response to the February 2007 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 proposed optimized standards for MYs 2011-2015 as follows:

Table VI-2.--Required CAFE Levels (mpg) for Light Trucks

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015

BMW	28.2	29.9	31.2	31.4	31.7
Chrysler	25.2	26.6	28.0	28.5	29.1
Ford	24.7	26.1	28.0	28.3	28.8
Fuji (Subaru)	30.0	31.7	33.1	33.2	33.4
General Motors	23.9	25.4	26.5	27.0	27.4
Honda	26.1	27.7	28.9	29.2	29.6
Hyundai	27.5	29.1	30.4	30.6	31.0
Mercedes	28.4	30.1	31.4	31.6	31.9
Mitsubishi	29.4	30.8	32.2	32.3	32.6
Nissan	24.9	26.2	27.3	27.7	28.2
Porsche	25.9	27.4	28.7	29.0	29.4
Suzuki	30.3	32.1	33.5	33.5	33.7
Toyota	24.9	26.0	27.2	27.6	28.0
Volkswagen	26.2	27.8	29.0	29.3	29.7
Total/Average	25.0	26.4	27.8	28.2	28.6

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We recognize that the manufacturer product plans that we used in developing the manufacturers' required fuel economy levels for both passenger cars and light trucks will be updated in some respects before the final rule is published. To that end, the agency is publishing a separate request for product plans at the same time as this NPRM to obtain whatever updates have been made already. Further, we note that a manufacturer's required fuel economy level for a model year under the adjusted 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 and develop a product plan that would comply with that level.

3. Energy and Environmental Backstop

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. * * *'' \162\ 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.

\162\ 49 U.S.C. 32902(b)(4).

NHTSA calculated 92 percent of the proposed projected passenger car standards as the minimum standard, which is presented below. The calculated minimum standards will be updated for the final rule to reflect any changes in the projected passenger car standards.

Model year	Minimum standard
2011	28.7
2012	30.2
2013	31.3
2014	32.0
2015	32.9

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 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. We do not believe that further discussion is warranted because Congress has spoken directly on this issue since the Ninth Circuit's decision.

The enactment of EISA resolved this issue. Congress expressly mandated that CAFE standards for automobiles be attribute-based. That is, they must be based on an attribute related to fuel economy, e.g., footprint and they must adjust in response to changes in vehicle mix. Taken by itself, this mandate precludes the agency from adopting a fixed minimum standard. The only exception to that mandate is the provision in which Congress mandated a fixed and flat \163\ minimum standard for one of the three compliance categories. It required one for domestic passenger cars, but not for either nondomestic passenger cars or light trucks.

\163\ A flat standard is one that requires each manufacturer to achieve the same numerical level of CAFE.

Given the clarity of the requirement for attribute-based standards and the equally clear narrow exception to that requirement, the agency tentatively 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, do so. Absent explicit statutory language that provides the agency authority to set flat standards, the agency believes 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.

Regardless, the agency notes that the curve of an attribute-based standard has features that limit backsliding. Some of these features, which are fully described in Section V.B of the notice, were added as the agency refined and modified the Volpe model for the purpose of this rulemaking. Others, such as the lower asymptote, which serves as a backstop, are inherent in the logistic function. We believe that these features help address the concern that has been expressed regarding the possibility of vehicle upsizing without compromising the benefits of reform. In addition, the agency notes that the 35 mpg requirement in and of itself serves as a backstop. 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. If the agency finds that this requirement might not be achieved, it will consider setting standards for model years 2016 through 2015 early enough and in any event high enough to ensure reaching the 35 mpg requirement.

4. Combined Fleet Performance

The combined industry wide average fuel economy (in miles per gallon, or mpg) levels 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
MY 2012: 29.2 mpg
MY 2013: 30.5 mpg
MY 2014: 31.0 mpg
MY 2015: 31.6 mpg

The annual average increase during this five year period is approximately 4.5 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 greater in the early years in this period. In order for the combined industry wide average fuel economy to reach at least 35 mpg by MY 2020, it would have to increase an average of 2.1 percent per year for MYs 2016 through 2020.

B. Estimated Technology Utilization Under Proposed Standards

NHTSA anticipates that manufacturers will significantly increase the use of fuel-saving technologies in response to the standards we are proposing for passenger cars. Although it is impossible to predict exactly how manufacturers will respond, the Volpe model provides estimates of technologies manufacturers could apply in order to comply with the proposed standards. The preliminary Regulatory Impact Analysis (PRIA) presents estimated increases in the industry-wide utilization of each technology included in agency's analysis. Tables VI-3 and VI-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 fleet in response to the baseline and proposed standards.

The average penetration rate is the percentage of the entire fleet to which the technology is applied. For example, tables VI-3 and VI-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 5 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 proposed 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 powertrains to 19 percent of its passenger car fleet to comply with the proposed MY 2015 standard.

As tables VI-3 and VI-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 proposed standards. (Most of the hybrids are integrated starter generators, although significant numbers of IMA and power-split hybrids also penetrate the fleet.) For example, the Volpe model estimated that one of the seven largest light truck manufacturers could be including diesel engines in 45 percent of its light trucks by MY2015 in response to the proposed standards.

Table VI.--3. Estimated Technology Penetration Rates in MY2015 for Passenger Cars

[In percent]

Technology	Average among seven largest manufacturers			Maximum among seven largest manufacturers		
	Under proposed standard	Product plan	Adjusted baseline	Under proposed standard	Product plan	Adjusted baseline
Passenger Cars						
Automatically Shifted Manual Transmission..............	10	10	39	59	59	86
Spark Ignited Direct Injection..........................	22	22	30	76	76	82
Turbocharging & Engine Downsizing.......................	5	5	17	11	11	51
Diesel Engine...	0	0	2	0	0	5
Hybrid Electric Vehicles................................	5	5	15	14	14	19

Table VI.--4. Estimated Technology Penetration Rates in MY2015 for Light Trucks

[In percent]

Technology	Maximum among seven largest manufacturers			Maximum among seven largest manufacturers		
	Under proposed standard	Product plan	Adjusted baseline	Under proposed standard	Product plan	Adjusted baseline
Automatically Shifted Manual Transmission..............	10	14	55	41	41	72
Spark Ignited Direct Injection..........................	23	24	40	46	46	73
Turbocharing & Engine Downsizing........................	9	11	31	32	32	44
Diesel Engine...	3	6	10	7	29	45
Hybrid Electric Vehicles................................	2	6	25	5	13	32

The agency uses Volpe model analysis of technology application rates as a way of determining the economic practicability and technological feasibility of the proposed standards, but we note that manufacturers may always comply with the standards by applying different technologies in different orders and at different rates.

Insofar as our conclusion of what the maximum feasible standards would be is predicated on our analysis, however, the agency requests comment on the feasibility of these rates of increase in the penetration of these advanced technologies, and for other technologies discussed in the PRIA.

C. Benefits and Costs of Proposed Standards

1. Benefits

We estimate that the proposed standards for passenger cars would save approximately 19 billion gallons of fuel and prevent 178 billion 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).\164\

\164\ See supra text accompanying note 103.

We estimate that the value of the total benefits of the proposed passenger car standards would be approximately $31 billion \165\ 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, account for 85 percent ($29.5 billion) of the roughly $35 billion in gross \166\ consumer benefits resulting from increased passenger car CAFE. Petroleum market externalities account for roughly 10 percent ($3.6 billion). Environmental externalities, i.e., reduction of air pollutants accounts for roughly 5 percent ($1.8 billion). Over half of this $1.8 billion figure is the result of greenhouse gas (primarily CO_2) reduction ($1.0 billion). Increased congestion, noise and accidents from increased driving will offset roughly $3.8 billion of the $35 billion in consumer benefits, leaving net consumer benefits of $31 billion.

\165\ The $31 billion estimate is based on a 7% discount rate for valuing future impacts. NHTSA estimated benefits using both 7% and 3% discount rates. Under a 3% rate, total consumer benefits for passenger car CAFE improvements total $36 billion.

\166\ 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 criteria pollutants, and reduced greenhouse gas production. Negative impacts from the rebound effect include added congestion, noise, and crash costs due to additional driving.

The following table sets out the relative dollar value of the various benefits of this rulemaking on a per gallon saved basis:

Table VI-5.--Economic Benefits and Costs per Gallon of Fuel Saved
[Undiscounted]

Category	Variable	Value (2006 $ per gallon)
Benefits......................	Savings in Fuel Production Cost.	$1.99
	Reduction in Oil Import Externalities.	.28
	Value of Additional Rebound-Effect Driving.	.24
	Reduction in Criteria Pollutant Emissions.	.16
	Value of Reduced Refueling Time.	.12
	Reduction in CO2 Emissions.	\167\ .02
	Gross Benefits.........	2.81
Costs.........................	Externalities from Additional Rebound-Effect Driving.	0.30
Net Benefits..................	Net Benefits..........	2.51

We estimate that the proposed standards for light trucks would save approximately 36 billion gallons of fuel and prevent 343 million metric tons of tailpipe CO2 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.

\167\ Based on a value of $7.00 per ton of carbon dioxide.

We estimate that the value of the total benefits of the proposed light truck standards would be approximately $57 billion \168\ 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, account for 84 percent ($52.7 billion) of the roughly $63 billion in gross consumer benefits resulting from increased light truck CAFE. Petroleum market externalities account for roughly 10 percent ($6.5 billion). Environmental externalities, i.e., reduction of air pollutants accounts for roughly 6 percent ($3.5 billion). Over half of this figure is the result of greenhouse gas (primarily CO2) reduction ($1.9 billion). Increased congestion, noise and accidents from increased driving will offset roughly $5.4 billion of the $63 billion in consumer benefits, leaving net consumer benefits of $57 billion.

\168\ The $57 billion estimate is based on a 7% discount rate for valuing future impacts. NHTSA estimated benefits using both 7% and 3% discount rates. Under a 3% rate, total consumer benefits for light truck CAFE improvements are $72 billion.

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2. Costs

The total costs for manufacturers just complying with the standards for MY 2011-2015 passenger cars 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 passenger cars would be recovered or paid back \169\ in additional fuel savings in an average of 56 months, assuming fuel prices ranging from $2.26 per gallon in 2016 to $2.51 per gallon in 2030.\170\

\169\ See Section V.A.7 below for discussion of payback period.

\170\ The fuel prices (shown here in 2006 dollars) used to calculate the length of the payback period are those projected (Annual Energy Outlook 2008, revised early release) by the Energy Information Administration over the life of the MY 2011-2015 light trucks, not current fuel prices.

The total costs for manufacturers just complying with the standards for MY 2011-2015 light trucks would be approximately $31 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 in an average of 50 months, assuming fuel prices ranging from $2.26 to $2.51 per gallon.

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 VI-6.--Passenger Cars

Model year	2011	2012	2013	2014	2015	Total 2011-2015
Benefits	2,596	4,933	6,148	7,889	9,420	30,986
Costs	1,884	2,373	2,879	3,798	4,862	15,796
Net Benefits	712	2,560	3,269	4,091	4,558	15,190

Table VI-7.--Light Trucks

Model Year	2011	2012	2013	2014	2015	Total 2011-2015
Benefits	3,909	8,779	13,560	14,915	16,192	57,355
Costs	1,649	4,986	7,394	8,160	8,761	30,949
Net Benefits	2,260	3,793	6,166	6,755	7,431	26,406

The average annual per vehicle cost increases are shown in the PRIA.

D. Flexibility Mechanisms

The agency's 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 proposed standards. In reality, however, manufacturers are likely to rely to some extent on three flexibility mechanisms provided by EPCA and will thereby reduce the cost of complying with the proposed standards. First, some manufacturers will rely on a combination of technology and compliance credits that they earn (including credits transferred from one compliance category to another) as their compliance strategy. Second, they may also supplement their technological efforts by relying on the special fuel economy adjustment procedures provided by EPCA as an incentive for manufacturers to produce flexible fuel vehicles (FFV). Third, the agency is instituting a credit trading program that, if taken advantage of, would further provide flexibility.

The agency believes that manufacturers are likely to take advantage of these flexibility mechanisms, thereby reducing benefits and costs meaningfully, but does not have any reliable basis for predicting which manufacturers might use compliance credits, how they might use them or the extent to which they might do so.

With respect to earned credits through over-compliance NHTSA notes that while the manufacturers have relatively few light truck credits, several manufacturers already have a substantial amount of banked passenger car credits earned under the long term 27.5 mpg flat or nonattributed-based standard for those automobiles. Further, they will earn significant additional passenger car credits through MY 2010, the last year before the passenger car standards are increased and the first year in which those standards will be attribute-based. These pre-MY 2011 passenger car credits can be carried forward into the MY 2011-2015 period.

While manufacturers might use credits to a significant extent, thereby reducing benefits and costs to a meaningful level, the agency believes it important to note that the potential effect of these flexibility mechanisms is largely limited to MY 2011-2015. The earning of credits will become more difficult in MY 2011. MY 2011 is the first year in which all manufacturers will be required to comply with attribute-based CAFE standards for passenger cars and light trucks. The earning of compliance credits will be more challenging under attribute-based standards since each manufacturer's legal obligation to improve CAFE will be based, in part, on that manufacturer's own product mix. Further, the standards will significantly increase every year. On the other hand, credits earned in MY 2011 or thereafter can be transferred across fleets to a limited extent, adding additional flexibility to the system.

With respect to overcompliance through production of FFV vehicles, EISA also extended the FFV adjustment through 2019. Manufacturers can build enough FFV vehicles to raise the CAFE of their fleets. FFVs are assigned high fuel economy values using a formula specified in the Alternative Motor Fuels Act (AMFA). For example, a Ford Taurus has a fuel economy of 26.39 mpg--if it is converted to a FFV, its fuel economy increases to 44.88 mpg. Converting a vehicle into an FFV is more cost-effective than converting it, for example, into a diesel, which is more costly and achieves lower fuel economy. However, the maximum extent to which the adjustments can be used to raise the CAFE of a manufacturer's fleet is 1.2 mpg in MY 2011-2014. In MY 2015, the cap begins to decline. The cap continues to decline each year thereafter by 0.2 mpg until it reaches 0 mpg in MY 2020 and beyond.

Given that there will be considerably less opportunity to use credits in lieu of installing fuel saving technologies after MY 2015, the manufacturers may elect to apply technology early in the MY 2011-2020 period when redesign

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[[Continued from page 24450]]

opportunities arise rather than relying on credits or FFV adjustments, but then face being limited compliance options in later years. The declining influence of the flexibility mechanisms during this period guarantees that the standards for that year will be met almost entirely through the use of technology, thus helping to ensure the 35.0 mpg goal of EISA will be achieved.

Finally, with respect to cost reduction through reliance on credit trading, credits earned in MY 2011 or thereafter can be traded. There is a study in which the Congressional Budget Office estimated that credit trading would cut the costs of achieving a combined 27.5 mpg standard by 16 percent.\171\ This study assumed that manufacturer compliance costs varied widely and that manufacturers were willing to engage in trading. While some manufacturers have expressed reluctance to trade with competitors, we believe that the credit trading program has the potential to reduce compliance costs meaningfully without any impact on overall fuel savings.

\171\ ``The Economic Costs of Fuel Economy Standards Versus a Gasoline Tax'', Report from the Congressional Budget Office, December, 2003.

E. Consistency of Proposed Passenger Car and Light Truck Standards With EPCA Statutory Factors

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. 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, along with additional relevant factors such as safety. In determining how to weigh these considerations, we are mindful of EPCA's overarching purpose of energy conservation. NHTSA's NEPA analysis for this rulemaking (see Section XIII.B of this document) also will inform the agency's final action.

The section above proposes footprint-based CAFE standards for MY 2011-2015 passenger cars and light truck. The agency has considered this set of standards in light of both the relevant factors and EPCA's overarching purpose of energy conservation, and seeks comment on whether the public agrees that the agency's analysis is sound or should have considered the factors differently or considered additional factors.

We have tentatively determined that the proposed passenger car and light truck standards are at the maximum feasible level for passenger car and light truck manufacturers for MY 2011-2015. As discussed above, the standards are basically determined by following the same procedure as for setting the optimized light truck standards for 2008-2011.

1. Technological Feasibility

We tentatively conclude that the proposed standards are technologically feasible. Whether a technology may be feasibly applied in a given model year is not simply a function of whether the technology will exist in that model year, but also whether the data sources reviewed by the agency indicate that the technology is mature enough to be applied in that year, whether it will conflict with other technologies being applied, and so on. The Volpe model maximizes net benefits by applying fuel-saving technologies to vehicle models in a cost-effective manner, which generally prevents it from applying technologies to vehicles before manufacturers would be ready to do so. Thus, we tentatively conclude that standards that maximize net benefits based on Volpe model analysis are technologically feasible.

We described above how we tentatively conclude that the additional measures used to set the optimized standards do not take the standards out of the realm of technological feasibility, because if targets are feasible in one year, they will continue to be feasible.

2. Economic Practicability

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). We tentatively conclude that the proposed standards are economically feasible. Making appropriate assumptions about key factors such as leadtime and using them in the Volpe model provides a benchmark for assessing the economic practicability of a proposed standard, because it avoids applying technologies at an infeasible rate and avoids application of technologies whose benefits are insufficient to justify their costs when the agency determines a manufacturer's capability. In other words, this approach ensures that each identified private technology investment projected by the model produces marginal benefits at least equal to marginal cost. The Volpe model also takes into account other factors closely associated with economic practicability, such as lead time and phase-in rates for technologies that it applies. By limiting the consideration of technologies to those that will be available and limiting their rate of application using these assumptions, the cost-benefit analysis assumes that manufactures will make improvements that are cost-justified.

In addition to carefully making these assumptions and using cost-benefit analysis, the agency also performs sales and employment impacts analysis on individual manufacturers. The sales analysis looks at a purchasing decision from the eyes of a knowledgeable and rational consumer, comparing the estimated cost increases versus the payback in fuel savings over 5 years (the average new vehicle loan) for each manufacturer. This relationship depends on the cost-effectiveness of technologies available to each manufacturer. Overall, based on a 7 percent discount rate for future fuel savings, we expect there would be no significant sales or job losses for these proposed standards. Therefore, we tentatively conclude that the proposed standards are economically practicable.

3. Effect of Other Motor Vehicle Standards of the Government on Fuel Economy

We tentatively conclude that the proposed standards for passenger cars and light trucks account for the effect of other motor vehicle standards of the Government on fuel economy. This statutory factor constitutes an express recognition that fuel economy standards should not be set without due consideration given to the effects of efforts to address other regulatory concerns, such as motor vehicle safety and 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 information in their product plans, which are accounted for as part of 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., MY 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 completed a preliminary evaluation of the impact of the Federal motor vehicle safety standards (FMVSSs) using MY 2010 vehicles as a baseline for passenger cars. We have issued or proposed to issue a number of FMVSSs that become effective between the baselines and MY 2015. These have been analyzed for their potential impact on vehicle weights for vehicles manufactured in these years: 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 is 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 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 their vehicles.

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 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 20 percent of vehicles; and in MY 2012, to another 5 percent of vehicles.

The agency's analysis of weight impacts found that ABS 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 52 percent would have ESC. Thus, the total added weight in MY 2011 for passenger cars would be about 2.5 lbs. (0.15 x 10.7 + 0.48 x 1.8), and in MY 2012 would be about 0.6 lbs. For light trucks, manufacturers' plans indicate that 99 percent of all light trucks would have ABS by MY 2011 and that 52 percent would have ESC by that time. Thus for light trucks, the incremental weight impacts of adding ESC would be slightly less than 1 pound (0.01 x 10.7 + 0.48 x 1.8).

FMVSS No. 214, Side Impact Protection

NHTSA recently issued a final rule to incorporate a dynamic pole test into FMVSS No. 214, ``Side Impact Protection.'' \172\ The rule will lead to the installation of new technologies, such as side curtain air bags and torso side air bags, which are capable of improving head and thorax protection to occupants of vehicles and that crash into poles and trees and vehicles that are laterally struck by a higher vehicle. The phase-in requirements for the side impact test are as shown below: \173\

\172\ 72 FR 51907 (Sept. 11, 2007).

\173\ Id. 51971-72.

Phase-in date	Percent of each manufacturer's light vehicles that must comply during the production period
September 1, 2009 to August 31, 2010.	20 percent (excluding vehicles GVWR > 8,500 lbs.).
September 1, 2010 to August 31, 2011.	50 percent of vehicles (excluding vehicles GVWR > 8,500 lbs.).
September 1, 2011 to August 31, 2012.	75 percent of vehicles (excluding vehicles GVWR > 8,500 lbs.).

September 1, 2012 to August 31, 2013.	All vehicles including limited line vehicles, except vehicles with GVWR > 8,500 lbs., alterers, and multi-stage manufacturers.
On or after September 1, 2013	All vehicles, including vehicles with

GVWR > 8,500 lbs., alterers and multi-stage manufacturers.

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 2010. A very similar percentage is estimated for MY 2011. A teardown study of 5 thorax air bags resulted in an average weight increase per vehicle of 4.77 pounds (2.17 kg).\174\ A second study performed teardowns of 5 window curtain systems.\175\ 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.

\174\ 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.

\175\ Ludtke & Associates, ``Perform Cost and Weight Analysis, Head Protection Air Bag Systems, FMVSS 201'', page 4-3 to 4-5, DOT HS 809 842.

Assuming in the future 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 standard from 1.5 times the vehicle weight to 2.5 times the vehicle weight.\176\ 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. Thus, it is still possible that the final rule could be effective with MY 2011. 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.

\176\ 70 FR 49223 (Aug. 23, 2005). The PRIA for this NPRM is available at Docket No. NHTSA-2005-22143-2.

Planned NHTSA Initiative on Ejection Mitigation

The agency is planning on issuing a proposal on ejection mitigation. The likely result of the planned 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 1 pound; 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 in MY 2010 or later to institute the above discussed standards or likely rulemakings. In summary, NHTSA estimates that weight additions required by final rules and likely NHTSA regulations effective in MY 2011 and beyond for passenger cars, compared to the MY 2010 fleet, will increase passenger car weight by an average of 12.2 pounds or more (5.5 kg or more). The agency estimates that weight additions required by final rules and likely NHTSA regulations effective in MY 2011 and beyond for light trucks, compared to the MY 2010 fleet, will increase light truck weight by an average of 10.1 pounds or more.

Table VI-8.--Minimum Weight Additions Due to Final Rules or Likely NHTSA Regulations Compared to MY 2010 Baseline Fleet

Standard no.	Added weight in pounds	Added weight in kilograms
126	3.1	1.4
214	2.0	0.9
216	6.1-?	2.8-?
Ejection Mitigation	1.0-?	0.4-?
Total	12.2-?	5.5-?

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 0.025 to 0.04 mpg or more for already issued or likely future safety standards.

Federal Motor Vehicle Emissions Standards

EPA's Fuel Economy Labeling Rule 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.\177\ The rule became effective January 26, 2007, and will take effect starting with MY 2008.

\177\ See 71 FR 77872 (December 26, 2006).

The new testing procedures will combine measured fuel economy over the two current fuel economy tests, the FTP and HFET, as well as that over the US06, SC03 and cold FTP tests into estimates of city and highway fuel economy for labeling purposes. The test results from each cycle will be weighted to represent the contribution of each cycle's attributes to onroad driving and fuel consumption. The labeling rule does not alter the FTP and HFET driving cycles, the measurement techniques, or the calculation methods used to determine CAFE.

The EPA Labeling Rule will not impact CAFE standards or test procedures or other USG regulations.\178\ Rather, the changes to existing test procedures will allow for the collection of appropriate fuel economy data to ensure that existing test procedures better represent real-world conditions.\179\ Further, the labeling rule does not have a direct effect upon a vehicle's weight, nor on the fuel economy level that a vehicle can achieve. Instead, the labeling rule serves to provide consumers with a more accurate estimate of fuel economy based on more comprehensive factors reflecting real-world driving use.

\178\ Id. section I.F.
\179\ Id. sections II, IV.

There are two groups of State emissions standards do not qualify under 49 U.S.C. 32902(f), and therefore are not considered. One is consists of State standards that cannot be adopted and enforced by any State because there has been no waiver granted by the EPA under the preemption waiver provision in the Clean Air Act.\180\ The other consists of 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:

\180\ 42 U.S.C. 7543 (a).

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(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 (i.e., a State tailpipe CO_2 standard).

4. Need of the U.S. 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'' 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.

The need to conserve energy is, from several different standpoints, more crucial today as 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. Crude oil prices are currently around $100 per barrel, despite having averaged about $13 per barrel as recently as 1998, and gasoline prices have doubled in this period.\181\ Net petroleum imports now account for 60 percent of U.S. domestic petroleum consumption.\182\ 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 VI-3 below shows the increase of crude oil imports and the decline of U.S. oil production since 1920.

\181\ 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).
\182\ 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).

[GRAPHIC] [TIFF OMITTED] TP02MY08.034

The need to conserve energy is also more crucial today because of growing greenhouse gas emissions from petroleum consumption by motor vehicles and growing concerns about the effects of those emissions. Since 1999, the transportation sector has led all U.S. end-use sectors in emissions of carbon dioxide. 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 carbon dioxide emissions from all sectors over the period. Petroleum consumption, which is directly related to fuel economy, is the largest source of carbon dioxide emissions in the transportation sector.\183\ Moreover, transportation sector emissions from gasoline and diesel fuel combustion generally parallel total vehicle miles traveled. The need of the nation to conserve energy also encompasses all of these issues, insofar as carbon dioxide emissions from passenger cars and light trucks decrease as fuel economy improves and more energy is conserved.\184\

\183\ 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).

\184\ 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 Feb. 3, 2008).

The need of the nation to reduce energy consumption would be properly reflected in the buying decisions of vehicle purchasers, if:

Vehicle buyers behave as if they have unbiased expectations of their future driving patterns and fuel prices; and

The public social, economic, security, and environmental impacts of petroleum consumption are fully identified, quantified and reflected in current and future gasoline prices; and

Vehicle buyers behave as if they account 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 which EPCA requires NHTSA to address.

By accounting for the need of the nation to conserve energy in setting CAFE standards, NHTSA helps to mitigate the risks posed by petroleum consumption. In its analysis, 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 CO2 emissions, criteria pollutant emissions, noise, safety, and others).

The Volpe model uses values for these effects in helping to determine each model year's CAFE standards. Thus, each model year's CAFE standards are set based on an attempt to quantify the need of the United States to conserve energy, balanced against the other factors considered in the Volpe model, such as the technology inputs that help the model establish economically practicable and technologically feasible standards.

Also, as Congress intended, by accounting for the need of the nation to conserve energy in setting CAFE standards, NHTSA fulfills EPCA's overall goal of improving energy conservation. Factors that increase the need of the nation to conserve energy, such as rising oil prices or environmental concerns, may be reflected in more stringent, but still demonstrably economically practicable fuel economy standards. Balancing the EPCA factors against each other, and considering NHTSA's NEPA analysis for this rulemaking (see Section XIII.B. of this document), NHTSA may decide to set higher CAFE standards, and achieve more fuel savings and CO_2 emissions reduction, by expressly including the quantifiable values of the factors that affect the need of the nation to conserve energy.

These standards will enhance the normal market response to higher fuel prices, and will reduce light duty vehicle 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 55 billion gallons of fuel and 521 million metric tons of CO_2 over the lifetime of the regulated vehicles. NHTSA will evaluate the potential environmental impacts associated with such CO_2 emissions reductions and other environmental impacts of the proposed standards through the NEPA process.

F. Other Considerations in Setting Standards Under EPCA

As explained above, EPCA requires NHTSA to balance the four 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 in setting CAFE standards for passenger cars and light trucks. As discussed above, EPCA also prohibits NHTSA from considering certain factors (e.g., credits) in setting CAFE standards. The next section highlights some of the issues that NHTSA may (and does) and may not take into account in setting CAFE standards under EPCA.

1. Safety

NHTSA has historically included the potential for adverse safety consequences when deciding upon a maximum feasible level, and has been upheld by courts in doing so.\185\ Currently, we account for safety in the model as we develop the standards: Because downweighting is a common compliance strategy, and because the agency believes that downweighting of lighter vehicles makes them less safe, our model does not rely on weight reductions to achieve the standards for vehicles under 5,000 pounds GVWR,\186\ and then only up to 5 percent. As explained above, 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 greatest amount of fuel savings without leading to adverse economic or other societal consequences.

\185\ See, e.g., Competitive Enterprise Institute v. NHTSA (CEI I), 901 F.2d 107, 120 at 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.'')

\186\ Kahane study, supra note 78.

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2. Alternative Fuel Vehicle Incentives

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.\187\ Dedicated vehicles often achieve higher mile per gallon (or equivalent) ratings than regular gasoline vehicles, so this prohibition prevents NHTSA from raising CAFE standards by averaging these vehicles into our determination of a manufacturer's maximum feasible fuel economy level.

\187\ 49 U.S.C. 32901(a)(7).

Section 32902(h) also directs NHTSA to ignore the fuel economy incentives for dual-fueled (e.g., E85-capable) automobiles in setting CAFE standards. Sec. 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 identical regular automobiles. Through MY 2014, manufacturers may use this ``dual-fuel'' incentive to raise their average fuel economy up to 1.2 miles a gallon higher than it would otherwise be; after MY 2014, Congress has set a schedule by which the dual-fuel incentive diminishes ratably until it is extinguished after MY 2019.\188\ 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.

\188\ 49 U.S.C. 32906(a).

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3. Manufacturer Credits

Section 32903 was recently revised by EISA, and allows manufacturers to earn credits for exceeding CAFE standards in a given year and to apply them to CAFE compliance for up to three model years before and five model years after the year in which they were earned. However, section 32903(a) states expressly that fuel economy standards must be ``determined * * * without regard to credits under this section.'' Thus, NHTSA may not raise CAFE standards because manufacturers have enough credits to meet the higher standards, nor may NHTSA lower standards because manufacturers do not have enough credits to meet existing standards.

G. Environmental Impacts of the Proposed Standards

As noted above, environmental concerns are among the issues bearing on the need of the nation to conserve energy. They are also relevant under the National Environmental Policy Act (NEPA), 42 U.S.C. 4321-4347. Requiring improvements in fuel economy will necessarily reduce CO_2 emissions, because the less fuel a vehicle burns, the less CO_2 it emits. Reductions in CO_2 emissions, in turn, may slow or mitigate climate change and associated environmental impacts. Increased fuel economy also may affect other aspects of the environment, such as emissions of criteria air pollutants and air quality.\189\ In order to inform its consideration of the proposed standards, NHTSA has initiated an environmental review of the proposed standards and reasonable alternatives pursuant to NEPA. On March 28, 2008, NHTSA published a notice of intent to prepare an environmental impact statement and requested scoping comments (73 FR 16615). NHTSA is publishing a supplemental notice of public scoping and request for scoping comments that invites Federal, State, and local agencies, Indian tribes, and the public to participate in the scoping process and to help identify the environmental issues and reasonable alternatives to be examined in the EIS. The scoping notice also provides information about the proposed standards, the alternatives NHTSA expects to consider in its NEPA analysis, and the scoping process.

\189\ Because CO_2 accounts for such a large fraction of total greenhouse gases (GHG) emitted during fuel production and use--more than 95%, even after accounting for the higher global warming potentials of other GHG--NHTSA's analysis of the GHG impacts of increasing CAFE standards focuses on reductions in CO_2 emissions resulting from the savings in fuel use that accompany higher fuel economy.

As discussed in the scoping notice, in preparing an EIS for this rulemaking, NHTSA expects to consider potential environmental impacts of the proposed standards and reasonable alternatives, including impacts associated with CO_2 emissions and climate change. NHTSA expects that its NEPA analysis will include: direct impacts related to fuel and energy use and emissions of CO_2 and air pollutants; indirect impacts related to emissions and climate change, such as impacts on air quality and temperature and resulting impacts on natural resources and on the human environment; and other indirect impacts. NHTSA's NEPA analysis will inform its decisions on the proposed standards, consistent with NEPA and EPCA.

H. Balancing the Factors to Determine Maximum Feasible CAFE Levels

While the agency carefully considered alternative stringencies as discussed in section X, it tentatively concludes that in stopping at the point that maximizes net benefits, it has achieved the best balancing of all of the statutory requirements, including the 35 mpg requirement. In striking that balance, the agency was mindful of the growing need of the nation to conserve energy for reasons that include increasing energy independence and security and protecting the environment. It was mindful also that this is the first rulemaking in which the agency has simultaneously proposed to raise both passenger car and light truck standards, and that it was doing so in the context of statutory requirements for significant annual increases over an extended period of years.

Among the steps it took in its analysis and balancing were the following:

First, the agency pushed many of the manufacturers in their application of technology. NHTSA is proposing standards that it estimates will entail risk that some manufacturers will exhaust available technologies in some model years. However, the agency has tentatively concluded that the additional risk is outweighed by the significant increase in estimated net benefits to society.

Second, as observed in the technology penetration table above, the agency believes that more and more advanced, but expensive fuel economy technologies will penetrate the fleet by 2015. However, the agency was careful to ensure that those technologies are applied in an economically and technologically feasible manner by focusing on linking certain expensive technologies to redesign and refresh dates and by phasing in technologies over time as it is difficult for companies to implement many of the technologies on 100 percent of their vehicles all at once. Sections III and V describe in fuller detail how the agency addressed these issues in its modeling.

Third, in assessing costs and benefits, the agency took into account the private and social benefits, including environmental and energy security benefits (e.g., it monetized important externalities, such as energy security and CO_2) and ensured that for every dollar of investment the country gets at least 1 dollar of benefits.

Fourth, in setting attribute based standards as required by EISA, the agency will minimize safety implications and preserve consumer choice. Further, through its choice of footprint as an attribute, the agency minimized the risk of upsizing as it is more difficult to change the footprint than to simply add weight to the vehicle.

Fifth, the agency evaluated the costs and benefits described above and ensured that the standards were achievable without the industry's being economically harmed through significant sales losses.

Sixth, the agency weighed those costs and benefits vis-a-vis the need of the nation to conserve energy for reasons that include increasing energy independence and security and protecting the environment and compared the results for a wide variety of alternatives as discussed in Chapter X.

NHTSA tentatively concludes that it has exercised sound judgment and discretion in considering degrees of technology utilization and degrees of risk, and has appropriately balanced these considerations against estimates of the resultant costs and benefits to society, thereby arriving at standards that represent the maximum feasible standards as required by EPCA. The agency invites comment regarding whether it has struck a proper balance and, if not, how it should do so.

VII. Standards for Commercial Medium- and Heavy-Duty On-Highway

Vehicles and ``Work Trucks''

NHTSA is not promulgating standards for commercial medium- and heavy-duty on-highway vehicles or ``work trucks'' \190\ as part of this proposed rule. EISA added a new provision to 49 U.S.C. 32902 requiring DOT, in consultation with the Department of Energy and the EPA, to examine the fuel efficiency of commercial medium- and heavy-duty on-highway vehicles and work trucks, 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.\191\

\190\ ``Work trucks'' are vehicles rated between 8,500 and 10,000 lbs GVWR and which are not medium-duty passenger vehicles. 49 U.S.C. 32901(a)(19).

\191\ 49 U.S.C. 32902(k)(1).

Within 2 years of the completion of the study, DOT 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 * * * 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 these vehicles.\192\ 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.\193\

\192\ 49 U.S.C. 32902(k)(2).

\193\ 49 U.S.C. 32902(k)(2) and (3).

VIII. Vehicle Classification

A. Origins of the Regulatory Definitions

NHTSA developed the regulatory definitions for passenger cars and light trucks based on our interpretation of EPCA's language and of Congress' intent as evidenced through the legislative history. The statutory language is clear that some vehicles must be passenger automobiles and some must be non-passenger automobiles. Passenger automobiles were defined 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 Sec. 501(2), 89 Stat. 901.

Thus, under EPCA, there are two general groups of automobiles that qualify as non-passenger automobiles: (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.

EPCA also defined vehicle ``capable of off-highway operation'' as one that NHTSA decides by regulation:

has a ``significant feature'' (other than 4-wheel drive) which is designed to equip such automobile for off-highway operation, and either (i) is a 4-wheel drive automobile or (ii) is rated at more than 6,000 pounds gross vehicle weight.''

Thus under the statute, any vehicle that has a ``significant feature'' and also is either 4-wheel drive or over 6,000 lbs GVWR can never be a passenger vehicle. Generally speaking, the ``significant feature'' that NHTSA's regulation focuses on relates to high ground clearance. EPCA does not prohibit us from choosing other or additional significant features, but Congress has had multiple opportunities to disagree with our interpretation and has not done so.

In its final rule establishing its vehicle classification regulation, NHTSA noted the ambiguity of the statutory definitions of ``automobile'' and ``passenger automobile'' and considered at length the legislative history of those definitions.\194\ The agency concluded that ``* * * both houses of Congress had expressed an intent that vehicles classed by EPA as light duty vehicles be subject to average fuel economy standards separate from the standards imposed on passenger cars.''\195\ The agency thus found it necessary to analyze what Congress meant by ``primarily.''

\194\ 42 FR 38362, 38365-67; July 28, 1977.
\195\ Id. 38366.

In establishing 49 CFR part 523 in the 1970s, we determined that Congress intended ``primarily'' to mean ``chiefly'' [or firstly, in the first place], not ``substantially'' [or largely, in large part],\196\ for two main reasons. First, if ``primarily'' meant ``substantially'' or ``in large part,'' ``then almost every automobile would be a passenger automobile, since a substantial function of almost all automobiles is to transport at least two persons. The only non-passenger automobiles under this interpretation would be those specifically excluded by the definition * * * ''\197\ Because Congress gave NHTSA authority to develop the definitions by regulation, it did not make sense to read ``primarily'' as limiting the category of non-passenger automobiles to just those specifically excluded by the precise language of the statute.

\196\ We stated that ``the word `primarily' has two ordinary, everyday meanings in legal usage--`chiefly' and `substantially.' '' See Board of Governors of the Federal Reserve System v. Agnew, 329 U.S. 441, 446 (1947).
\197\ 42 FR 38362, 38365 (Jul. 28, 1977).

And second, we concluded that considering ``primarily'' ``against a legislative backdrop of other statutes using the identical phrase, and the remedial purposes of this Act,'' justified a broad interpretation of ``non-passenger automobile.''\198\ The remedial purposes of EPCA--to improve fuel efficiency and increase fuel savings--do not require all vehicles to be classified as passenger automobiles. Since non-passenger automobile CAFE standards must still be set at the maximum feasible level, fuel economy of all vehicles would be improved regardless of how the vehicles were classified.\199\ Additionally, interpreting ``non-passenger automobile'' broadly was determined to be consistent with the Vehicle Safety Act \200\ and EPA emissions regulations promulgated under the Clean Air Act. A broad interpretation of ``non-passenger automobile'' served to ``minimize the possibility of inconsistent regulatory requirements.''\201\ And finally, analyzing the legislative history, NHTSA concluded that ``By using existing terms with existing applications [such as ``light duty truck'' as used by EPA], Congress gave a clear indication of the types of automobiles that were intended to be treated separately from passenger automobiles.''[202 203]

\198\ Id. at 38365-66.
\199\ Id. at 38366.
\200\ The Vehicle Safety Act distinguished between ``passenger cars'' and ``trucks.''
\201\ 42 FR 38362, 38366.
\202\ Id.
\203\ We note that the 2003 ANPRM that preceded the 2006 CAFE rule incorrectly summarized the agency's review of the legislative history in the late 1970s. The 2003 ANPRM erroneously stated that Congress intended that passenger automobiles be defined as those used primarily for the transport of individuals. 68 FR 74926 (Dec. 29, 2003)

Thus, as NHTSA developed the regulatory definitions, we kept these indications from Congress in mind, which resulted in four basic types of non-passenger automobiles:

(1) Automobiles designed primarily to transport more than 10 persons.

As a practical matter, this category basically encompasses large passenger vans.

(2) Automobiles designed primarily for purposes of transportation of property.

NHTSA has included in this category both vehicles with open beds like pickup trucks, and vehicles which provide greater cargo-carrying than passenger-carrying volume. As we stated in the 1977 final rule, pickup trucks are not ``manufactured chiefly to transport individuals, since well over half of the available space on those automobiles consists of the cargo bed, which is exclusively cargo-carrying area. Further, this type of automobile is designed to carry heavy loads.'' \204\ Regarding vehicles which provide greater cargo-carrying than passenger-carrying volume, we stated that ``Since more of the space inside the vehicle has been dedicated to transporting cargo, and such vehicles are typically designed to carry heavy loads, this agency

concludes that the chief consideration in designing the vehicle was the ability to transport property.'' This included, for example, cargo vans and multistop vehicles.

\204\ Id. at 38367.

(3) Automobiles which are derivatives of automobiles designed

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primarily for the transportation of property.

This could include vehicles in which the cargo-carrying area has been converted to provide temporary living quarters, because they would typically be a derivative of a cargo van or a pickup truck. Additionally, these could include a passenger van with seating positions for less than 10 people. Such a vehicle would be basically a cargo van with readily removable seats, so removing the seats would create more cargo-carrying than passenger-carrying volume. These vehicles would be distinguished from station wagons, which have seats that can fold down to create a flat cargo space, but are not ``derivatives,'' in that their parent vehicle is not a non-passenger automobile, and do not have the same chassis, springs, or suspension system as a non-passenger automobile.

(4) Automobiles which are capable of off-highway operation.

NHTSA generally defines ``capable of off-highway operation'' as meeting the high ground clearance characteristics of Sec. 523.5(b)(2) and either having 4-wheel drive or being rated at more than 6,000 pounds gross vehicle weight, or both. We note that a vehicle is considered as having 4-wheel drive only if it is manufactured with 4-wheel drive. The fact that the same model is available in 4-wheel drive would not be sufficient to classify a 2-wheel drive vehicle as one that ``has'' 4-wheel drive under Sec. 523.5(b)(1)(i).

B. The Rationale for the Regulatory Definitions in Light of the Current Automobile Market

The categories listed above make up the various criteria which allow classification of a vehicle as a light truck under Part 523. However, as the 2002 NAS Report noted, the national vehicle market has evolved, and the fleets have changed. Until the passage of the Energy Independence and Security Act of 2007, Congress had provided no further insight since EPCA's enactment into how new types of vehicles that have developed since the 1970s should be classified. NHTSA had to classify these vehicles based on the words of the statute and on its own interpretation of what Congress appears to have wanted. The following section identifies the main vehicle types currently classified as light trucks, and explains the agency's reasoning for each.

Pickup trucks were among the original automobiles identified by Congress in EPCA's legislative history as vehicles that would not be passenger automobiles.\205\ As mentioned earlier, we originally identified automobiles ``which can transport property on an open bed'' as ones ``not manufactured chiefly to transport individuals, since well over half of the available space on those automobiles consists of the cargo bed, which is exclusively cargo carrying area.'' \206\ We stated further that ``this type of automobile is designed to carry heavy loads,'' and is therefore properly a non-passenger automobile or light truck.

\205\ EPA included pickup trucks as ``light duty trucks,'' and the Senate bill which became EPCA used EPA's definition of light duty trucks as examples of vehicles that would be non-passenger automobiles. 42 FR 38362, 38366 (Jul. 28, 1977).

\206\ Id. 38367.

NHTSA recognizes that pickup trucks have evolved since the 1970s, and that some now come with extended cabs for extra passenger room and smaller open beds. These features, however, do not change the fact that pickup trucks are designed to carry loads. Moreover, even with an extended cab and a smaller open bed, the fact that the open bed is still present indicates to us that the vehicle was manufactured chiefly for transporting cargo. If the manufacturer intended the vehicle's first purpose to be the carrying of passengers, it could have enclosed the entire vehicle. Thus, as 49 CFR 523.5(a)(3) indicates, a pickup truck with an open bed is to be classified as a light truck regardless of any other features it may possess.

Sport utility vehicles (SUVs), which possess a substantial market share today, had not yet developed when EPCA was enacted or when NHTSA first promulgated Part 523, although their forebears like the AMC Jeep and other off-road and military style vehicles were known at the time. These vehicles originally tended to be classified as light trucks because they were capable of off-highway operation, and possessed either the necessary high ground clearance characteristics or 4-wheel drive or both. They may also be greater than 6,000 pounds GVWR, and/or manufactured to permit expanded use of the automobile for cargo-carrying or other nonpassenger-carrying purposes.

Part of the overall popularity of SUVs is due to the great variety of forms in which they are available. For example, consumer demand has led manufacturers to offer smaller SUVs (i.e., less than 6,000 pounds GVWR) with features such as the high ground clearance that many drivers enjoy. These vehicles may come with two or even three rows of seats as standard. If these smaller vehicles actually have 4-wheel drive and the requisite number of clearance characteristics, they would properly be classified as light trucks under Sec. 523.5(b) without regard to functional considerations such as cargo volume.

However, if these lighter vehicles (i.e., under 6,000 pounds) have

2-wheel drive, they would not qualify as light trucks under Sec. 523.5(b) despite having the clearance characteristics. Such vehicles may nevertheless be classified as light trucks if they meet one or more of the functional criteria in Sec. 523.5(a). For example, if a vehicle has three standard rows of seats, it should be classified in accordance with Sec. 523.5(a)(5)(ii), on the same basis as many minivans are currently classified--that it provides a certain minimum potential cargo-carrying capacity that NHTSA has believed is consistent with what Congress had in mind when it originally considered the distinction between passenger and non-passenger automobiles. Alternatively, a 2-wheel drive automobile may properly be classified as a light truck under Sec. 523.5(a)(4) if it provides ``greater cargo-carrying than passenger-carrying volume'' as discussed in one of NHTSA's longstanding interpretations.\207\

\207\ In 1981, General Motors asked NHTSA whether a 2-wheel drive utility vehicle would be properly classified as a light truck as long as the cargo-carrying volume exceeded the passenger-carrying volume. We agreed in a letter of interpretation responding to GM 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.'' (Emphasis added.) This letter of interpretation indicates that in order to be properly classified as a light truck under Sec. 523.5(a)(4), a 2-wheel drive SUV must have greater cargo-carrying volume than passenger-carrying volume ``in base form.'' 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 equipment. For example, a base vehicle that comes equipped with a standard second-row seat would not be classified as a light truck merely because the purchaser has an option to delete the second-row seat.

Minivans are another general category of vehicles that essentially developed after the enactment of EPCA and the promulgation of Part 523 are minivans. Minivans are classified as light trucks under the ``flat floor'' provision of Sec. 523.5(a)(5), because their seats may be easily removed or folded down to create a large flat level surface for cargo-carrying. The flat floor provision was originally based on the agency's

determination that passenger vans with removable seats and a flat load floor were derived from cargo vans, and should therefore be classified as light trucks.\208\

\208\ 42 FR 38362, 38367 (Jul. 28, 1977).

In the preamble to the final rule establishing the MY 1983-1985 light truck fuel economy standards, in response to a comment by Chrysler, we explained that the regulations classified ``large passenger vans as light trucks based on the ability of passenger van users to readily remove the rear seats to produce a flat, floor level cargo-carrying space.'' \209\ Manufacturers generally responded to NHTSA's statement by building compact passenger vans--i.e., minivans--with readily removable rear seats in order to qualify as light trucks under the flat floor provision. In short, because minivans often have removable seats and a flat floor, they have traditionally been classified as light trucks for fuel economy purposes. EPA also classifies minivans as light duty trucks for emissions purposes, as derivatives of light trucks.

\209\ 45 FR 81593, 81599 (Dec. 11, 1980).

In recent years, many minivans have been designed with seats that fold down flat or into the floor pan, rather than being completely removable. In the 2006 light truck CAFE final rule, NHTSA revised Sec. 523.5(a)(5) to allow these minivans to continue to qualify for classification as light trucks, requiring ``vehicles equipped with at least 3 rows of seats'' to be able to create a ``flat, leveled cargo surface'' instead of a ``flat, floor level, surface.'' We believe that this is consistent with Congress' intent that vehicles manufactured with the capacity to permit expanded use of the automobile for cargo-carrying or other nonpassenger-carrying purposes be classified as light trucks. Minivans have this capacity just as passenger vans do. In order to distinguish them from other vehicles like station wagons that also arguably have this capacity, we require vehicles to have three rows of seats in order to qualify as light trucks on this basis. This helps to guarantee a certain amount of potential cargo-carrying volume, since manufacturers will not be able to fit an additional row of seats in a vehicle under a certain size. Congress did not specify how much cargo volume was necessary for a vehicle to be classified as a light truck. We believe that this requirement for light truck classification is both consistent with Congress' intent that light trucks permit expanded use for cargo-carrying purposes, and accommodates the evolution of this section of the modern vehicle fleet.

The latest vehicle type growing rapidly in the U.S. market today is the ``crossover'' vehicle. Crossover vehicles are generally designed on passenger car-like platforms (unibody construction), but are also designed with the functionality of SUVs and minivans. Crossover vehicles blur the typical divisions between passenger cars, SUVs and minivans (higher ground clearance, two or three rows of seats, and varying amounts of cargo space). These vehicles can come in any shape or size, they may or may not look like traditional passenger cars, SUVs or minivans, and they may be available in a variety of drive configurations (2WD, 4WD, AWD, or some combination). As more and more of these vehicles become available it will become more difficult to categorize them into one particular vehicle category. The majority of existing crossover vehicles have been categorized by vehicle manufacturers as light trucks under section 523.5(b) if they are off-highway capable, or under section 523.5(a) due to their functional characteristics. NHTSA plans to continue to allow these vehicles to be classified as light trucks as long as they continue to meet the light truck classification requirements as specified in part 523. As with SUVs, when determining off road capability, a vehicle ``has'' 4-wheel drive (or AWD) if it is actually equipped with it; a 2-wheel drive vehicle is counted as a 2-wheel drive vehicle regardless of whether the same model is available in 4-wheel drive. Furthermore, when evaluating the functional capabilities against the requirements of section 523.5(a), vehicles should be classified by model, including all vehicles of a particular model. When the light truck determination is made based upon the functional characteristics requirements of section 523.5(a), the base or standard vehicle (vehicle with no options) is used to classify the associated model. For example, if a vehicle model does not come standard with a third row of seats, but can be purchased with an optional third row seat, the vehicle, and all the vehicles within that model line, cannot be classified as a light truck under 523.5(a)(5), which requires vehicles to be equipped, as standard equipment, with at least 3 rows of seats and able to create a ``flat, leveled cargo'' surface.

C. NHTSA Is Not Proposing To Change the Regulatory Definitions at This Time

As explained above, NHTSA's regulations defining vehicle classifications for fuel economy purposes (49 CFR part 523) are based on the underlying statute. We continue to believe that they are valid, as discussed above. In addition, 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.

Accordingly, other than by incorporating EISA's new and revised definitions, we are not proposing to change the agency's regulations defining vehicle classification. Congress has indicated no need for us to do so and such changes would not help achieve Congress' objectives.

Moreover, Congress has given clear direction that overall objectives must be obtained regardless of vehicle classification. The 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.

With respect to the impact on fuel savings, our tentative conclusion is that moving large numbers of vehicles from the light truck to the passenger car category would not increase fuel savings or stringency of the standards. Under a Reformed attribute-based CAFE system, passenger car and light truck CAFE standards will simply be reoptimized if vehicles are moved from one category to another. To the extent that some relatively fuel-efficient vehicles are moved out of the light truck category, the optimization for the remainder of the group would likely result in lower standards, because there would now be fewer higher performers in the light truck category. However, when these trucks are moved into the car category, they are likely to be less fuel-efficient than similarly sized cars. Thus,

including those vehicles could well drag down the optimized targets for the car category. Preliminary analyses have suggested that this is what happens, but the agency specifically requests comments on this and any supporting data for the commenter's position. Further, since EISA now permits manufacturers to transfer CAFE credits earned for their passenger car fleet to their light truck fleet and vice versa, it makes even less difference how a vehicle is classified, because the benefit a manufacturer gets for exceeding a standard may be applied anywhere. If there is no fuel savings benefit to be gained from revising the regulatory definitions, NHTSA does not see how doing so would facilitate achieving EPCA's overarching goal of improving fuel savings. Although NHTSA does not propose to change the vehicle classification standards, the agency does intend to apply those definitions strictly and in accordance with agency interpretations, as set out above, and the standards presented in the final rule will reflect this. NHTSA seeks comment on its reading of the statute with regard to vehicle classification and its decision not to change its definitions.

IX. Enforcement

A. Overview

NHTSA's enforcement under the CAFE program essentially consists of gauging a manufacturer's compliance in each model year with the passenger car and light truck standards against their credit status. If a manufacturer's average miles per gallon for a given fleet falls below the relevant standard, and the manufacturer cannot make up the difference by using credits earned previously or anticipated to be earned for over-compliance, the manufacturer is subject to penalties. The penalty, as adjusted for inflation by law,\210\ 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 $735,422,635.50 to date in CAFE penalties, the largest ever being paid by DaimlerChrysler for its MY 2006 import passenger car fleet, $30,257,920.00. For their MY 2006 fleets, six manufacturers paid CAFE fines for not meeting an applicable standard--Ferrari, Maserati, BMW, Porsche, Volkswagen, and DaimlerChrysler--for a total of $43,170,896.50.

\210\ 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, Sec. 31001(s).

EPCA authorizes increasing the civil penalty up to $10.00, 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.\211\

\211\ 49 U.S.C. 32912(c).

The agency requests comment on whether it should initiate a proceeding to consider raising the civil penalty. Paying civil penalties represents a substantial less expensive alternative to installing fuel saving technology in order to achieve compliance with the CAFE standards or buying credits from another manufacturer. (See discussion of credit trading below.)

Manufacturers can earn CAFE credits to offset deficiencies in their CAFE performances under 49 U.S.C. 32903. Specifically, when the average fuel economy of either the domestic or imported passenger car or light truck fleet for a particular model year exceeds the established standard for that category of vehicles, the manufacturer earns credits. The amount of credit a manufacturer earns is determined by multiplying the tenths of a mile per gallon that the manufacturer exceeded the CAFE standard in that model year by the number of vehicles in that category it manufactured in that model year. Credits are discussed at much greater length in the section below.

NHTSA begins to determine CAFE compliance by considering pre- and mid-model year reports submitted by manufacturers pursuant to 49 CFR part 537, Automotive Fuel Economy Reports. The reports for the current model year are submitted to NHTSA every December and July. Although the reports are used for NHTSA's reference only, they help the agency, and the manufacturers who prepare them, anticipate potential compliance issues as early as possible, and help manufacturers plan compliance strategies.

NHTSA makes its ultimate determination of manufacturers' CAFE compliance based on EPA's official calculations, which are in turn based on final model year data submitted by manufacturers to EPA pursuant to 40 CFR 600.512, Model Year Report, no later than 90 days after the end of the calendar year. EPA then verifies the data submitted by manufacturers and issues final CAFE reports to manufacturers and to NHTSA between April and October of each year (for the previous model year). NHTSA identifies the manufacturers' fleets that have failed to meet the applicable CAFE fleet standards, and issues enforcement letters to manufacturers not meeting one or more of the standards. Letters are generally issued within one to two weeks of receipt of EPA's final CAFE reports.

For the enforcement letters, NHTSA calculates a cumulative credit status for each of a manufacturer's vehicle categories according to 49 U.S.C. 32903. If sufficient credits are available, NHTSA determines a carry-forward credit allocation plan. If the manufacturer does not have enough credits to offset the shortfall, NHTSA requests payment of a corresponding civil penalty unless the manufacturer submits a carry-back credit allocation plan. We note that any penalties paid are paid to the U.S. Treasury and not to NHTSA itself.

After enforcement letters are sent, NHTSA continues to monitor civil penalty payments that are due within 60 days from the date of receipt of the letter by the vehicle manufacturer, and takes further action if the manufacturer is delinquent in payment. NHTSA also monitors receipt of carry-back plans from manufacturers who choose this compliance alternative. Plans are required within 60 days from the date of receipt of the enforcement letter by the vehicle manufacturer.

B. CAFE Credits

The ability to earn and apply credits has existed since EPCA's original enactment,\212\ but the issue of the ability to trade credits, i.e., to sell credits to other manufacturers or buy credits from them, was first raised in the 2002 NAS Report. NAS found that

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\212\ The credit provision (currently codified at 49 U.S.C. 32903) was originally section 508 of EPCA's Public Law version.

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.\213\

\213\ NAS, Finding 11, 113.

After receiving the 2002 NAS Report, Secretary of Transportation Mineta wrote to Congress asking for authority to implement all of NAS'' recommendations.

While waiting for that express authority, NHTSA raised the issue of

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credit trading in both its 2002 Request for Comments \214\ and its 2003 ANPRM.\215\ The initial response to the idea was mixed: environmental and consumer groups expressed concern that vehicle manufacturers would use a credit trading system in lieu of increasing fuel economy to meet the CAFE standards, while vehicle manufacturers generally supported the prospect of increased flexibility in the CAFE program.\216\ However, without clear authority to implement a credit trading program, NHTSA was unable to take further action at the time.

\214\ 67 FR 5767, 5772 (Feb. 7, 2002).
\215\ 68 FR 74908, 74915-16 (Dec. 29, 2003).
\216\ Id.

NHTSA raised the issue of credit transfer, i.e., the application of credits earned by manufacturer in one compliance category to another compliance category, in its 2005 NPRM \217\ and 2006 final rule for the MY 2008-11 light truck standards, but concluded that it would interfere with the transition to Reformed CAFE by making it more difficult for manufacturers to determine their compliance obligations.\218\ The 2006 final rule also stated that the agency would not adopt a credit trading program, again on the basis that its authority to do so was unclear.\219\ However, NHTSA submitted several draft bills to Congress during this time period and after, most recently in February 2007. In an address to the Senate Committee on Commerce, Science, and Transportation on March 6, 2007 regarding the February 2007 bill, Administrator Nason stated that credit trading was a ``natural extension'' of the existing EPCA credit framework, and that trading would be ``purely voluntary, and [that] we believe[d] it will help lower the industry's cost of complying with CAFE.'' \220\

\217\ 70 FR 51414, 51439-40 (Aug. 30, 2005).
\218\ 71 FR 17566, 17616 (Apr. 6, 2006).
\219\ Id. 17653-54.
\220\ Transcript available at http://commerce.senate.gov/public/index.cfm?FuseAction=Hearings.TestimonyHearing--ID=1827--Witness--ID=2362 (last accessed Feb. 2, 2008).

EISA provided express authority for both credit trading and transferring and made other changes as well to EPCA regarding credits:

Authorizing the establishment of a credit trading program;

Requiring the establishment of a credit transferring program; and

Extending the carry-forward period from 3 to 5 years.

NHTSA has developed a proposal for a new Part 536 setting up these two credit programs. We believe that our proposal is consistent with Congress' intent. The agency seeks comment generally on the following three topics with respect to the proposed Part 536: (1) Whether the agency has correctly interpreted Congress' intent; (2) whether there are any ways to improve the proposed credit trading and transferring system 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 are either inconsistent with EISA and Congress' intent or the rest of the CAFE regulations, or are otherwise unworkable. The following section describes the proposed credit trading and transfer programs, as well as several other related ideas that the agency is considering.

1. Credit Trading

EPCA, as amended by EISA, states

The Secretary of Transportation [by delegation, the Administrator of NHTSA] may establish by regulation a fuel economy credit trading program to allow manufacturers whose automobiles exceed the average fuel economy standards prescribed under section 32902 to earn credits to be sold to manufacturers whose automobiles fail to achieve the prescribed standards 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.\221\

\221\ 49 U.S.C. 32903(f)(1).

EISA also prevents traded credits from being used by a manufacturer to meet the minimum fuel economy standard for domestically-manufactured passenger cars.\222\

\222\ 49 U.S.C. 32903(f)(2).

Proposed new part 536 would permit credit trading, beginning with credits earned in MY 2011. Although only manufacturers may earn credits and apply them toward compliance, NHTSA would allow credits to be purchased and traded by both manufacturers and non-manufacturers in order to facilitate greater flexibility in the credit market.

NHTSA proposes that credit trading be conducted as follows: 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 specific credits to be traded by quantity, vintage (model year of origin), compliance category of origin (domestic passenger cars, imported passenger cars, or light trucks), and originating manufacturer. These identification requirements are intended to help ensure accurate calculation for preserving total oil savings. If the credit recipient is not already an account holder, it must provide sufficient information for NHTSA to establish an account for them. Once an account has been established or identified, NHTSA will complete 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.

Manufacturers need not restrict their use of traded credits to the compliance category from which the credits were earned. However, if a manufacturer wishes to transfer a credit received by trade to another compliance category, it must instruct NHTSA of its intention so that NHTSA can apply an adjustment factor in order to preserve ``total oil savings,'' as required by EISA.\223\ 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 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.

\223\ 49 U.S.C. 32903(f)(1).

Table IX-1 shows a simple numerical example of this on an individual vehicle level. Vehicle A has a fuel economy of 30 mpg and is driven 150,000 miles over its lifetime, consuming 5,000 gallons of fuel. Increasing the fuel economy of vehicle A by one mpg lowers the lifetime fuel consumption by 161 gallons to 4,839 gallons. Vehicle B has a fuel economy of 15 mpg and is driven 150,000 miles over its lifetime, consuming 10,000 gallons of fuel. Increasing the fuel economy of vehicle B by one mpg lowers the lifetime fuel consumption by 625 gallons to 9,375 gallons. Both vehicles' fuel economy rises by the same amount, one mpg, but much more fuel is saved by vehicle B because it uses much more gas per mile than does vehicle A.

Table IX-I.--Comparison of Fuel Savings at Different Fuel Economy Baselines

	Vehicle A	Vehicle B
Lifetime Miles Driven..................	150,000	150,000
Initial Fuel Economy...................	30	15
Initial Lifetime Fuel Consumption.......	5,000	10,000
Final Fuel Economy.....................	31	16
Final Lifetime Fuel Consumption.........	4,839	9,375
Savings................................	161	625

To preserve total oil savings in credit trading, NHTSA would apply an adjustment factor to traded credits. More specifically, the agency would 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:
[GRAPHIC] [TIFF OMITTED] TP02MY08.033

Where:

A = adjustment factor applied to traded credits by multiplying mpg for a particular credit;
VMTe = 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);
VMTu = 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);
MPGe = fuel economy standard for the originating

manufacturer, compliance category, and model year in which the credit was earned;
MPGu = fuel economy standard for the manufacturer, compliance category, and model year in which the credit will be used.

The effect of applying this formula would be to increase the value of credits that were earned for exceeding a relatively low CAFE standard and are to be applied to a compliance category with a relatively high CAFE standard and decrease the value of credits that were earned for exceeding a relatively high CAFE standard and are to be applied to a compliance category with a relatively low CAFE standard. NHTSA is 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 seek comment on those two alternatives, since they may be more precise in their ability to account for fuel savings.

Congress also restricted the use of credit trading in EISA by providing that manufacturers must comply with the minimum domestic passenger car standard specified in 49 U.S.C. 32902(b)(4) without the aid of credits obtained through trading. The minimum standard equals the greater of 27.5 mph or 92 percent of the projected average fuel economy level for all passenger cars for the model year in question. 49 U.S.C. 32903(f)(2) states that trading and transferring of credits to the domestic passenger car compliance category are limited to the extent that the fuel economy of such automobiles shall comply with the minimum standard without regard to trading or transferring of credits from other compliance categories. Thus, our proposed credit trading regulation prevents the use of traded credits to comply with the minimum domestic passenger car standard.

In developing this regulation, NHTSA has proposed additional restrictions on the use of credits as necessary for consistency with Congress' intent in EISA. For example, a credit that has been traded and is then traded back to the originating manufacturer is deemed never to have been traded, to avoid manufacturers gaining value from the same credit twice.

2. Credit Transferring

If a credit holding manufacturer wishes to transfer credits that it has earned, it need simply instruct NHTSA which credits to transfer to which alternate compliance category, identifying the quantity, vintage, and original compliance category in which the credits were earned. NHTSA will then transfer the credits. As explained above, if a credit holding manufacturer wishes to transfer credits that it has received by trade, it must similarly instruct NHTSA. NHTSA will apply an adjustment factor to the traded credits to ensure, pursuant to EISA, that total oil (fuel) savings are preserved.

Credit transfers are limited by EISA both in the extent to which they may increase a manufacturer's average fuel economy in a compliance category, and when they may be begun to be used. Section 32903(g)(3) states that a manufacturer's average fuel economy in a compliance category cannot be increased through the use of transferred credits by more than 1 mpg in MYs 2011-2013, more than 1.5 mpg in MYs 2014-2017, or more than 2 mpg in MYs 2018 and after. Section 32903(g)(5) also states that credits can only be transferred if they are earned after MY 2010. Our proposed credit transferring regulation reflects these limitations.

Congress also restricted the use of credit transferring in EISA by providing that manufacturers must comply with the minimum domestic passenger car standard without the aid of credits obtained through transfer. 49 U.S.C. 32903(g)(4) states that transferring of credits to the domestic passenger car compliance category is limited to the extent that the fuel economy of such automobiles shall comply with the minimum standard without regard to transferring of credits from other compliance categories. Thus, our proposed credit transferring regulation prevents the use of transferred credits to comply with the minimum domestic passenger car standard.

NHTSA is proposing to denominate credits in miles per gallon (mpg), not in gallons. NHTSA requests comments, however, on whether transferred credits

should be denominated in gallons, because doing so would ensure that no transfers result in any loss of fuel savings or in a missed opportunity to reduce CO2 emissions.\224\ The risk of fuel savings loss can be illustrated by the following example. Suppose there were a manufacturer that produces the same number of automobiles in two different compliance categories. Each of the two categories is required to meet the same level of CAFE. If the manufacturer exceeds the standard for one category by one mile per gallon and falls short of the other standard by the same amount, the additional fuel saved by the automobiles subject to the first standard would be less than the additional fuel consumed by the automobiles subject to the second standard. The risk is even greater if the example is changed so that the standards are different and the manufacturer exceeds the higher standard and falls short of the lower standard.

\224\ NHTSA previously addressed this issue in the 2006 final rule establishing CAFE standards for MY 2008-2011 light trucks. See 71 FR 17566, 17616.

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3. Credit Carry-Forward/Carry-Back

Credit lifespan has always been dictated by statute. A manufacturer may only use credits for a certain number of model years before and after the year in which it was earned. Congress intended credits to provide manufacturers greater compliance flexibility, but did not wish that flexibility to be so great as to obviate the need to continue improving fleet fuel economy. Before EISA's enactment, EPCA permitted credits to be used for 3 model years before and after the model year in which a credit was earned; EISA extended the ``carry-forward'' time to 5 model years. Because EISA was enacted in the middle of model year 2008,\225\ NHTSA concluded that the best interpretation of this change in lifespan was to apply it only to vehicles manufactured in or after MY 2009; the alternative of finding some way to prorate the change in lifespan presents considerable administrative difficulties, especially since credits are denominated by year of origin, not month and year of origin. Thus, credits earned for MYs 2008 and earlier will continue to have a 3-year carry-forward/carry-back lifespan; credits earned in MY 2009 or thereafter will have a 5-year carry-forward and a 3-year carry-back lifespan.

\225\ EISA's effective date was December 20, 2007; the 2008 model year began on October 1, 2007.

C. Extension and Phasing Out of Flexible-Fuel Incentive Program

EPCA encourages manufacturers to build alternative-fueled and dual-fueled vehicles. This is accomplished by using a special, statutorily specified calculation procedure for determining the fuel economy of these vehicles. The specially calculated fuel economy figure 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. These vehicles can then be factored into a manufacturer's general fleet fuel economy calculation, thus raising the average fuel economy level of the fleet. EPCA limited the extent to which a manufacturer could raise its fuel economy level due to the incentive to 1.2 mpg per compliance category.

Prior to the enactment of EISA, this incentive was only available through MY 2010. EISA extended the incentive, but also provided for phasing it out between MYs 2015 and 2019, by progressively reducing the amount by which fleet fuel economy could be raised due to the incentive.\226\ Thus, the maximum fuel economy increase which may be attributed to the incentive is as follows for:

\226\ 49 U.S.C. 32906.

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	mpg
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 promulgated 49 CFR part 538 to implement the statutory alternative-fueled and dual-fueled vehicle manufacturing incentive. We are not now proposing to amend Part 538 to reflect the EISA changes, due to the already-large scope of the current rulemaking, but will do so in an upcoming rulemaking.

X. Regulatory Alternatives

As noted above, in developing the proposed standards, the agency 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) as well as other relevant considerations such as safety. NHTSA assessed what fuel saving technologies would be available, how effective they are, and how quickly they could be introduced. This assessment considered technological feasibility, economic practicability and associated energy conservation. We also considered other standards to the extent captured by EPCA \227\ and environmental and safety concerns. This information was factored into the computer model used by NHTSA for applying technologies to particular vehicle models. The agency then balanced the factors relevant to standard setting. NHTSA's NEPA analysis, discussed in Section XIII.B. of this document, also will inform NHTSA's consideration of the proposed standards and reasonable alternatives in developing a final rule.

\227\ 71 FR 17566, 17669-70; April 6, 2006.

In balancing these factors, NHTSA generally observes that the increasing application of technologies increases fuel economy and associated benefits, but it also increases costs. Initial applications of technologies provide far more fuel savings per dollar of expenditure on them than applications of remaining technologies, which provide less incremental fuel savings at greater cost and, with progressive additions of technologies, eventually far greater cost. At some stage, the increasing application of technologies is not justified. A significant question is what methodology and decisionmaking criteria are used in the balancing to determine when to cease adding technologies and thus arrive at regulatory fuel economy targets.

In developing its proposed standards, the agency used a net benefit-maximizing analysis that placed monetary values on relevant externalities (both energy security and environmental externalities, including the benefits of reductions in CO_2 emissions) and produced what is called the ``optimized scenario.'' The optimized standards reflect levels such that, considering the seven largest manufacturers, net benefits (that is, total benefits minus total costs) are higher than at every other examined level of stringency. The agency also reviewed the results of the model's estimates of stringencies maximizing net benefits to assure that the results made sense in terms of balancing EPCA's statutory factors and in meeting EISA's requirements for improved fuel economy.

In addition to the optimized scenario, NHTSA considered and analyzed five additional regulatory alternatives that do not rely upon marginal benefit-cost

analysis. In ascending order of stringency, the six alternatives are:

Standards that fall below the optimized scenario by the same absolute amount by which the +25 percent alternative exceeds the optimized scenario (``25 percent below optimized'' alternative),

Standards based on applying technologies until net benefits are maximized (optimized scenario), and

Standards that exceed the optimized scenario by 25 percent of the interval between the optimized scenario and the TC = TB alternative (see below) (``25 percent above optimized'' alternative),

Standards that exceed the optimized scenario by 50 percent of the interval between the optimized scenario and the TC = TB alternative (``50 percent above optimized'' alternative),

Standards based on applying technologies until total costs equal total benefits (zero net benefits) (TC = TB alternative),\228\ and

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\228\ The agency considered the ``TC = TB'' alternative because one or more commenters in the rulemaking on standards for MY 2008-2011 light trucks urged NHTSA to consider setting the standards on this basis rather than on the basis of maximizing net benefits. In addition, while the Ninth Circuit Court of Appeals concluded that EPCA neither requires nor prohibits the setting of standards at the level at which net benefits are maximized, the Court raised the possibility of tilting the balance more toward reducing energy consumption and CO_2.

Standards based on applying all feasible technologies without regard to cost (technology exhaustion alternative).\229\

\229\ This was accomplished by determining the stringency at which a reformed standard would require every manufacturer to apply every technology estimated to be potentially available. At such stringencies, all but one manufacturer would be expected to fail to comply with the standard, and many manufacturers would owe large civil penalties as a result. The agency considered this alternative because the agency wished to explore the stringency and consequences of standards based solely on the potential availability of technologies at the individual manufacturer level.

NHTSA chose these alternatives in order to consider and evaluate the impacts of balancing the EPCA factors differently in determining