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Of Transportation

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PRELIMINARY REGULATORY IMPACT ANALYSIS

CORPORATE AVERAGE FUEL ECONOMY and CAFE REFORM FOR MY 2008-2011 LIGHT TRUCKS

Office of Regulatory Analysis and Evaluation
National Center for Statistics and Analysis
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EXECUTIVE SUMMARY

This assessment examines the costs and benefits of improving the fuel economy of light trucks for model years (MY) 2008-2011. It includes a discussion of the technologies that can improve fuel economy, analysis of the potential impact on light truck retail prices, lifetime fuel savings and their value to consumers, safety, and other societal benefits such as improved energy security, reduced emissions of greenhouse gases and other pollutants.

The agency is proposing to establish corporate average fuel economy (CAFE) standards under a reformed system (Reformed CAFE) for MY 2008-2011. Manufacturers would have the choice of complying with standards established under either the traditional system (Unreformed CAFE) or the Reformed CAFE system during a transition period spanning MY 2008-2010. In MY 2011, manufacturer would comply with a Reformed CAFE standard. Under Reformed CAFE, the Agency would set standards based on a vehicle attribute referred to as footprint[1]. Six different footprint categories are proposed and a separate average fuel economy target level would be set for each category. Individual manufacturers would be required to comply with a single fuel economy level that would be based on the distribution of its production among the footprint categories in each particular model year.

Two alternative scenarios are examined in the analysis. The Scenarios are:

1: Unreformed CAFE system for MY 2008-2010

2: Reformed CAFE system for MY 2008-2011

[1] Vehicle Footprint is defined as the wheelbase (the distance from the center of the front axle to the center of the rear axle) times the average track width (the distance between the center line of the tires) of the vehicle (in square feet).

Costs: Costs were estimated based on the specific technologies that were applied to improve each manufacturer's fuel economy up to the level of the proposed scenario. Table 1 provides those cost estimates on an average per vehicle basis and Table 2 provides those estimates on a fleet-wide basis in millions of dollars.

Benefits: Benefits are determined mainly from fuel savings over the lifetime of the vehicle, but also include externalities such as reductions in criteria pollutants. Table 3 provides those estimates on an industry-wide basis.

Improved fuel economy also reduces greenhouse gas emissions. The dollar value of avoiding greenhouse gas emissions has not been quantified. However, our analysis indicates that if the proposed standards were adopted, they would result in an estimated reduction of greenhouse gas emissions by 39.4 million metric tons of carbon equivalent over the life of MY 2011 vehicles alone. [2]

Net Benefits: Table 4 shows that comparing the costs and benefits, the proposed fuel economy standards are cost beneficial on a societal basis.

Fuel Savings: Table 5 shows the lifetime fuel savings in millions of gallons.

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[2] Also see the "Draft Environmental Statement, National Highway Traffic Safety Administration, Proposed Corporate Average Fuel Economy (CAFE) Standards", July 2005

Table 1
Incremental Cost Analysis
Per Vehicle
(In Year 2003 Dollars)

	MY 2008	**MY 2009**	**MY 2010**	**MY 2011**
Unreformed CAFE in 2008-2010	56	130	185	NA
Reformed CAFE 2008-2011	54*	142*	186*	275

Table 2
Incremental Total Cost
(In Millions of Year 2003 Dollars)

	MY 2008	**MY 2009**	**MY 2010**	**MY 2011**
Unreformed CAFE in 2008-2010	528	1,244	1,798	NA
Reformed CAFE 2008-2011	505*	1,332*	1,802*	2,656

* By policy design, the proposed mpg levels under Reformed CAFE are set so that the industry-wide costs of Reformed CAFE are roughly equal to the industry-wide costs of Unreformed CAFE for MY 2008-2010.

Table 3
Incremental Total Societal Benefits
Over the Vehicle's Lifetime – Present Value
(Discounted 3% and 7%, In Millions of Year 2003 Dollars)

Discounted 3%	**MY 2008**	**MY 2009**	**MY 2010**	**MY 2011**
Unreformed CAFE in 2008-2010	723	1,695	2,400	NA
Reformed CAFE 2008-2011	836	1,975	2,575	3,683
Discounted 7%				
Unreformed CAFE in 2008-2010	605	1,366	2,007	NA
Reformed CAFE 2008-2011	694	1,633	2,144	3,069

Table 4
Net Total Benefits
Over the Vehicle's Lifetime – Present Value
(Discounted 3% and 7%, In Millions of Year 2003 Dollars)

Discounted 3%	MY 2008	MY 2009	MY 2010	MY 2011
Unreformed CAFE in 2008-2010	195	451	602	NA
Reformed CAFE 2008-2011	331	643	773	1,027
Discounted 7%				
Unreformed CAFE in 2008-2010	77	122	209	NA
Reformed CAFE 2008-2011	189	301	342	413

Table 5
Savings in Millions of Gallons of Fuel
Undiscounted over the Lifetime of the Model Year

	MY 2008	**MY 2009**	**MY 2010**	**MY 2011**
Unreformed CAFE in 2008-2010	826	1,860	2,715	NA
Reformed CAFE	942	2,218	2,892	4,110

Both Scenarios provide net benefits for both consumers and society. The Reformed CAFE scenarios provide more net benefits for each model year than the Unreformed Scenarios. By policy design, the proposed mpg levels under Reformed CAFE are set so that the industry-wide costs of Reformed CAFE are roughly equal to the industry-wide costs of Unreformed CAFE for MY 2008-2010. Costs for specific manufacturers under the Reform CAFE may be lower or higher than under the Unreformed CAFE.

I. INTRODUCTION

The purpose of this document is to analyze the effects of changes in the fuel economy standards for light trucks from MY 2008 to MY 2011. It includes a discussion of the technologies that can improve fuel economy, the potential impacts on light truck retail prices, safety, the discounted lifetime net benefits of fuel savings, and the potential gallons of fuel saved.

The agency issued a final rule on March 29, 2002 (67 FR 16052), setting the CAFE standard applicable to light trucks for MY 2005 at 21.0 mpg, for MY 2006 at 21.6 mpg, and for MY 2007 at 22.2 mpg.

On February 7, 2002 (67 FR 5767), the agency issued a Request for Comments, seeking information upon which it could assess the viability of a reinvigorated CAFE program. The Request for Comments also sought comment on the findings and recommendations arising from the National Academy of Sciences study[3] published in January 2002. We also sought comments on possible reforms to the CAFE program, as it applies to both passenger cars and light trucks, to protect passenger safety, advance fuel-efficient technologies, and obtain the benefits of market-based approaches. The data provided by vehicle manufacturers in response to the Request for Comments and data from the NAS Report were used in developing the basis for the proposed levels.

[3] "Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards", National Research Council, 2002. The link for the NAS report ishttp://www.nap.edu/books/0309076013/html/

While we have considered the comments, the original Request for Comments was quite general and the comments received tended to focus on the various alleged shortcomings of the current program or the generic admonishment against CAFE reform--and not on specific potential options. On December 29, 2003, the agency published an advanced notice of proposed rulemaking (ANPRM) seeking comment on various issues relating to reforming the CAFE program (68 FR 74908). The agency sought comment on possible enhancements to the program that would assist in further fuel conservation while protecting motor vehicle safety and the economic vitality of the automobile industry. This document, while not espousing any particular reform, sought more specific input than the 2002 RFC on various options set forth in an effort to adapt CAFE to today's vehicle fleet. A detailed summary of comments can be found in the docket to the ANPRM (Docket No. 2003-16128).

Need for Reform

The ANPRM discussed the principal criticisms of the current CAFE program that led the agency to explore light truck CAFE reform. They relate to energy security, traffic safety, and economic practicability.

First, the energy-saving potential of the CAFE program is hampered by the current regulatory structure. The Unreformed approach to CAFE does not distinguish between the various market segments of light trucks, and therefore does not recognize that some vehicles designed for classification purposes as light trucks may achieve fuel economy similar to that of passenger cars. The Unreformed CAFE approach instead applies a single standard to the light truck fleet as a whole, encouraging manufacturers to offer small light trucks that will offset the larger vehicles that get lower fuel economy.

Second, because weight strongly affects fuel economy, the current light truck CAFE program encourages vehicle manufacturers to reduce weight in their light truck offerings to achieve greater fuel economy.[4] As the NAS report and a more recent NHTSA study have found, downweighting of the light truck fleet, especially those trucks in the low and medium weight ranges, creates more safety risk for occupants of light trucks and all motorists combined.[5]

Third, the agency noted the adverse economic impacts that might result from steady future increases in the stringency of CAFE standards under the current regulatory structure. Rapid increases in the light truck CAFE standard could have serious adverse economic consequences.

To address these concerns, the agency proposes a new size-based CAFE system. The agency is proposing an attribute-based system (the Reformed CAFE system) based on the vehicle footprint (wheel base x average wheel track width). Manufacturers would have the choice of complying with standards established under either the traditional system (Unreformed CAFE) or the Reformed CAFE system during a transition period spanning MYs 2008-2010 . The "reformed" standard would be based on fuel economy targets set for attribute-based subcategories of the light truck fleet in vehicle "categories". Each category would be assigned a fuel economy target

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[4] Manufacturers can reduce weight without changing the fundamental structure of the vehicle by using lighter materials or eliminating available equipment or options. In contrast, reducing vehicle size, and particularly footprint, generally entails an alteration of the basic architecture of the vehicle.

[5] However, both studies also suggest that if downweighting is concentrated on the heaviest light trucks in the fleet there would be no net safety impact, and there might even be a small fleet-wide safety benefit. There is substantial uncertainty about the curb weight cut-off above which this would occur.

level. A single composite standard would then be calculated based on a manufacturer's production level in each category and would represent the fuel economy target for that manufacturer. Beginning model year 2011, the new size-based CAFE system would be applied to the entire industry.

The dual fuel incentive program, for which manufacturers receive CAFE credits for producing vehicles capable of operating on alternative fuels, is not considered in this analysis. By law, the agency has always analyzed fuel economy without considering the dual fuel credits, since it is an incentive program designed to increase the availability of alternative fuel vehicles.

Throughout this document, confidential information is presented in brackets [ ].

II. NEED OF THE NATION TO CONSERVE ENERGY

Conserving energy, especially reducing the nation's dependence on petroleum, benefits the United States of America in several ways[6]. Reducing total petroleum use and reducing petroleum imports decrease our economy's vulnerability to oil price shocks. Reducing dependence on oil imports from unstable regions enhances our energy security. Reducing the growth rate of oil use will help relieve pressures on already strained domestic refinery capacity, decreasing the likelihood of product price volatility. Finally, conserving energy helps achieve the goal of decreasing our economy's greenhouse gas intensity.[7]

U.S. oil use has become increasingly concentrated in the transportation sector, the sector that has shown the least ability to substitute alternative energy sources for petroleum. In 1973, the U.S. transportation sector accounted for 51% of total U.S. petroleum use (8.4 of 16.5 million barrels per day (mmbd)). By 2003, transportation's share of U.S. oil use had increased to 66% (13.2 out of 20.0 mmbd).[8] The DOE/EIA reference case shows petroleum demand for transportation fuels reaching a level in 2025 that is more than 50 percent greater than petroleum transportation demand in 2003.[9] Inadequacies in U.S. energy infrastructure have caused regional supply disruptions and price volatility. Domestic refining capacity has not kept pace with increases in demand, resulting in increased imports of petroleum products.

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[6] http://www.whitehouse.gov/energy/National-Energy-Policy.pdf

[7] http://www.state.gov/g/oes/rls/fs/46741.htm

[8] USDOE/EIA, Monthly Energy Review, April 2005, Table 11.2

[9] "Challenging Times for Making Refinery Capacity Decisions", DOE/EIA, NPRA Annual Meeting 2004.

We believe that the continued development of advanced technology, such as fuel cell technology, and an infrastructure to support it, may help in the long term to achieve reductions in foreign oil dependence and stability in the world oil market[10]. During the transition period to fuel cells, the continued infusion of advanced diesels and hybrid propulsion vehicles into the U.S. light truck fleet may also contribute to reduced dependence on petroleum. However, it is uncertain how much these technologies will penetrate the light truck market in the relative short term.

Trends and Outlook

The overall fuel efficiency of the new passenger cars and light trucks , measured as an industry-wide average, went up from 1988 to 2003. Passenger car CAFE increased from 28.8 mpg in 1988 to 29.5 mpg in 2003. Light truck CAFE increased from 21.3 mpg in 1988 to 21.8 mpg in 2003. Yet the total fleet of light vehicle CAFE decreased from 26.0 in 1988 to 25.2 in 2003 due to the increased penetration of light truck sales in the light vehicle market, et combined with the freeze of the CAFE standards from model years 1996 through 2004.[11] Considering all light-duty vehicles on the road, average fuel economy has inched upward from 19.6 in 1991 to 20.0 in 2003,[12] as the oldest, least efficient vehicles were retired. Vehicle travel increased at an average annual rate of 2.0 percent.[13] From 2003 to 2025, the Energy Information Administration projects that light duty vehicle travel will increase by an additional 56 percent.[14] But light truck travel

[10] See the Administration's FreedomCAR and Fuel Partnership (http://www.hydrogen.energy.gov/freedomcar_partnership.html)
[11] USDOT,NHTSA, Summary of Fuel Economy Performance, March 2005.
[12] DOE/EIA, Annual Energy Outlook 2005, Table 7.
[13] Ibid.
[14] Ibid.

has been growing at a much faster rate of 4.9 percent per year, and light trucks are expected to dominate light-duty vehicle energy use in the future.

Increasing transportation oil consumption and declining domestic production have left the U.S. increasingly dependent on imported petroleum. Since 1985, U.S. net oil imports have grown from 4.3 million barrels per day (mmbd) to 11.2 mmbd.[15] As a percent of U.S. petroleum use, imports have also more than doubled: from 27 percent in 1985 to 56 percent in 2003,[16] the highest level of import dependency in our history. Over the past two years our trade deficit in oil has averaged $119 billion per year.[17]

Projections by the Energy Information Administration suggest further growth in U.S. import dependence and growing world dependence on OPEC oil producers. OPEC's share of U.S. crude imports is projected to increase from 47 percent in 2003 to 66 percent in 2005.[18] Total consumption of petroleum products in transportation is projected to expand from 12.7 mmbd in 2003 to 18.6 mmbd in 2025. Light vehicle petroleum consumption is projected to increase from 8.29 mmbd of oil in 2003 to 12.45 mmbd of oil in 2025.[19] Light truck petroleum consumption is projected to increase from 3.59 mmbd of oil in 2003 to 7.41 mmbd in 2025.[20]

[15] DOE/EIA, Annual Energy Review 2003, Table 5.1
[16] DOE/EIA, Monthly Energy Review, April 2005.
[17] U.S. Dept. of Commerce, U.S. Bureau of Economic Analysis, International Economic Accounts, Exhibit 11.
[18] DOE/EIA, Supplemental Table to Annual Energy Outlook 2005, Table 117.
[19] DOE/EIA, Annual Energy Outlook 2005, Table 7.
[20] DOE, John Maples, industry analyst.

The Importance of Passenger Car and Light Truck Fuel Economy

Reducing petroleum use by light-duty vehicles is an important part of any comprehensive program to address the nation's dependence on foreign oil and meet our energy challenges. Transportation is the predominant petroleum consumer in the U.S. economy. In 2003, the transportation sector alone required 68 percent more oil than the U.S. produced,[21] and because transportation consumes nearly all the high-value light products (motor gasoline and distillates) that drive the market, its economic importance is even greater than these statistics imply. Furthermore, transportation is 97% dependent on petroleum for energy.[22] Within the transportation sector, passenger cars and light trucks (the vehicles covered by fuel economy standards) account for almost 60% of U.S. petroleum consumption in 2003. [23]

Increases in the fuel economy of new vehicles eventually raise the mpg of all vehicles, as older cars and trucks are scrapped and replace by new vehicles. Past fuel economy increases have had a major impact on U.S. petroleum use. The National Research Council estimated that if fuel economy had not improved since the 1970s, U.S. gasoline consumption and oil imports in 2001 would have been about 2.8 million barrels per day higher than actual 2001 consumption (NRC, 2002, p.3).

Past reductions in U.S. petroleum consumption, similar reductions by other nations and increased non-OPEC oil supply helped to reduce U.S. oil imports and put downward pressure on world oil prices. From 1950 to 1973, U.S. consumption of petroleum products increased in every year, at

[21] Transportation Energy Data Book, Ed. 24, Table 1.12.
[22] DOE/EIA, Annual Energy Outlook 2005, Table 10.
[23] Transportation Energy Data Book, Ed. 24, Table 2.4.

an average annual rate of over 4%. From 1973 to 1985, U.S. petroleum consumption decreased from 17.3 to 15.7 mmbd and net imports of petroleum decreased from 6.0 mmbd to 4.3 mmbd.

III. CAFE REFORM

The CAFE standards set a minimum performance requirement in terms of an average number of miles a vehicle travels per gallon of gasoline or diesel fuel. Individual vehicles and models are not required to meet the mileage standard. Instead, each manufacturer must achieve a harmonically averaged level of fuel economy for all specified vehicles manufactured by a manufacturer in a given model year (MY). The statute distinguishes between "passenger automobiles" and "non-passenger automobiles." We generally refer to non-passenger automobiles as light trucks.

Each manufacturer's light truck fleet must meet the CAFE standard for light trucks, based on a harmonic average of the fuel economy for each light truck model. This can be considered a "one size fits all standard" (i.e., every manufacturer is required to comply with the same fuel economy level). Thus, the required fuel economy level does not vary with a manufacturer's product mix.

On December 29, 2003, the agency published an ANPRM seeking comment on various issues relating to reforming the CAFE program (68 FR 74908; Docket No. 2003-16128).[24] The agency sought comment on possible enhancements to the program that would assist in further fuel conservation, while protecting motor vehicle safety and the economic vitality of the automobile industry. The agency indicated that it was particularly interested in structural reform. This document, while not espousing any particular form of reform, sought more specific input than

[24] On the same date, we also published a request for comments seeking manufacturer product plan information for MYs 2008-2012 to assist the agency in analyzing possible reforms to the corporate average fuel economy (CAFE) program which are discussed in a companion notice published today. (68 FR 74931) The agency sought information that would help it assess the effect of these possible reforms on fuel economy, manufacturers, consumers, the economy, motor vehicle safety and American jobs.

the 2002 RFC on various options aimed at adapting the CAFE program to today's vehicle fleet and needs.

The 2003 ANPRM discussed the principal criticisms of the current CAFE program that led the agency to explore light truck CAFE reform (68 FR 74908, at 74910-13. First, the energy-saving potential of the CAFE program is hampered by the current regulatory structure. The Unreformed approach to CAFE does not distinguish between the various market segments of light trucks, and therefore does not recognize that some vehicles designed for classification purposes as light trucks may achieve fuel economy similar to that of passenger cars. The Unreformed CAFE approach instead applies a single standard to the light truck fleet as a whole, encouraging manufacturers to offer small light trucks that will offset the larger vehicles that get lower fuel economy. A CAFE system that more closely links fuel economy standards to the various market segments reduces the incentive to design vehicles that are functionally similar to passenger cars but classified as light trucks.

Second, because weight strongly affects fuel economy, the current light truck CAFE program encourages vehicle manufacturers to reduce weight in their light truck offerings to achieve greater fuel economy.[25] As the NAS report and a more recent NHTSA study have found, downweighting of the light truck fleet, especially those trucks in the low and medium weight ranges, creates more safety risk for occupants of light trucks and all motorists combined.[26]

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[25] Manufacturers can reduce weight without changing the fundamental structure of the vehicle by using lighter materials or eliminating available equipment or options. In contrast, reducing vehicle size, and particularly footprint, generally entails an alteration of the basic architecture of the vehicle.

[26] However, both studies also suggest that if downweighting is concentrated on the heaviest light trucks in the fleet there would be no net safety impact, and there might even be a small fleet-wide safety benefit. There is substantial uncertainty about the curb weight cut-off above which this would occur.

Third, the agency noted the adverse economic impacts that might result from steady future increases in the stringency of CAFE standards under the current regulatory structure. Rapid increases in the light truck CAFE standard could have serious adverse economic consequences. The vulnerability of full-line firms to tighter CAFE standards does not arise primarily from poor fuel economy ratings within weight classes, i.e., from less extensive use of fuel economy improving technologies. As explained in the 2003 ANPRM, their overall CAFE averages are low compared to manufacturers that produce more relatively light vehicles because their sales mixes service a market demand for bigger and heavier vehicles capable of more demanding utilitarian functions. An attribute-based (weight and/or size) system could avoid disparate impacts on full-line manufacturers that could result from a sustained increase in CAFE standards.

In discussing potential changes, the agency focused primarily on structural improvements to the current CAFE program authorized under the current statutory authority, and secondarily on definitional changes to the current vehicle classification system and whether to include vehicles between 8,500 to 10,000 lbs. GVWR.

The ANRPM discussed two structural reforms. The first reform divided light trucks into two or more classes based on vehicle attributes. The second was an attribute-based "continuous-function" system, such as that discussed in the NAS report. We chose various measures of vehicle weight and/or size to illustrate the possible design of an attribute-based system. However, we also sought comment as to the merits of using other vehicle attributes as the basis of an attribute-based system.

The 2003 ANPRM also presented two potential options under which vehicles with a GVWR of up to 10,000 lbs. could be included under the CAFE program, were the agency to make the requisite determinations to include them. One option would be to include vehicles defined by EPA as medium duty passenger vehicles (65 FR 6698, 6749-50, 6851-6852) for use in the CAFE program. This definition would essentially make SUVs and passenger vans between 8,500 and 10,000 lbs. GVWR subject to CAFE, while continuing to exclude most medium- and heavy-duty pickups and most medium- and heavy-duty cargo vans that are primarily used for agricultural and commercial purposes. A second option would be to make all vehicles between 8,500 and 10,000 lbs. GVWR subject to CAFE standards.

The agency also discussed and sought comment on the classification of vehicles as passenger cars or light trucks. As suggested in numerous of the comments, we are proposing only to clarify the applicability of the "flat floor provision" to vehicles with folding seats. The current regulation classifies as a light truck any vehicle with readily removable seats that, once removed, leave a flat, floor-level surface extending from the forward most removable seat mount to the rear of the vehicle (the flat floor provision). The agency has tentatively decided to amend the "flat floor provision" in the light truck definition to include expressly vehicles with seats that fold and stow in a vehicle's floor pan.

CAFE Reform Proposal

The agency is now proposing structural reforms to the CAFE program that would permit manufacturers to comply with a required level of CAFE derived from fuel economy targets set for different segments of the light truck fleet and weighted according to a manufacturer's production. For MY 2008-2010 manufacturers could elect to comply under the Reformed CAFE system, or they could continue to comply under the Unreformed CAFE system. Beginning in MY 2011, the entire industry would be required to comply with the Reformed Cafe system.

Size- Based System

The required CAFE levels under the Reformed CAFE system would be derived from fuel economy targets set for size-based categories within the vehicle fleet. The light truck fleet would be subdivided into six categories according to vehicle footprint and each category would be assigned a target fuel economy level. The target for any category in a particular model year would be the same for all manufacturers. The required fuel economy level for a manufacturer in a particular model year would be based on the target levels for that model year and the distribution of the manufacturer's vehicle production across the categories in that same model year.

Choice of the Size Metric

Reliance on vehicle footprint would minimize the incentives for manufacturers to downsize vehicles or to promote a heavily weight-divergent fleet mix; both which may have negative safety implications. A footprint based system, as opposed to a weight-based category system, would do a better job of controlling “size creep” than the latter would do in controlling “weight creep”, which can have negative safety impacts. It is easier and less costly to add weight than it is to increase footprint since increasing footprint involves changes to the vehicle platform and the overall vehicle architecture.

Adding a significant amount of size to a vehicle is much more difficult and costly than adding weight to a vehicle. This is especially true if the measure of size is vehicle footprint – the product of track width and wheelbase. Although vehicle shadow (vehicle length times width) was described as a potential choice of a size measure in the ANPRM, the agency now believes footprint has advantages over shadow.

These two measures are highly correlated (as shown in Figures III-1 and III-2). However, compared to vehicle footprint, a vehicle’s shadow could potentially be changed with relatively inexpensive cosmetic modifications. For example, a manufacturer could add body panels or bumper extensions to increase a vehicle’s shadow at less cost than those associated with adjusting footprint. Conversely, the costs associated with changing a vehicle’s footprint would require design changes to a vehicle’s platform, which is typically established for multiple production years and potentially multiple vehicle models. The ability to make short-term modifications to footprint would be limited.

Further, as discussed by Honda in its comments, changes to footprint would result in design changes perceptible to consumers, (e.g., a longer and/or wider vehicle). Changes to the vehicle weight may not be visible. The potential impact of changes to footprint on consumer preference would further limit a manufacturer's ability to redesign a vehicle for the sole purpose of subjecting that vehicle to a less stringent requirement. Moreover, a footprint-based system would not reduce the incentive for manufacturers to use lighter, but potentially safer materials in their vehicles as a weight-based system might do.

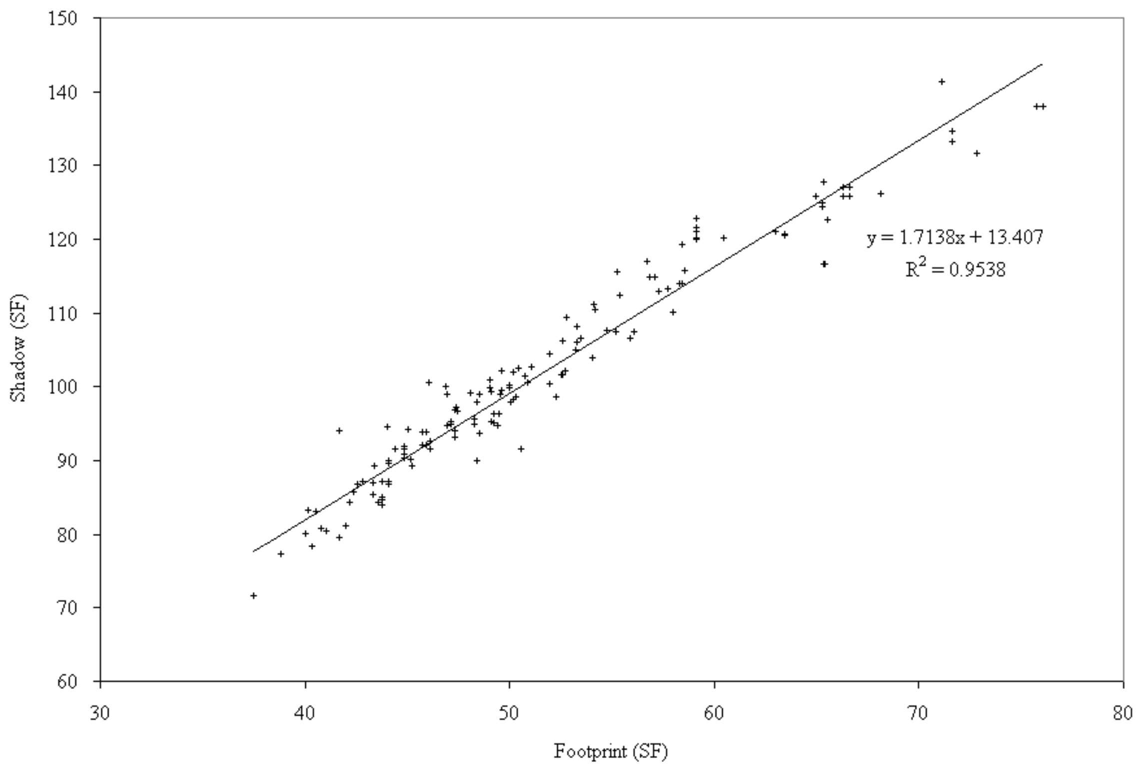
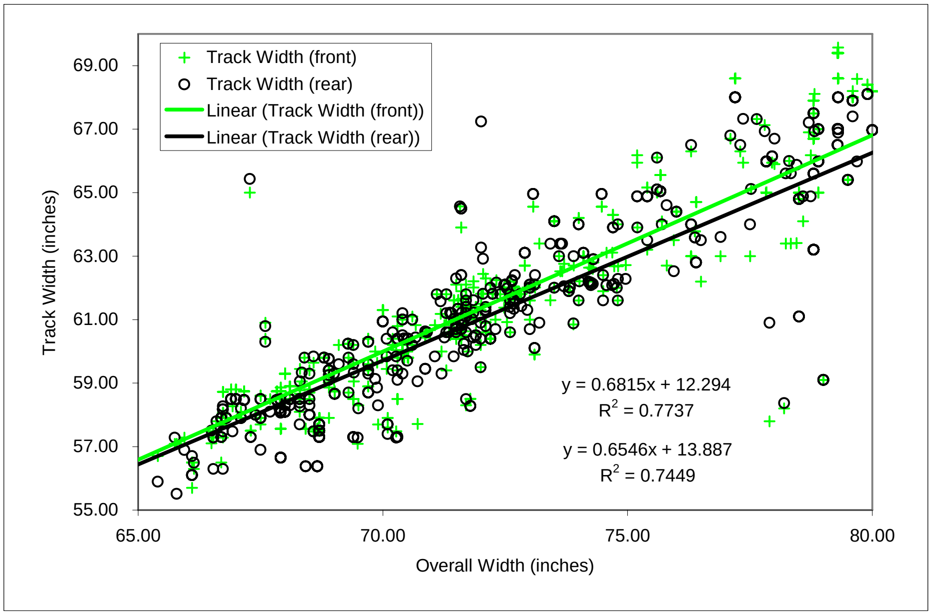


Figure III-1



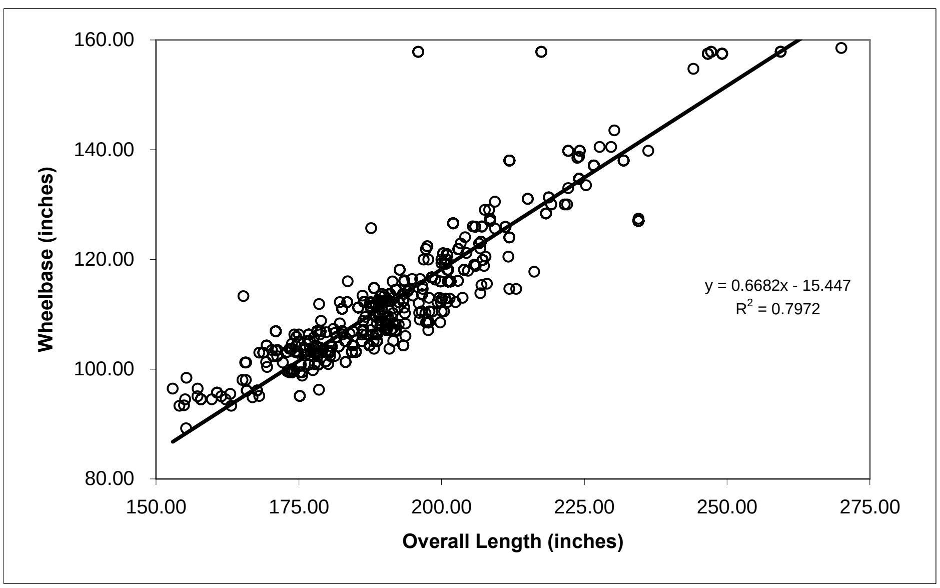


Figure III-2

Analysis indicates that there is a relationship between footprint and fuel economy. A DOE analysis demonstrates a moderate correlation between vehicle wheelbase times track width and fuel economy.[27] Confidential data from a vehicle manufacturer regarding the relationship between fuel economy and consumption and a wheelbase times track width showed correlation coefficients of the order of 0.5 for light-duty vehicles, with the coefficients for light trucks higher than those for cars.

NHTSA notes that size is not as well correlated with fuel economy as is weight. However, this should not necessarily disqualify size as the basis for a fuel economy system. Some commenters stated that the curb weight is far better correlated with fuel consumption, with a correlation coefficient of the order of 0.7. Commenters argued that the stronger correlation of weight makes reliance on size inappropriate. However, neither of these correlations is strong (a strong correlation would be above 0.9). While it is true that weight is somewhat better correlated with fuel economy than vehicle size, both attributes are correlated with fuel economy, though neither attribute comes close to fully explaining the relationship between fuel economy and vehicle characteristics.

Footprint and safety

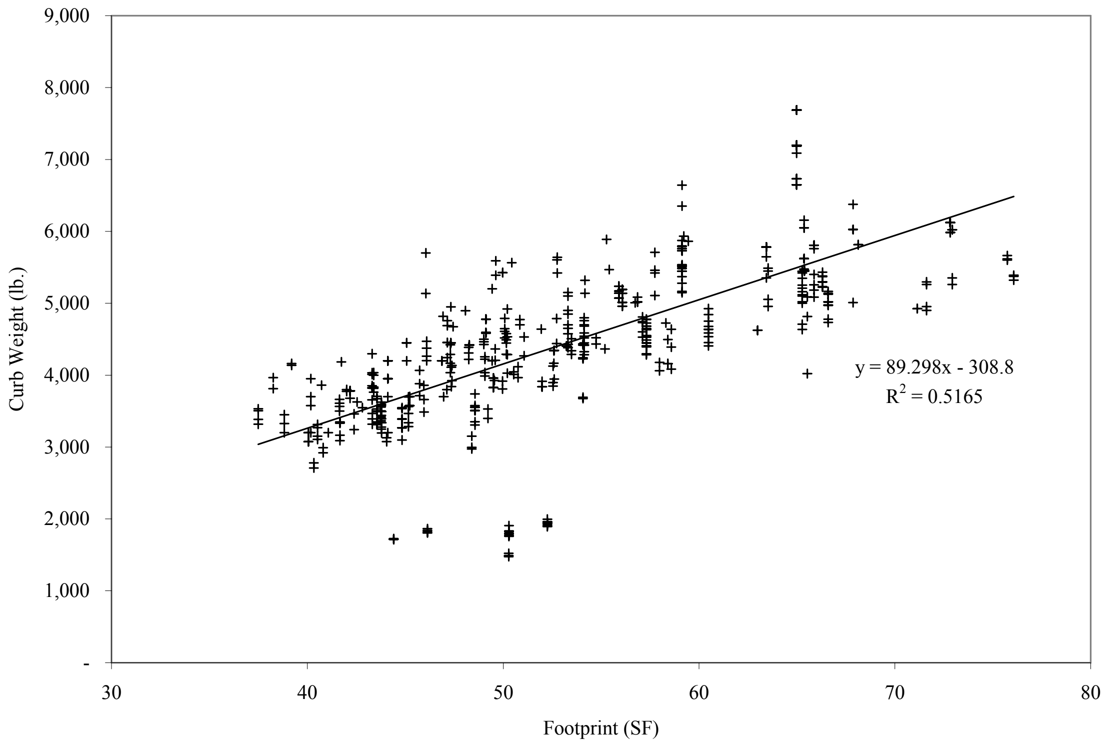
The impact of CAFE standards on motor vehicle and passenger safety has long been recognized as an integral part of the agency's process of determining maximum feasible average fuel economy. The agency notes that there are no compelling studies that quantify the precise and separate effects of vehicle size and weight on safety, in part because there is a high degree of correlation between size and weight among vehicles now in widespread use.

[27] Plotkin, S., Greene, D., and Duleep, K.G., Examining the Potential for Voluntary Fuel Economy Standards in the United States and Canada, Argonne National Laboratory report ANL/ESD/02-5, October 2002.

Both the NAS report and a more recent NHTSA safety study[28] cited in the ANPRM made explicit links between weight and vehicle safety. It is important to note that both of these studies linking weight and safety are historical in nature. That is, these relationships are based on data observed at the time of the study (in the mid 1980's for the NAS study and 1991-1999 for the NHTSA study), but may not necessarily persist into the future. During this time period, vehicle size and weight were highly correlated. Figure III-3 shows a least-squares regression of vehicle size (foot print) on vehicle weight (curb weight) for model year 2002 data. This figure clearly shows a positive linear relationship between these two attributes. Since size is a good predictor of weight, and weight is good measure of safety, it follows that size should also be a good measure of safety, at least in the historical data that has been analyzed.

[28] "Vehicle Weight, Fatality Risk and Crash Compatibility of Model Year 1991-99 Passenger Cars and Light Trucks", Charles J. Kahane, PH.D., NHTSA, October 2003, DOT HS 809-662.

Figure III-3


9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
-
Curb Weight (lb.)
30
40
50
60
70
80
Footprint (SF)
y = 89.298x - 308.8
R2 = 0.5165

This relationship is mentioned in Dr. Kahane's response to a safety study submitted by Dynamic Research, Inc., Marc Ross (University of Michigan) and Tom Wenzel (Lawrence Berkeley National Laboratory), and William E. Wecker Associates, Dr. Kahane wrote:

> The objective of the NHTSA study was to calibrate the historical (MY 1991-99) relationships of vehicle mass and fatality risk, after controlling for driver age/gender, geographical location, and vehicle equipment. In this type of analysis, "vehicle mass" incorporates not only the effects of mass per se but also the effects of many other size attributes that are historically and/or causally related to mass, such as wheelbase, track width and structural integrity. (As vehicles get longer and wider, they almost always get heavier.)
>
> The study does not claim that mass per se is the specific factor that increases or decreases fatality risk (except in its role in determining the relative Delta V of two vehicles that collide). On the contrary, Chapter 5 of the NHTSA report shows that certain 4,000-pound SUVs have significantly higher fatal-crash rates than 3,500-pound cars. The study only shows the historical relationship between mass – taking into account all the other size attributes that have typically varied with mass – and fatality risk, for vehicles of the same type. If historical relationships between mass and other size attributes continue, in the absence of compelling reasons that would change those relationships, future changes in mass are likely to be associated with similar changes in fatality risk. (However, the increased use of advanced restraint systems and sophisticated crash avoidance safety devices in recent and future production vehicles could have a noticeable impact on the historical relationship between vehicle mass and fatality risk in future vehicle fleets.)

In that sense, it is irrelevant whether mass, wheelbase, track width or some other attribute is the principal causal factor on fatality risk. If you decrease mass, you will also tend to reduce wheelbase, track width and other dimensions of size.

Changes in technology could influence the relationship between weight and size. Several comments to the ANPRM claim that there is emerging evidence that vehicle weight can be reduced without reductions in size or safety through the use of high strength, lightweight materials. Currently, we do not observe many vehicles built with lightweight materials in the historical data and therefore cannot separate the impact of size versus weight when lightweight materials are utilized. The agency received comments on the use of lightweight materials in response to the ANPRM. Public Citizen, The Aluminum Association and Honda all noted that a weight-based standard would remove the incentive to use lightweight materials. The Aluminum Association claimed that high strength aluminum is increasingly being used in vehicles to reduce weight and improve fuel economy without detrimental safety impacts. The Rocky Mountain Institute mentioned the use of carbon composites that are cost prohibitive in today's market, but might not be in the future. Environmental Defense provided information on the use of high strength steel that can be used to lower vehicle weight while maintaining or even increasing stiffness and crash worthiness. They claimed that several manufacturers currently use this technology in vehicles being sold today. Responses from the ANPRM made by Honda cite several recent studies examining vehicle size and safety:

- A 2001 study by Dr. Leonard Evans[29], modeled the risk of driver fatality in car 1 in a head on collision with car 2. The equations in the report indicate that reducing the curb weight of car 1 would increase the risk to the driver of car 1, while reducing the curb weight of car 2 would decrease the risk to the driver of car 1. However, the equations also indicate that reducing the wheelbase of either car increases the total risk to both drivers, supporting DRI's findings.

[29] Evans, L., "Causal Influence of Car Mass and Size on Driver Fatality Risk", American Journal of Public Health, Vol. 91, No. 7, July 2001, pp 1076-1081

- A 2004 SAE paper by Dr. Leonard Evans, found that increasing the amount of lightweight materials in vehicle design can provide reduced occupant risk both in two-vehicle and single vehicle crashes, and also reduce risk for occupants in other vehicles[30].

- Advocates for Highway and Auto Safety submitted comments to the Docket that Kahane's (NHTSA's) 2003 analysis may not apply if the effects of size and weight reductions are disaggregated, "weight reductions without corresponding reductions in vehicle wheelbase length and track width could be expected to produce net benefits in reducing occupant crash risks".

If manufacturers respond to this proposal by building lighter vehicles of constant size, the historical relationship between mass and safety would gradually weaken.

The agency has tentatively determined that an attribute system based on footprint would minimize incentives for design changes that would reduce motor vehicle safety. In a weight-based system, a manufacturer can add weight to a vehicle in order to take advantage of a category with a lower fuel economy target. As discussed above, this up-weighting can have positive and negative safety implications, with possibly negative impacts for the fleet as a whole if weight is added to heavier light trucks. A manufacturer could not as readily increase footprint as it could vehicle weight. However, if a manufacturer did make design changes to a vehicle's footprint for the purpose of placing that vehicle in a less stringent category, the extra size could actually improve the safety of a vehicle and overall fleet-wide safety.

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[30] Evans, L., "How to make a car lighter and safer," SAE 2004-01-1 172, Society of Automotive Engineers, 11 March 2004.

In order to increase footprint, a manufacturer would have to either extend a vehicle's track width, wheelbase, or both. Maintaining and increasing track width should play a positive role in limiting rollover vulnerability, whereas maintaining and increasing wheelbase should play a positive role in improving handling – especially directional stability, which is crucial in preventing unintended off-road excursions that often lead to rollovers – and maximizing crush space (though total length is probably more closely correlated with crush space than is wheelbase).

Vehicle "Categories"

Under the agency's Reform CAFE proposal, the light truck fleet would be segmented according to vehicle footprint into a series of six categories. The values generated for each category would then provide the basis for developing an overall required CAFE level that a manufacturer must comply.

Upon reviewing current production and manufacturers' production plans, the agency is proposing categories as follows. Examples of make/models that fall into each category are shown below. Some make models fall into more than one category because they have short and long versions of the same nameplate.

< 43 square feet

GM Equinox/Torrent, Toyota Rav4, DCC PT Cruiser, DCC Jeep Wrangler 2-Door, Subaru Forester, Suzuki Vitara

43.0 to < 47.0 square feet

GM Vue, Uplander, Colorado/Canyon, Honda CR-V, Honda Element, Toyota Highlander, Ford Escape, Suzuki Grand Vitara, Hyundai Sportage, Nissan Xterra, BMW X3, DCC Jeep Willys, DCC Jeep Liberty

47.0 to < 52.0 square feet

GM Trailblazer/Envoy, Colorado/Canyon, H3, Honda Pilot, Ford Explorer, Ford Mountaineer ,DCC Grand Cherokee, Porsche Cayenne, Toyota 4 Runner 4WD D-cab, Toyota Sienna, Nissan Pathfinder, Nissan Murano,

52.0 to < 56.5 square feet

GM Tahoe/Yukon/Escalade, Envoy XUV, and Colorado/Canyon, Honda Odyssey, Ford Expedition, Nissan Frontier, DCC Pacifica

56.5 to < 65.0 square feet

GM Suburban/Silverado/Sierra, Express/Savannah, Ford F-150, Ford Navigator, Nissan Armada, Nissan Quest, DCC Dakota Club Cab, DCC Ram 1500 Standard Cab, Toyota Tundra,

≥65.0 square feet

GM Silverado/Sierra, Express/Savannah, Nissan Titan, DCC Ram 1500 Quad Cab,

Determining "Maximum Feasible"

The CAFE statute sets forth the parameters within which the agency is required to establish corporate average fuel economy standards. Determination of "maximum feasible" entails four considerations: technological feasibility, economic practicability, the effect of other motor vehicle standards, and the need of the U.S. to conserve energy. In addition to these explicit factors, motor vehicle safety has long been recognized as an integral part of the agency's consideration when establishing new standards. With regard to economic practicability and feasibility, the agency has typically taken industry-wide considerations into account and has not restricted our analysis to any particular company's ability to meet a standard.

In considering technological feasibility and economic practicability under the Unreformed CAFE system, we project the capabilities of those manufacturers whose vehicles constitute a substantial share of the market. Using data submitted by manufacturers, we apply a three-stage analysis to project potential technological improvements to the product plans for each of these manufacturers. Stage 1 of the analysis takes existing product plans and applies technologies, particularly those not associated with major powertrain upgrades or changes, that manufacturers indicated would be available . Stage 2 applies more advanced transmission upgrades and engine improvements to planned model and engine changeovers. Stage 3 then considers more comprehensive changes such as the production of hybrid and diesel vehicles.

At each stage of that analysis, we added technologies based on our engineering judgment about possible adjustments to the detailed product plans submitted by the manufacturers in response to the 2003 request for product plans. Our decisions whether and when to add technology reflected our consideration of the practicability of applying a specific technology and the necessary leadtime for its application. In addition, the agency added technologies in a cost minimizing fashion. That is, we generally first added technologies that are most cost-effective (i.e., provided the greatest fuel savings per dollar.

In order to determine tentative maximum feasible corporate average fuel economy levels under the Reformed CAFE system, we used a three-phased process for determining targets that represent the social optimum for the manufacturers as a group. We assessed the ability of the seven manufacturers with the largest share of the market (combined they have about 95 percent of the annual light truck sales)[31] to make further fuel economy improvements beyond their product plans.

In phase one, we applied technologies to each manufacturer's fleet until we reached the point at which the marginal cost of adding technology equaled the marginal benefit of that technology. Then, we disaggregated the manufacturers' fleets into the proposed footprint categories.

In phase two, we determined the position of the target for each footprint category relative to each other, and the preliminary level of the target by calculating the average CAFE of the seven manufacturers that had vehicles in that category.

In phase three, we determined the proposed level of the targets by adjusting the targets upward or downward in unison until we reached the level at which the marginal cost of adding technology to meet the level equaled the marginal benefits, considering the seven largest manufacturers as a group. This process for determining targets was based on the application of technology under the Volpe model. Unlike the Unreformed CAFE system, the Stage analysis was not used.

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[31] General Motors, Ford, DaimlerChrysler, Toyota, Honda, Hyundai, and Nissan.

Both systems rely on the same balancing of considerations. We consider potential impacts on jobs and competitiveness, the consequences for motor vehicle safety, effects on air quality, and the ability of the nation to conserve fuel consumption and reduce its dependence on foreign oil. We have tentatively concluded that Reformed CAFE standards established through this analysis not only promote the objectives of EPCA, but also represent average fuel economy standards that are the maximum feasible fuel economy level that manufacturers can achieve.

Calculating compliance

Under the agency's proposal, compliance would be determined by calculating the minimum level of average fuel economy applicable to a manufacturer, given that manufacturer's overall distribution of model lines across the fuel economy categories. The overall required CAFE for each model year would be a mathematical formula of production-weighted, harmonically averaged fuel economy in which the targets are constants and a manufacturer's total production and production in each footprint category are variables. The value generated by this standard would then be compared to the production-weighted harmonic average fuel economy of a manufacturer's entire product line, taking into account the actual fuel economy levels achieved by each model line. If the value based on the actual fuel economy levels were equal to or greater than the overall required level, then the manufacturer would be in compliance.

All manufacturers would be subject to the same fuel economy targets for the specified footprint categories and all manufacturers would be required to comply based on calculations under the same formula. Individual manufacturers would face different fuel economy requirements only because they produced different mixes of vehicle models, but all manufacturers would face the same system of vehicle size categories and would be subject to targets set at the same stringency levels

Assessing compliance under the proposed system can be illustrated using an example of a manufacturer that produces four models with the following characteristics:

Model	Fuel Economy (mpg)	Production (units)	Footprint (sq. ft.)	Category	CAFE Target (MPG)
A	27	100,000	43	1	24.5
B	24	100,000	42	1	24.5
C	22	100,000	52	2	21.0
D	19	100,000	54	2	21.0

Under this approach, the manufacturer would be required to achieve an average mpg value of:

$$\frac{400{,}000}{\frac{100{,}000}{24.5mpg}+\frac{100{,}000}{24.5mpg}+\frac{100{,}000}{21.0mpg}+\frac{100{,}000}{21.0mpg}+} = 22.6 \text{ mpg}$$

This fuel economy figure would be compared with the manufacturer's actual CAFE for its entire fleet, computed by its production-weighted harmonic mean fuel economy level:

$$\text{Actual CAFE} = \frac{400{,}000}{\frac{100{,}000}{27.0}+\frac{100{,}000}{24.0}+\frac{100{,}000}{22.0}+\frac{100{,}000}{19.0}} = 22.6 \text{ mpg}$$

In this example, the manufacturer's actual CAFE (22.6 mpg) equals the CAFE requirement, meaning it has complied with the standard. Using each manufacturer's overall required CAFE level to assess its compliance in effect allows fuel savings to be transferred from categories in which CAFE levels exceed the targets, and used to offset under-compliance with the targets in other categories. Fuel savings from under- and over-compliance with each category's target are generated and used under this system almost identically to the way in which this occurs under the current unreformed system. Thus, this approach can solve the problem of how to treat credits earned under the current system during the transition to a Reformed CAFE system. That is, averaging across the fleet under the category-based system using the harmonic mean has the same result as in the present system, meaning that credits generated under the existing system could be transferred to the category-based system without the need for discounting or other adjustments.

The compliance of each manufacturer would be determined by comparing the manufacturer's overall average fuel economy, as calculated by the Environmental Protection Agency, as in the case of the current light truck standards with the overall required CAFE level. If the calculated average fuel economy were greater than the required level, the manufacturer would earn credits based on the manufacturer's production volume and the number of tenths of a mile per gallon by which the manufacturer exceeded the required level. If the calculated average were less than the required level, the manufacturer would be subject to a civil penalty based on the manufacturer's production volume and the numbers of tenths of the shortfall.

Baseline and alternatives

The baselines, against which costs and benefits are estimated for all the scenarios, are the manufacturer's plans for each model year 2008-2011 or the MY 2007 standard of 22.2 mpg, whichever is higher. This is named the "Adjusted Baseline". The two Proposed Alternatives are named "Unreformed CAFE" and "Reformed CAFE". Each manufacturer and each year is calculated separately and compared to the Adjusted Baseline of the manufacturer's plans or 22.2 mpg.

The Alternatives examined are:

1: Unreformed CAFE system for 2008-2010,

2: The Reformed CAFE system for 2008-2011

The proposal is to allow the manufacturers to choose between the two alternatives for 2008-2010 and then require Reformed CAFE in MY 2011.

The strategy for determining the level of the Reformed CAFE target mpg level for MY 2008-2010 is to keep overall fleet technology costs for the seven largest manufacturers (not on an individual basis) at the same level, as far as possible, as the costs that would be incurred under the Unreformed CAFE system. The strategy for the reform system under MY 2011 is different, since there is no Unreformed CAFE system to compare it to. For MY 2011, we raise the levels to a point that would be economically efficient based on net-benefit considerations. Economically efficient is defined as a set of target mpg levels where the marginal cost of achieving the target levels just equals the marginal societal benefit derived from improving fuel economy. Social costs and social benefits are defined as both private consumer costs or benefits plus externalities as discussed later in this analysis.

Examined CAFE Levels and Category Targets

Table III-1 shows the Adjusted Baseline and the examined Unreformed CAFE levels for MY 2008-2010. Table III-2 shows the category targets for the Reformed Cafe for MY 2008-2011.

Table III-1
Examined Unreformed CAFE Scenarios
(in mpg)

	2008	**2009**	**2010**	**2011**
Adjusted Baseline	21.64	21.92	22.00	22.01
Unreformed CAFE	22.5	23.1	23.5	N.A.

Table III-2
Proposed Category Targets for Reformed CAFE
(in mpg)

Reformed CAFE				
Category	**2008**	**2009**	**2010**	**2011**
1 < 43.0 square feet	26.8	27.4	27.8	28.4
2 43.0 to < 47.0	25.6	26.4	26.4	27.1
3 47.0 to < 52.0	22.3	23.5	24.0	24.5
4 52.0 to < 56.5	22.2	22.7	22.9	23.3
5 56.6 to < 65.0	20.7	21.0	21.6	21.9
6 ≥ 65.0	20.4	21.0	20.8	21.3

Tables III-3, 4, and 5 show examples of how the category system works. Shown are historical data, which do not divulge manufacturer projections. The tables show historical sales and fuel economy, and the total harmonically weighted average fuel economy for each manufacturer under the Unreformed CAFE and Reformed CAFE proposals. The right side of the table shows how some manufacturers would have more credits under the Reformed CAFE proposal, while other would have fewer credits.

Table III-3
Model Year 2002

	<43.0	43.0-47.0	47.0-52.0	52.0-56.5	56.5-65.0	≥65.0	Total					
Sales	**647,227**	**1,653,734**	**2,359,848**	**1,251,782**	**1,167,149**	**761,756**	**7,841,496**					
BMW	-	-	39,620	-	-	-	39,620					
DCC	295,068	480,443	443,921	255,261	35,423	261,036	1,771,152					
FMC	75,510	240,357	940,405	259,357	499,508	45,386	2,060,523					
GMC	159,191	150,005	584,413	508,412	520,647	455,334	2,378,002					
HON	-	138,061	48,998	148,857	-	-	335,916					
HYU	-	82,824	-	-	-	-	82,824					
ISU	5,822	73,091	-	-	-	-	78,913					
NIS	-	175,239	112,063	-	-	-	287,302					
SUZ	15,147	35,114	-	-	-	-	50,261					
TOY	96,489	273,515	184,956	79,895	111,571	-	746,426					
VWA	-	5,085	5,472	-	-	-	10,557					
Target:	23.2	22.1	21.1	20.2	18.6	18.3		**Unreformed**		**Reformed**		
CAFE (mpg)	**21.6**	**22.1**	**20.7**	**20.2**	**18.6**	**18.3**	**20.3**	**Std. Value**	**Credits**	**Std. Value**	**Credits**	**ΔCredits**
BMW			20.2				20.2	20.7	(0.19)	21.1	(0.36)	(0.17)
DCC	23.0	19.6	21.4	21.0	18.7	17.1	20.3	20.7	(7.64)	21.0	(13.00)	(5.36)
FMC	19.9	24.3	20.4	20.1	19.2	18.7	20.4	20.7	(7.09)	20.4	(1.32)	5.77
GMC	22.2	24.3	21.6	19.3	17.9	19.1	19.9	20.7	(19.47)	19.9	(0.75)	18.72
HON		28.2	22.5	24.2			25.4	20.7	15.78	21.1	14.60	(1.18)
HYU		24.5					24.5	20.7	3.14	22.1	2.01	(1.13)
ISU	21.6	21.0					21.0	20.7	0.25	22.1	(0.88)	(1.13)
NIS		19.9	22.1				20.7	20.7	(0.05)	21.7	(2.89)	(2.84)
SUZ	23.0	21.5					21.9	20.7	0.62	22.4	(0.23)	(0.84)
TOY	29.6	23.2	22.0	18.1	18.8		22.1	20.7	10.24	21.2	6.88	(3.36)
VWA		20.3	20.9				20.6	20.7	(0.01)	21.6	(0.11)	(0.09)

Notes

1. Category targets are based on average of DCC, FMC, GMC, HON, NIS, and TOY
2. Credits are calculated as (number of units) * (CAFE - standard) * 10, and are shown in millions.

Table III-4
Model Year 2003

	<43.0	43.0-47.0	47.0-52.0	52.0-56.5	56.5-65.0	≥65.0	Total	Unreformed		Reformed		
Sales	**561,018**	**1,539,949**	**1,956,642**	**2,013,193**	**955,812**	**677,484**	**7,704,098**					
BMW	-	-	43,552	-	-	-	43,552					
DCC	231,414	370,504	205,972	430,570	150,109	152,101	1,540,670					
FMC	64,643	321,016	627,759	649,038	257,461	29,140	1,949,057					
GMC	140,109	208,574	511,122	657,542	434,502	496,243	2,448,092					
HON	-	215,906	178,921	165,197	-	-	560,024					
HYU	-	98,515	-	-	-	-	98,515					
ISU	259	17,214	-	-	-	-	17,473					
NIS	-	154,222	83,777	42,328	-	-	280,327					
SUZ	8,844	20,585	-	-	-	-	29,429					
TOY	115,749	128,157	300,877	68,518	113,740	-	727,041					
VWA	-	5,256	4,662	-	-	-	9,918					
Target:	23.83	23.70	20.80	20.67	18.25	18.63						
CAFE (mpg)	**23.3**	**22.9**	**20.2**	**20.7**	**18.2**	**18.6**	**20.6**	**Std. Value**	**Credits**	**Std. Value**	**Credits**	**ΔCredits**
BMW			20.0				20.0	20.7	(0.30)	20.8	(0.35)	(0.04)
DCC	23.4	21.4	20.9	23.4	17.7	17.6	21.2	20.7	7.70	21.3	(1.54)	(9.24)
FMC	18.8	24.7	19.8	19.5	18.0	19.0	20.1	20.7	(11.69)	20.8	(13.64)	(1.95)
GMC	24.0	25.0	20.8	19.9	18.4	18.9	20.1	20.7	(14.69)	20.1	-	14.69
HON		27.6	22.5	24.2			24.7	20.7	22.40	21.8	16.24	(6.16)
HYU		24.4					24.4	20.7	3.65	23.7	0.69	(2.96)
ISU	22.6	22.3					22.3	20.7	0.28	23.7	(0.24)	(0.52)
NIS		21.3	24.0	20.9			21.9	20.7	3.36	22.3	(1.12)	(4.49)
SUZ	22.7	21.4					21.8	20.7	0.32	23.7	(0.56)	(0.88)
TOY	28.8	24.3	21.3	18.2	19.2		21.9	20.7	8.72	21.2	5.09	(3.64)
VWA		21.7	20.8				21.3	20.7	0.06	22.2	(0.09)	(0.15)

Notes
1. Category targets are based on average of DCC, FMC, GMC, HON, NIS, and TOY
2. Credits are calculated as (number of units) * (CAFE - standard) * 10, and are shown in millions.

Table III-5
Model Year 2004

	<43.0	43.0-47.0	47.0-52.0	52.0-56.5	56.5-65.0	?65.0	Total				
Sales	**430,734**	**1,708,582**	**2,003,588**	**1,890,040**	**842,762**	**1,321,914**	**8,197,620**				
BMW	-	40,200	36,800	-	-	-	77,000				
DCC	218,503	516,355	86,643	457,535	159,167	156,950	1,595,153				
FMC	20,683	271,400	595,224	341,440	104,902	524,861	1,858,510				
GMC	66,261	109,961	676,611	598,623	443,317	451,764	2,346,537				
HON	-	181,641	171,490	163,264	-	-	516,395				
HYU	-	130,385	-	-	-	-	130,385				
ISU	-	20,210	-	-	-	-	20,210				
NIS	-	139,929	94,573	45,567	120,463	94,806	495,338				
SUZ	8,281	22,669	-	-	-	-	30,950				
TOY	117,006	270,157	302,486	283,611	14,913	93,533	1,081,706				
VWA	-	5,675	39,761	-	-	-	45,436				
Target:	24.3	23.4	21.2	20.5	18.8	18.5		**Unreformed**		**Reformed**	
CAFE (mpg)	**24.1**	**22.7**	**20.4**	**20.5**	**18.8**	**18.5**	**20.5**	**Std. Value**	**Credits**	**Std. Value**	**Credits**
BMW		22.2	20.8				21.5	20.7	0.62	22.3	(0.63)
DCC	24.1	21.1	21.9	20.7	17.3	17.1	20.5	20.7	(3.79)	21.4	(15.36)
FMC	17.0	24.3	19.9	19.1	19.2	18.5	19.8	20.7	(17.37)	20.4	(11.72)
GMC	21.4	26.6	22.1	19.2	18.8	19.1	20.2	20.7	(12.29)	20.1	0.92
HON		27.4	22.3	24.2			24.5	20.7	19.61	21.7	14.49
HYU		24.2					24.2	20.7	4.54	23.4	1.00
ISU		23.1					23.1	20.7	0.48	23.4	(0.07)
NIS		22.1	24.1	21.3	20.8	18.1	21.1	20.7	2.21	20.5	3.29
SUZ	23.6	22.6					22.8	20.7	0.66	23.6	(0.25)
TOY	28.8	24.8	20.8	23.3	20.6	18.0	22.7	20.7	21.82	21.5	13.18
VWA		21.6	18.9				19.2	20.7	(0.66)	21.5	(1.03)

Notes
1. Category targets are based on average of DCC, FMC, GMC, HON, NIS, and TOY
2. Credits are calculated as (number of units) * (CAFE - standard) * 10, and are shown in millions.

Compliance in the Continuous Function Approach

The agency is also asking for comments on setting the CAFE standards using a continuous function approach. An example is shown below.

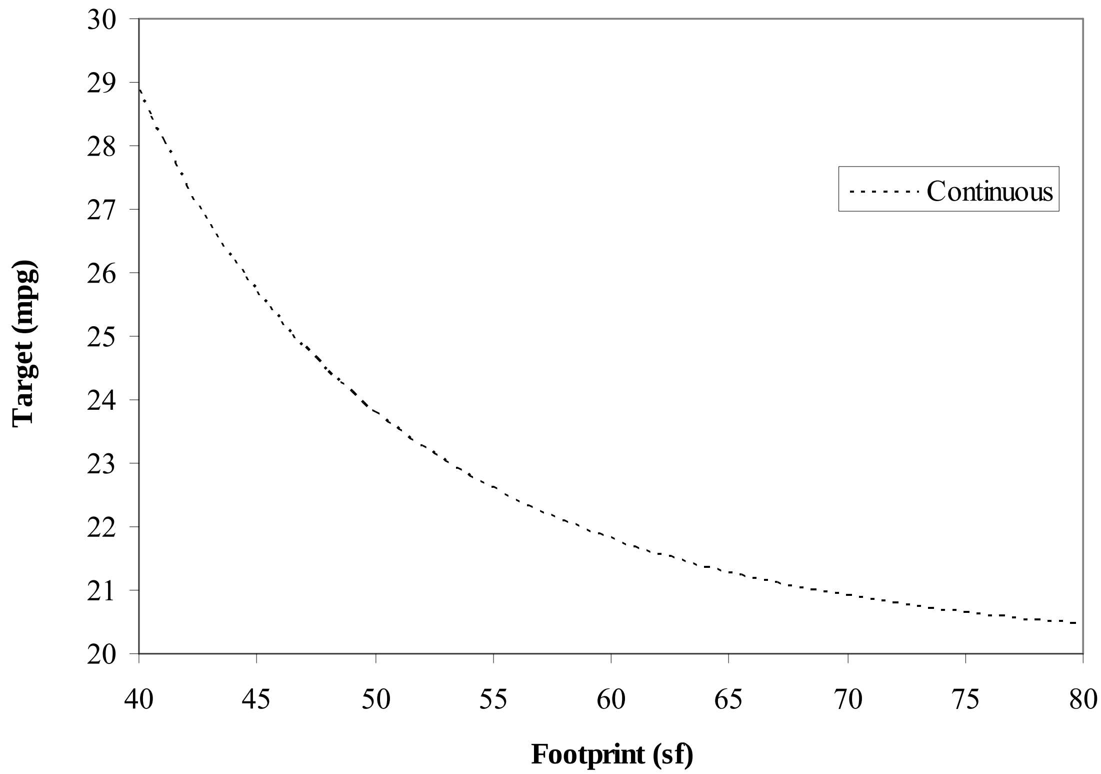

Figure III-4 Continuous Function

The continuous function shown in Figure III-4 is defined by the following mathematical function:

$$\frac{1}{\frac{1}{A} - \frac{1}{B}\exp\left(1 - \frac{FOOTPRINT}{C}\right)}$$

The function shown in Figure III-4 is specified as follows:

A = 20.0 mpg
B = 12.9 mpg
C = 15.3 square feet

The mechanics of defining a continuous function would be similar to the procedure used to set the proposed MY 2011 standard. The iterative process would be used to add technology onto each manufacturer's vehicles. Data points representing each vehicle's size and fuel economy would then be plotted on a graph. Using statistical techniques, a function would then be fitted through the data to obtain the continuous function. The last step would be to adjust the function to the point where marginal net benefits are zero. This is the overall industry social optimum.

Compliance in the continuous function system works exactly the same as with the step function except that there are no category targets. Instead, the function above is used to define a vehicle specific target that depends on footprint.

IV. IMPACT OF OTHER FEDERAL MOTOR VEHICLE STANDARDS ON LIGHT TRUCK FUEL ECONOMY

Introduction

The Act requires that fuel economy standards be set at the maximum feasible level after taking into account the following criteria: technological feasibility, economic practicability, the impact of other Federal Motor Vehicle Standards on fuel economy, and the need of the Nation to conserve energy. This section discusses the effects of other government regulations on model year (MY) 2008-2010 light truck fuel economy.

Baseline Weights

The average test weight (curb weight plus 300 pounds) of the light truck fleet in MY 2001 was 4,501 pounds. The average test weight for MY 2008 is expected to be 4,793 pounds, for MY 2009 is 4,762 pounds, and for MY 2010 is 4,774 pounds. The average test weight for General Motors, Ford, and DaimlerChrysler light trucks subject to the standard for MY 2001 was 4,627 pounds. The average test weight for these three manufacturers for MY 2008 is expected to be 4,904 pounds, for MY 2009 is 4,897 pounds, and for MY 2010 is 4,909 pounds. Thus, overall, weight in light trucks is anticipated to increased a little less than 300 pounds compared to MY 2001. The change in weight includes all factors, such as changes in the fleet mix of vehicles, required safety improvements, voluntary safety improvements, and other changes for marketing purposes.

Weight Impacts of Required Safety Standards

The National Highway Traffic Safety Administration (NHTSA) has issued a number of proposed and final rules on safety standards that are proposed to be effective or are effective between MY 2008-2010. These have been analyzed for their potential impact on light truck fuel economy weights for MY 2008-2010:

1. FMVSS 138, tire pressure monitoring system (Final Rule)
2. FMVSS 202, head restraints (Final Rule)
3. FMVSS 208, rear seat lap/shoulder belt (Final Rule)
4. FMVSS 301, fuel system integrity (Final Rule)

FMVSS 138, tire pressure monitoring system

As required by the Transportation Recall Enhancement, Accountability, and Documentation (TREAD) Act, NHTSA is requiring a Tire Pressure Monitoring System (TPMS) be installed in all passenger cars, multipurpose passenger vehicles, trucks and buses that have a Gross Vehicle Weight Rating of 10,000 pounds or less. The effective dates are based on the following phase-in schedule:

20 percent of light vehicles produced between September 1, 2005 and August 31, 2006,
70 percent of light vehicles produced between September 1, 2006 and August 31, 2007,
100 percent of light vehicles produced after September 1, 2007 must meet the final rule.

Thus, for Model Year 2008, an additional 30 percent of the fleet will be required to meet the standard. We estimate from a cost tear-down study that the added weight for an indirect system is about 0.156 lbs. and for a direct system is 0.275 to 0.425 lbs. Initially, direct systems will be more prevalent, thus, the increased weight is estimated to be average 0.35 lbs. (0.16 kilograms). For MY 2008, the weight increase from FMVSS 138 is anticipated to be 0.11 pounds (0.05

kilograms) [ ]. The TPMS system does not affect new vehicle CAFE, since the testing is performed with tires fully inflated. It will increase in-service fuel economy by warning drivers when their tire pressure is low and reminding drivers to inflate their tires.

FMVSS 202, Head Restraints

The final rule requires an increase in the height of front seat outboard head restraints in pickups, vans, and utility vehicles, effective September 1, 2008 (MY 2009). If the vehicle has a rear seat head restraint, it is required to be at least a certain height. The initial (1969) head restraint requirement resulted in the average front seat head restraints being 3 inches taller than pre-standard head restraints and adding 5.63 pounds[32] to the weight of a passenger car. With the new final rule, we estimate the increase in height for the front seats to be 1.3 inches and for the rear seat to be 0.26 inch, for a combined average of 1.56 inches[33]. Based on the relationship of pounds to inches from current head restraints, we estimate the average weight gain across light trucks would be 2.9 pounds (1.3 kilograms). (5.63/3 * 1.56 = 2.93 lbs.)

[32] "Cost and Weight Added by Federal Motor Vehicle Safety Standards for Model Years 1968-2001 in Passenger Cars and Light Trucks", NHTSA, December 2004, DOT-HS-809-834. Pg. 51.
[33] "Final Regulatory Impact Analysis, FMVSS No. 202 Head Restraints for Passenger Vehicles", NHTSA, November 2004, Docket No. 19807-1, pg. 74.

FMVSS 208, Occupant Crash Protection

This final rule requires a lap/shoulder belt in the center rear seat of light trucks. There are an estimated 5,061,079[34] seating positions in light trucks needing a shoulder belt, where they currently have a lap belt. This estimate of seating positions is a combination of light trucks, SUVs, minivans and 15 passenger vans that have either no rear seat, or 1 to 4 rear seats that need shoulder belts. This estimate was based on sales of 7,521,302 light trucks in MY 2000. Thus, the average light truck needs 0.67 shoulder belts. The average weight of a rear seat lap belt is 0.92 lbs. and the average weight of a manual lap/shoulder belt with retractor is 3.56 lbs.[35] Thus, the anticipated weight gain is 2.64 pounds per shoulder belt. We estimate the average weight gain per light truck for the shoulder belt would be 1.8 pounds (0.8 kilograms). (2.64 * .67 = 1.77 lbs.)

A second, potentially more important, weight increase depends upon how the center seat lap/shoulder belt is anchored. The agency has allowed a detachable shoulder belt in this seating position, which could be anchored to the ceiling or other position, without a large increase in weight (less than 1 lb.). If the center seat lap/shoulder belt is anchored to the seat itself, typically the seat would need to be strengthened to handle this load (the agency requests comments on this weight increase). If the manufacturer decides to change all of the seats to integral seats, having all three seating positions anchored through the seat, then both the seat and flooring needs to be strengthened (again the agency requests comments on this weight increase, which could be 10 to 20 lbs.). The agency requests manufacturer's plans in this area and predicted weight increases.

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[34] "Final Economic Assessment and Regulatory Flexibility Analysis, Cost and Benefits of Putting a Shoulder Belt in the Center Seats of Passenger Cars and Light Trucks", NHTSA, June 2004, Docket No. 18726-2, pg. 33.

[35] "Cost and Weight Added by Federal Motor Vehicle Safety Standards for Model Years 1968-2001 in Passenger Cars and Light Trucks", NHTSA, December 2004, DOT-HS-809-834. Pg. 84.

The effective dates are based on the following phase-in schedule:

50 percent of light vehicles produced between September 1, 2005 and August 31, 2006,
80 percent of light vehicles produced between September 1, 2006 and August 31, 2007,
100 percent of light vehicles produced after September 1, 2007 must meet the final rule.

Thus, for Model Year 2008, an additional 20 percent of the fleet will be required to meet the standard. We estimate the average weight gain per light truck for the shoulder belt would be 0.36 lbs. (0.16 kg) [ ] compared to MY 2007. For the anchorage, the average weight increase would be 0.2 pounds (0.09 kg) or more.

FMVSS 301, Fuel System Integrity

This final rule amends the testing standards for rear end crashes and resulting fuel leaks. Many vehicles already pass the more stringent standards, and those affected are not likely to be pick-up trucks or vans. It is estimated that weight added will be only light-weight items such as a flexible filler neck. We estimate the average weight gain across this vehicle class would be 0.24 pounds (0.11 kilograms).

The effective dates are based on the following phase-in schedule:

40 percent of light vehicles produced between September 1, 2006 and August 31, 2007,
70 percent of light vehicles produced between September 1, 2007 and August 31, 2008,
100 percent of light vehicles produced after September 1, 2008 must meet the final rule.

Thus, 60 percent of the fleet must meet FMVSS 301 during the MY 2008-2010 time period.

Thus, the average weight gain during this period would be 0.14 pounds (0.07 kilograms).

Weight Impacts of Voluntary Safety Improvements

There are several safety improvements that are being made voluntarily to meet market demand and/or to perform better on government or insurance industry tests involving vehicle ratings.

Anti-lock Brakes, Traction Control and Electronic Stability Control (ESC)

NHTSA and the Insurance Institute for Highway Safety have both released analyses indicating significant avoidance of single vehicle run off the road crashes with Electronic Stability Control. Many manufacturers are planning to install ESC on all their light vehicles. NHTSA is considering a rulemaking in this area. The ESC system needs both anti-lock brakes and traction control to work appropriately. Anti-lock brakes add about 12 pounds to the weight of a vehicle. Currently, about 91 percent of all light trucks have anti-lock brakes. Thus, if all light trucks added anti-lock brakes, average light truck weight would increase by 1.08 pounds. Traction Control and ESC are estimated to add less than 1 pound to a vehicle. Most light trucks currently don't have either. So, the total weight increase is about 2 pounds (0.91 kg.).

Side Impact and Ejection Mitigation Air Bags (Thorax and Head Air Bags)

Many manufacturers are installing side impact air bags (thorax bags, combination head/thorax bags, or window curtains). NHTSA proposed an oblique pole test as part of FMVSS 214 on May 17, 2004 (69FR 27990). Based on current technology, this NPRM would result in head protection by either a combination head/thorax side air bag or window curtains. NHTSA is also researching the use of window curtain air bags for ejection mitigation, which would result in taller and wider window curtains that would be tethered or anchored low to keep occupants in the vehicle.

A teardown study of 5 thorax air bags resulted in an average weight increase per vehicle of 4.77 pounds (2.17 kg)[36]. A second teardown study of 3 combination head/thorax air bags resulted in a similar average weight increase per vehicle of 4.38 pounds (1.99 kg)[37]. This second study also performed teardowns of 5 window curtain systems. 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) and is assumed to be average for all vehicles in the future.

Assuming in the future that the typical system will be thorax bags with a window curtain, the average weight increase would be 11.55 pounds (4.77 + 6.78) or 5.25 kg (2.07 + 3.08). In MY 2003, about 17 percent of the fleet had thorax air bags, 7 percent had combination air bags and, and 10 percent had window curtains. The combined average weight for these systems in MY 2003 was 1.8 pounds (0.82 kg). Thus, the future increase in weight for side impact air bags and window curtains compare to MY 2003 installations is 9.75 pounds (11.55 – 1.8) or 4.43 kg (5.25 - 0.82).

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[36] 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.
[37] Ludtke & Associates, “Perform Cost and Weight Analysis, Head Protection Air Bag Systems, FMVSS 201”, page 4-3 to 4-5, DOT HS 809 842.

Offset Frontal Crash Testing

The Insurance Institute for Highway Safety (IIHS) has been testing and rating vehicles using an offset deformable barrier crash test at 64 km/h. Many manufacturers have redesigned their vehicles to do better in these tests and have increased the weight of their vehicles. Four light trucks that the agency has tested, which improved from a poor rating to a marginal or good rating in the IIHS testing, increased their weights, some with other redesigns, as follows:

Table IV-1
Increases in Weight to Improve in
Offset Frontal Testing

	Before	**After Redesign**	**Increase in Weight**
SUV	1997 Chevrolet Blazer (4,686 lbs.)	2002 Trailblazer (5,181 lbs.)	495 lbs.
SUV	1999 Mitsubishi Montero Sport (4,646 lbs.)	2001 Mitsubishi Montero Sport (4,715 lbs.)	69 lbs.
Pickup	2001 Dodge Ram 1500 (4,930 lbs.)	2002 Dodge Ran 1500 (4,969 lbs.)	39 lbs.
Minivan	1996 Toyota Previa (3,810 lbs.)	1998 Toyota Sienna (3,937 lbs.)	127 lbs.

These weight increases have an affect on the vehicle's fuel economy. Whether increases in weight like this will continue for other vehicles in the future is unknown.

The next two tables summarize estimates made by NHTSA regarding the weight added in MY 2008 –2010 to institute these standards or potential voluntary safety improvements. Table IV-2 presents the actions that are required of the manufacturers by changes in the safety standards compared to a baseline of MY 2007. Table IV-3 presents voluntary actions compared to a baseline of MY 2003, which do not have to be considered in setting the fuel economy standards.

Table IV-2
Weight additions due to required FMVSS Regulations

Standard No.	**Effective Date**	**Added Weight in pounds**	**Added Weight in kilograms**
138	Last 30% in MY 2008	0.11	0.05
202	MY 2009	2.9	1.3
208 (belts)	Last 20% in MY 2008	0.36	.16
208 (anchorages)	Last 20% in MY 2008	0.2 - ?	0.09 - ?
301	Affect 60% total, Middle 30% inMY 2008, and Last 30% in MY 2009	0.14	0.07
Total		3.71 - ?	1.67 - ?

Table IV-3
Weight additions due to Voluntary Safety improvements

	Added Weight in pounds	Added Weight in kilograms
Anti-lock Brakes and ESC	2.0	0.91
Side Impact Air Bags (Thorax and Head Air Bags)	9.75	4.43
Improve Offset Frontal Crash Ratings	?	?
Total	11.75 - ?	5.34 - ?

In summary, NHTSA estimates that weight additions required by FMVSS regulations that will be effective in MY 2008-2010, compared to the MY 2007 fleet will increase light truck weight by an average of 3.71 pounds or more (1.67 kg or more). Likely voluntary safety improvements will add 11.75 pounds or more (5.34 kg or more) compared to MY 2003 installations.

Based on NHTSA weight versus fuel economy algorithms, a 3-4 pound increase in weight equates to 0.01 mpg fuel economy penalty. Thus, the agency's estimate of the safety weight effects are 0.01 mpg or more for required additions and 0.03 mpg or more for voluntary safety improvements for a total of 0.04 mpg or more.

CONFIDENTIAL SUBMISSIONS

Information on the fuel economy impacts of safety standards and voluntary safety improvements were submitted by some manufacturers. These are summarized in the tables below:

[ ]

[Table VI-4
Confidential Submissions on Safety Standards and Voluntary Safety Improvements
Affect on Fuel Economy
Incremental Impact Relative to Previous Model Year

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The Impact of Emission Standards

1. Tier II Requirements

On February 10, 2000, the Environmental Protection Agency (EPA) published a final rule (65 FR 6698) establishing new federal emissions standards for passenger cars and light trucks. These new emissions standards, known as Tier 2 standards, are designed to focus on reducing the emissions most responsible for the ozone and particulate matter (PM) impact from these vehicles - nitrogen oxides (NO[X]) and non-methane organic gases (NMOG), consisting primarily of hydrocarbons (HC) and contributing to ambient volatile organic compounds (VOC). For new passenger cars and light trucks, the Tier 2 standards phase-in began in 2004, and are to be fully phased-in by 2007.

In addition to establishing new emissions standards for vehicles, the Tier 2 standards also establish standards for the sulfur content of gasoline. When issuing the Tier 2 standards, EPA responded to comments regarding the Tier 2 standard and its impact on CAFE by indicating that it believed that the Tier 2 standards would not have an adverse effect on fuel economy.

2. California Air Resources Board LEV II

The State of California Low Emission Vehicle II regulations (LEV II) are phased-in for passenger cars and light trucks during the 2004-2007 model years. The zero emission vehicles (ZEV) regulation applies to passenger cars and light trucks up to 3,750 lbs. loaded vehicle weight (LVW) beginning in MY 2005. Trucks between 3,750 lbs. LVW and 8,500 lbs. GVWR are phased-in to the ZEV regulation from 2007-2012. The ZEV requirements begin at 10 percent in 2005 and ramp-up to 16 percent for 2018 under different paths.

[ ]

[Table IV-5
Confidential Submissions on the Impact of Emissions Standards on Fuel Economy
Incremental Impact Relative to Previous Model Year
(in mpg)

]

V. FUEL ECONOMY ENHANCING TECHNOLOGIES

Available Technologies

A variety of vehicle technologies could conceivably be applied in many potential combinations to increase the fuel economy of light trucks. This chapter provides a short description of the nature of each technology. This information was derived from confidential data provided by the manufacturers as well as information publicly available found and found in the literatue. The technologies relied upon in this analysis, in the order that they are presented in Table VI-4 are as follows:

Low-Friction Lubricants

The use of lower viscosity engine and transmission lubricants can reduce fuel consumption. The NAS report projected that low-friction lubricants could reduce fuel consumption by 1 percent at a cost impact of $8 to $11[38]. However, even without any changes to fuel economy standards, most MY 2008-2010 light trucks 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. Most manufacturers therefore attributed smaller potential fuel economy reductions and cost increases to lubricant improvements.

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 and, therefore, fuel consumption. The NAS report projected that vehicles using tires with lower rolling resistance

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[38] The price increases noted in this chapter are slightly higher than shown in the NAS study, since they have been converted into calendar year 2003 prices.

could achieve fuel consumption reductions of 1.0 to 1.5 percent at a RPE cost of $15 to $58. Many manufacturers have already adopted rolling resistance reductions.

Low Drag Brakes

Low drag brakes reduce the sliding friction of disc brake pads on rotors when the brakes aren't engaged because the brake shoes are pulled away from the rotating drum. The latest available information to the agency (not NAS data) [ ] predicts that low drag brakes could reduce fuel consumption by 1 percent to 2 percent at a cost of $50 to $125.

Reduction of Engine Friction Losses

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 reductions, improved engine operation, greater fuel economy and reduced emissions. Examples include low-tension piston rings, roller cam followers, material substitution, more optimal thermal management, and piston surface treatments, as well as lubricant friction reduction. The NAS report predicted that such technologies could reduce fuel consumption by 1 percent to 5 percent at a cost of $36 to $146. However, even without any changes to fuel economy standards, most MY 2008-2011 light trucks are likely to employ one or more such techniques to reduce engine friction and other mechanical and hydrodynamic losses.

Front Axle Disconnect for Four wheel-drive

To provide shift-on-the-fly capabilities, many part-time four-wheel drive systems use some type of front axle disconnect. The front axle disconnect is normally part of the front differential assembly. As part of a shift-on-the-fly four-wheel drive system, the front axle disconnect serves two basic purposes. First, in two-wheel-drive mode, it 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. Second, 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 a front axle disconnect typically do not have either manual- or automatic-locking hubs. To isolate the front wheels from the rest of the front driveline, front axle disconnects use a sliding sleeve to connect or disconnect an axle shaft from the front differential side gear. Recent information available to the agency (not NAS) projects that front axle disconnect for 4WD vehicles reduce fuel consumption by [ ] at a cost of [ ].

Cylinder Deactivation

For the vast majority of light trucks, 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. 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. The NAS report projected that cylinder deactivation could reduce fuel consumption by 3.0

to 6.0 percent at a cost of $116 to $262. Some manufacturers are getting results in excess of 6 percent and most are at the high end of the range.

Multi-valve Overhead Camshaft Engine

Without changes to fuel economy standards, it appears likely that many MY 2008 light trucks would use overhead valve (OHV) engines with pushrods and one intake and one exhaust valve per cylinder. Engines with overhead cams (OHC) and more than two valves per cylinder achieve increased airflow at high engine speeds and reduction 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 reduce fuel consumption by 2 percent to 5 percent at a cost of $109 to $146. However, some of this reduction is attributed to engine downsizing that would reduce available torque at low engine speeds. For multi-valve OHC engines, manufacturers provided fuel consumption reduction estimates that were similar and cost estimates that were more divergent.

Variable Valve Timing

Some light trucks currently use variable valve timing (VVT), which is a system that provides for some optimization of valve opening and closing over the engine's operating region. 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. The NAS report projected that VVT could reduce fuel consumption by 2.0 to 3.0 percent at a cost of $36 to $146. Manufacturers estimated considerably lower potential benefits, in part because of increases in engine friction, as well as theoretical limits on the amount of fuel consumption reduction that can be attributed to pumping loss reduction.

Electric Power Steering

In a vehicle with a 42 V electrical system, it may be feasible to replace a hydraulic power steering system that consumes energy even under straight-line driving conditions with a more efficient electric power steering system that only consumes energy when required to meet steering loads. However, a 42-Volt electrical system is not a prerequisite for electric power steering. The NAS report projected that electric power steering could reduce fuel consumption by 1.5 to 2.5 percent at a cost of $109 to $156.

Engine Accessory Improvement

Internal combustion engines rely on a number of accessory components, such as coolant, oil, and power steering fluid pumps. Incremental improvements to such components could help to reduce overall fuel consumption. Further reductions could be achieved by replacing mechanically driven accessories with electrically powered counterparts. However, the potential for such replacement will be greater for vehicles with 42-Volt electrical systems. The NAS report projected that engine accessory improvement could reduce fuel consumption by 1.0 to 2.0 percent at a cost of $87 to $116.

Five- and Six-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 light trucks by MY 2008. The NAS report projected that a 5-speed automatic transmission could reduce fuel consumption by 2.0 to 3.0 percent at a cost of $73 to $160 (relative to a 4-speed automatic transmission), and that a 6-speed automatic transmission could further reduce fuel consumption by 1.0 to 2.0 percent at a cost of $146 to $291.

Aggressive Shift Logic

Automatic transmission energy losses are lower when torque converter lock-up (if available) is engaged. Through partial lock-up under some operating conditions and early lock-up under others—that is, aggressive shift logic—automatic transmissions can achieve some reduction in overall fuel consumption. The NAS report projected that aggressive shift logic could reduce fuel consumption by 1.0 to 3.0 percent at a cost of $0 to $73.

Continuously Variable Transmission

Unlike manual and automatic transmissions with fixed transmission ratios, continuously variable transmissions (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. Compared to 5-speed automatic transmissions, the NAS report projected that CVTs could reduce fuel consumption by 4.0 to 8.0 percent at a cost of $146 to $364. The NAS report also projected that torque requirements would limit the near-term applicability of CVTs to compact light trucks (less than or equal to 4,250 lbs. GVWR), but that higher-torque "advanced" CVTs could eventually further reduce fuel consumption by 0.0 to 2.0 percent at a cost of $364 to $874.

Automatically Shifted Clutch Transmission

Unlike current manual transmissions, which drive through a positive clutch and gears, current automatic transmissions use hydraulic torque converters in place of the clutch, which are less mechanically efficient. Adding automatic electronic controls to a clutch transmission yields an "automatic shift manual transmission," or more precisely, an automatically shifted clutch transmission without the need for a torque converter. Automatically shifted clutch transmissions that have a dual wet clutch system can provide shift quality that equals or exceeds the smoothness of current automatic transmissions. The NAS report projected that such transmissions could reduce fuel consumption by 3.0 to 5.0 percent at a cost of $73 to $291.

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 fuel consumption. Areas for potential aerodynamic drag improvements include skirts, air dams, underbody covers, and more aerodynamic side view mirrors. The NAS report projected that further reductions in light truck aerodynamic drag could reduce fuel consumption by 1.0 to 2.0 percent at a cost of $0 to $146.

Variable Valve Lift and Timing

Some light trucks use 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. The NAS report projected that VVLT could reduce fuel consumption by 1.0 to 2.0 percent over VVT alone at a cost of $73 to 218.

Direct Injection Spark Ignition

With direct fuel injection, spark ignition engines can utilize well-controlled lean mixtures, resulting in higher thermodynamic efficiency. This can be done under stoichiometric or lean burn conditions. This technology yields 10 percent or more improvement in fuel consumption in European applications. Some passenger cars sold in Europe and in Japan use this technology. However, the more stringent NOx and particulate emissions standards in the U.S. limit the improvement for light trucks to 1.0 to 3.0 percent at a cost of $200 to $250. These are NHTSA estimates, not NAS estimates [ ].

Engine Downsizing and Supercharging

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. By increasing the pressure differential between the atmosphere and the charging cylinders, superchargers and turbochargers increase this available airflow, and thereby the engine's specific power. Like other technologies that increase specific power, superchargers and turbochargers make it possible to reduce engine size while maintaining performance. Assuming such engine downsizing, the NAS report projected that supercharging could reduce fuel consumption by 5.0 to 7.0 percent at a cost of $364 to $582.

Forty-Two Volt Electrical System

Light trucks currently use 12 V 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 increases to the point that new and more efficient systems, such as electric power steering, may be feasible. A 42-volt system can also accommodate an integrated starter generator. The NAS report projected that 42 V electrical systems could reduce fuel consumption by 1.0 to 2.0 percent at a cost of $73 to $291.

Integrated Starter/Generator

In a vehicle with a 42 V electrical system, the alternator and starter could be integrated into one component that is powerful enough to quickly restart an idle engine, enabling the engine to be turned off while the vehicle is stopped (with the air conditioner off). Given sufficient battery capacity, an integrated starter/generator (ISG) could recapture some braking energy and provide some initial acceleration (i.e., launch). The NAS report projected that ISGs could reduce fuel consumption by 4.0 to 7.0 percent at a cost of $218 to $364.

Intake Valve Throttling

VVLT engines reduce pumping losses and increase thermal efficiency by providing some optimization of valve timing and lift. Intake valve throttling (IVT) would use more complex systems of sensors, electronic controls, and variable valve lifts to enable further optimization of valve timing and lift. The NAS report estimates that IVT engines could achieve a 3.0 to 6.0 percent reduction in fuel consumption at a cost of $218 to $437 when compared to VVLT.

Camless Valve Actuation

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. This level of control can enable even further incremental reductions in fuel consumption. The NAS report projected that camless valve actuation could reduce fuel consumption by 5.0 to 10.0 percent over VVLT at a cost of $291 to $582.

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 reduce fuel consumption by 2.0 to 6.0 percent over 4-valve VVT at a cost of $218 to $510.

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. We project that advanced CVT could reduce fuel consumption by up to 2.0 percent at a cost of $364 to $874. These are NHTSA estimates based on public information, not NAS estimates.

Dieselization

A diesel engine's much higher compression ratio, lean burn operation and direct injection make it not only more fuel efficient, but give it more torque than a spark-ignition gasoline engine of the same displacement. In addition, diesel fuel contains about 10 percent more energy by volume than gasoline. The diesel engines that will be appearing on MY 2008 – 2010 light trucks must meet Tier 2 emission standards for NOx and particulate matter. Compliance strategies are expected to include a combination of combustion improvements and aftertreatment. Combustion improvements should include those related to higher-pressure fuel injectors and improved exhaust gas recirculation. Aftertreatment technologies are projected to include lean NOx traps, particulate traps, oxidation catalysts and the use of injectable urea. The latest data shows that diesels can reduce fuel consumption by 15 to 20 percent beyond gasoline engines with other engine technologies having been applied at a cost of $1,000 to $2,000. These are NHTSA estimates based on public information[39], not NAS estimates.

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[39] "A New Dawn for Diesel", John DeGaspari, January 2005, *Mechanical Engineering* magazine. http://www.memagazine.org/contents/current/features/newdawn/newdawn.html

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. See Table VI-4 for the range of improvements and costs ($0.75 to $1.25 per pound reduced).

Hybrid Vehicles

Hybrid vehicles may be designed in several configurations. Generally, they will include electric motors, regenerative braking, integrated starter/generators, launch assist, and battery storage for regenerated energy. Honda is currently selling three hybrid passenger cars in the U.S., the Insight, the Civic Hybrid and the Accord Hybrid that utilizes the Integrated Motor Assist System.

Toyota is selling the Prius, Highlander HEV and Lexus RX-400h which use Toyota's Integrated Hybrid System that utilizes an electronically controlled variable transmission with a planetary gear set in addition to all the components of a hybrid such as the Insight. In the Toyota hybrids, the electric motor is used for vehicle propulsion at low speeds (under 15 mph) and to provide additional acceleration at highway speeds. Toyota recently announced plans to build a hybrid version of the Camry in 2006.

Ford (Escape) and DaimlerChrysler (Ram 1500, Durango) have announced plans or have shown prototype hybrid light trucks. These are believed to be "mild" hybrids.

General Motors is currently producing Silverado/Sierra hybrid using a flywheel alternator starter generator. GM has announced plans to produce a Saturn VUE using a belt alternator starter hybrid system in MY 2006 and using this same technology on a Chevrolet Malibu in MY 2007. In addition, starting with MY 2007, GM will be replacing the flywheel alternator starter generator used in the Silverado/Sierra hybrid with a Two Mode Full Hybrid design. This system, which will be available in GM's full-size pickups and SUVs, uses an electrically variable transmission with two hybrid modes of operation is designed to optimize the power and torque delivered depending on driving conditions. We project that manufacturers could decrease fuel consumption by anywhere from 25 to 35 percent at a cost of $3,000 to $5,000 for a midrange hybrid. These are NHTSA estimates, not NAS estimates [ ].

<u>Effect of Weight and Performance Reductions on Light Truck Fuel Economy</u>

We assume that manufacturers will meet the proposed CAFE levels without any meaningful deviation from the planned performance and weight of their vehicles. Additionally, we do not assume any manufacturers to engage in any meaningful type of mix shifting to meet these standards, other than those already being planned. The Agency's analysis includes some CAFE gains through weight reduction of vehicles with curb weights over 5,000 pounds that are not in their product plans. According to Dr. Kahane's revised weight and safety study[40], if manufacturers reduced weight while keeping footprint constant for all light trucks over 3,900 pounds, the net mortality effect will be near zero. In other words, manufacturers can remove some weight from all LTVs over 3,900 pounds without any measurable effect on safety, if you hold footprint constant. There is, however, significant statistical uncertainty around the 3,900 lbs. point of zero net impact. We assume a confidence bound of approximately 1,000 lbs., based on additional empirical work found in Kahane's study. Kahane estimated a crossover weight[41] of 5,085 lbs. if manufacturers changed both weight and footprint, and the interval estimated ranged from 4,224 lbs. to 6,121 lbs., i.e., an interval +/-1000 lbs. around the point estimate (Kahane, 2003, p. 166). Although the crossover weight differs from the point of zero net impact, they would both tend to have similar sampling errors. We applied this interval to the 3,900 lbs. point of zero net impact (which is based on the assumption that footprint is held constant); therefore, the agency felt it would be prudent to limit weight reductions to those vehicles above 5,000 lbs. curb weight.

[40] Assuming footprint is held constant, there would be no effect on rollovers, the net fatality change per 100 pound reduction for light trucks weighing 3,870 pounds would be a loss of 15 lives (71 overall – 56 in principal rollover). "Vehicle Weight, Fatality Risk and Crash Compatibility of Model Year 1991-99 Passenger Cars and Light Trucks", NHTSA, October 2003, DOT HS 809 662. (See page 159)). Under the same assumption, the net fatality change per 100 pound reduction for light trucks weighing 4,000 pounds would be a gain of 15 lives (25 overall – 40 in principal rollover) (See page 162). Thus, the point estimate of the point of zero net impact is somewhere between 3,870 and 4,000 pounds curb weight.

[41] The crossover weight is the weight at which a reduction in weight would produce a zero effect on safety. All LTVs weighing more than the crossover weight would experience a net benefit from reduced weight. All those below the crossover weight would experience a net loss in safety.

VI. MANUFACTURER SPECIFIC CAFE CAPABILITIES

On February 7, 2002 and December 27, 2003, NHTSA requested information—including detailed information regarding manufacturer product plans—to assist the agency in developing a proposal regarding CAFE standards. We utilized this information and we also made selective use of industry trade publications (e.g., Ward's Automotive Yearbook) to obtain some information regarding the technical characteristics (e.g., gross vehicle weight rating, cylinder counts) of some light trucks.

Table VI-1a shows the MY 2008/9/10/11 CAFE product plans for each of the manufacturers, based on the manufacturer's plans without taking into account any alternative fueled vehicle credits.

Table VI-1b shows the **ADJUSTED BASELINE**. Note that when we do cost and benefit analyses, we use the **ADJUSTED BASELINE** from Table VI-1b throughout the analysis. The adjusted baseline assumes for the analysis that each manufacturer, below the MY 2007 standard level of 22.2 mpg, (except BMW, Porsche and Volkswagen) would apply technology to achieve 22.2 mpg[42]. Those mpg levels of those manufacturers with product plans above 22.2 mpg are retained for the adjusted baseline. Our rationale for this adjustment of the baseline is that the costs and benefits of achieving 22.2 mpg have already been analyzed and estimated in previous analyses. The methodology in this analysis is to apply technologies to the manufacturers plans and increase them to 22.2 mpg. The costs of these technologies are estimated, but they are not

[42] Note that a manufacturer could be complying with the current standard of 22.2 mpg by using alternative fueled vehicles, but their average mpg in this analysis will not reflect that because the analysis must be done without considering alternative fueled vehicles impacts, since they are part of an incentive program.

considered part of this rule. We then estimate the costs and benefits of going from the adjusted baseline to the level of the standard[43].

Table VI-2a shows what we believe the manufacturers' fuel economy could be for "meeting" the Unreformed CAFE standards of 22.5 for MY 2008, 23.1 for MY 2009, and 23.5 for MY 2010. Note that the agency is not proposing to use the Unreformed CAFE standards in setting requirements for MY 2011, thus no estimates were made for MY 2011 under this situation. Note that not all manufacturers would attempt to "meet" the proposed unreformed CAFE standards. We assume that BMW, Volkswagen, and Porsche would not meet these levels because, for them, the cost of meeting these levels is more than the cost of paying penalties. These three manufacturers have shown, in the past, the willingness to pay penalties rather than spend more money to improve the fuel economy of their products.

Table VI-2b shows what we believe the manufacturer's fuel economy could be under the Reform CAFE, again without taking into account fuel economy adjustments for alternative fueled vehicles.

[43] Some manufacturer's plans are above the level of the standard already and are assumed to remain at that level. Some manufacturer's levels go slightly above the proposed mark since some technologies are applied to all models of a particular manufacturer so that the exact level for each manufacturer may be slightly higher than the level of the standard and costs and benefits are estimated to that level.

The agency has performed two separate analyses of how manufacturers could respond to changes in the proposed CAFE levels. These are the “Technology Application Analysis” (or the “Volpe Analysis”) and the “Stage Analysis”. The Technology Application Analysis was applied to all manufacturers and uses an automated technology application algorithm to consistently apply technologies to the entire industry on a truckline-by-truckline basis. The Stage Analysis is based on engineering judgment and emphasizes particular technologies identified by the manufacturer.

The proposed Unreformed CAFE levels for MYs 2008-2010 were developed using the Stage analysis. However, because the analysis conducted using the technology application algorithm covers the entire industry, it was used to estimate the overall economic impacts (benefits and costs) of the scenarios, including increases in new vehicle prices on a manufacturer-wide, industry-wide, and average per-vehicle basis.

Our analyses of the potential effects of alternative CAFE standards was founded on two major elements: (1) projections of the technical characteristics and sales volumes of future product offerings and (2) estimates of the applicability and incremental cost and fuel savings associated with different hardware changes—technologies—that might be utilized in response to alternative CAFE standards.

Table VI-1a
Manufacturers Production Plans
Estimated mpg

	MY 2008	**MY 2009**	**MY 2010**	**MY 2011**
BMW	21.29	21.29	21.29	21.31
DC	21.87	22.34	22.34	22.47
Ford	21.63	21.97	22.27	22.27
Fuji – Subaru	25.69	26.17	26.17	26.17
GM	21.17	21.30	21.32	21.32
Honda	24.37	24.37	24.37	24.38
Hyundai	21.82	23.15	22.79	22.79
Isuzu	20.38	20.24	20.14	20.11
Nissan	20.74	20.78	21.19	21.19
Porsche	16.80	16.80	16.80	16.80
Suzuki	21.93	21.93	21.93	21.93
Toyota	22.90	22.90	22.89	22.91
VW	18.78	18.78	18.78	18.76
Harmonic Ave.	21.76	22.05	22.13	22.16

Table VI-1b
Estimated Fuel Economy Levels
Adjusted Baseline mpg

	MY 2008	MY 2009	MY 2010	MY 2011
BMW	21.29	21.29	21.29	21.31
DC	22.16	22.63	22.62	22.76
Ford	22.16	22.37	22.67	22.67
Fuji – Subaru	25.69	26.17	26.17	26.17
GM	22.15	22.17	22.16	22.19
Honda	24.37	24.37	24.37	24.38
Hyundai	22.21	23.36	23.10	23.10
Isuzu	22.26	22.22	22.22	22.21
Nissan	22.19	22.24	22.42	22.42
Porsche	16.80	16.80	16.80	16.80
Suzuki	22.22	22.22	22.22	22.22
Toyota	22.90	22.90	22.89	22.91
VW	18.78	18.78	18.78	18.76
Harmonic Ave.	22.35	22.56	22.63	22.66

Table VI-2
Estimated Fuel Economy Levels
Estimated mpg for Unreformed CAFE

	MY 2008	**MY 2009**	**MY 2010**
BMW	21.29	21.29	21.29
DC	22.47	23.05	23.51
Ford	22.46	23.06	23.45
Fuji – Subaru	25.69	26.17	26.17
GM	22.45	23.05	23.45
Honda	24.37	24.37	24.37
Hyundai	22.55	23.83	23.45
Isuzu	22.49	23.04	23.48
Nissan	22.53	23.07	23.46
Porsche	16.80	16.80	16.80
Suzuki	22.69	23.10	23.51
Toyota	22.90	23.08	23.50
VW	18.78	18.78	18.78
Harmonic Ave.	22.61	23.15	23.50

Table VI-2c
Estimated Fuel Economy Required Levels
Estimated mpg with Reformed CAFE

	MY 2008	MY 2009	MY 2010	MY 2011
BMW	21.29	21.29	21.29	21.31
DC	22.78	23.49	23.65	24.16
Ford	22.35	22.85	23.18	23.55
Fuji – Subaru	25.69	26.17	26.17	26.43
GM	22.15	22.75	23.16	23.66
Honda	24.37	24.37	24.37	24.77
Hyundai	24.19	25.87	25.70	26.27
Isuzu	22.28	22.89	23.20	23.67
Nissan	22.09	22.76	23.14	23.65
Porsche	16.80	16.80	16.80	16.80
Suzuki	25.84	26.68	26.79	27.91
Toyota	23.19	24.09	24.50	24.94
VW	18.78	18.78	18.78	18.76
Harmonic Ave.	22.64	23.27	23.55	24.00

Note: All of the fuel economy estimates exclude the impacts of alternative fuel credits.

Sales Projections

The manufacturers provided us with projected sales for passenger cars and light trucks. Taken together, the sales projections provided by the individual companies to NHTSA yielded unrealistically high industry-wide passenger car and light truck sales volumes. Therefore, we assumed that (1) overall total passenger car and light truck sales volumes (their total, not individually) would match projections in the Department of Energy, Energy Information Administration (EIA's) Annual Energy Outlook 2005. These values were 16.164 million in 2008, 16.292 million in 2009, 16.397 million in 2010, and 16.277 million in 2011 and (2) each manufacturer's share of the overall total passenger car and light truck market started at the 2002 levels. However, these percentages changed based on the next factor. (3) We assumed that each manufacturer's ratio of their own passenger car to light truck sales was a better prediction than that of the Department of Energy, so we used the individual manufacturer's ratio of light truck sales to its total light vehicle sales in each year. Overall, this changed the projected percent of light trucks from around 53 percent of total light vehicle sales in the Department of Energy predictions to light trucks being around 60 percent of total light vehicle sales. Table VI-3 shows the total fuel economy related sales projections.

Table VI-3
Projected Light Truck Sales

Model Year	0-8,500 GVWR
2008	9,480,200
2009	9,613,100
2010	9,754,700
2011	9,741,000

Technology Assumptions

Potential cost and fuel consumption impacts of different technologies are discussed in Chapter V. Within the range of values anticipated for each technology, we selected the cost and fuel consumption impacts considered most plausible during the model years under consideration. In the Volpe model, we used the expected impacts as summarized in Table VI-4. We sometimes deviated from these impacts in the Stage analysis, using estimates that were appropriate for specific manufacturers. As discussed in chapters III and IV, we have decided to use the National Academy of Sciences[44] estimates of fuel consumption improvements and costs. The low and high estimates from the NAS report become the bases for the uncertainty ranges used in the Uncertainty Analysis (see Chapter X). The last column of Table IV-4 shows the cost per percentage point improvement in fuel consumption - gallons per mile (gpm). We use the technology with the lowest cost in this column that is available for a specific manufacturer first, and work our way down the line of available technologies on a cost per percent improvement. As shown below the table, most technologies are available starting in MY 2008, with a few exceptions.

The agency considered whether wholesale performance reductions or mix shifts would occur and determined that they are not likely. The manufacturers have been improving the performance of their engines for years. It is not likely that they would reduce performance as a result of market forces alone. The Reform Cafe scenario takes away much of the incentive for mix shifts, since each category of vehicles is compared to its target mpg level. However, the manufacturers can

[44] The link for the NAS report is http://www.nap.edu/books/0309076013/html/

choose to use these and/or any other approaches to achieve the level of the standard. Another option available to the manufacturer is to pay CAFE fines, rather than make the investments to improve fuel economy, which we assume will be done by BMW, Porsche, and Volkswagen.

Table VI-4
Fuel Consumption and Cost Estimates

	Fuel Consumption Benefit			**Cost in $2003**			**Cost/%Imp**
Technology	**Low**	**Expected**	**High**	**Low**	**Expected**	**High**	
Low Friction Lubricants	1.0%	1.0%	1.0%	$8	$9.50	$11	9.50
Improve Rolling Resistance	1.0	1.25	1.5	15	36.50	58	29.20
Low Drag Brakes	0.75	1.0	1.25	15	80.50	146	80.50
Engine Friction Reduction	1.0	3.0	5.0	36	91	146	30.33
Front Axle Disconnect	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Cylinder Deactivation	3.0	4.5	6.0	116	189	262	42.00
Multi-Valve, Overhead Cam	2.0	3.5	5.0	109	127.50	146	36.43
Variable Valve Timing	2.0	2.5	3.0	36	91	146	36.40
Electric power Steering	1.5	2.0	2.5	109	132.50	156	66.25
Engine Accessory Impr.	1.0	1.5	2.0	87	101.5	116	67.67
5-Speed Automatic Trans.	2.0	2.5	3.0	73	116.50	160	46.60
6-Speed Automatic Trans.	1.0	1.5	2.0	146	218.50	291	145.7
Auto Trans, w/Aggressive Shift Logic	1.0	2.0	3.0	0	36.50	73	18.25
Continuously Variable Trans.	4.0	6.0	8.0	146	255	364	42.50
Auto Shift Manual Trans.	3.0	4.0	5.0	73	182	291	45.50
Aero Drag Reduction	1.0	1.5	2.0	0	73	146	48.67
Variable Valve Lift & Timing	1.0	1.5	2.0	73	145.50	218	97.00
Spark Ignited Direct Injection	1.0	2.0	3.0	200	225	250	112.5
Engine Supercharge & Down.	5.0	6.0	7.0	364	473	582	78.83
42 Volt Electrical Systems	1.0	1.5	2.0	73	182	291	121.3
Integrated Starter/Generator	4.0	5.5	7.0	218	291	364	52.91
Intake Valve Throttling	3.0	4.5	6.0	218	327.50	437	72.78
Camless Valve Actuation	5.0	7.5	10.0	291	436.50	582	58.20
Variable Compression Ratio	2.0	4.0	6.0	218	364	510	91.00
Advanced CVTs	0.0	1.0	2.0	364	619	874	619
Dieselization	15	17.5	20	1,000	1,500	2,000	85.71
Material Substitution 1st	0.6	0.65	0.7	.75*	.75*	.75*	
Material Substitution 2nd	0.6	0.65	0.7	1.0*	1.0*	1.0*	
Material Substitution 3rd	1.75	1.93	2.10	1.25*	1.25*	1.25*	
Material Substitution 4th	-0.6	-0.65	-0.70	.75*	.75*	.75*	
Midrange Hybrid Vehicle	25	30	35	3,000	4,000	5,000	1.33.3

*Costs are presented in $ per pound reduced

All of the technologies are available in 2008 with the following exceptions:
2009: Advanced CVTs
2010: Automatic Shift Manual Transmission, Intake Valve Throttling, Camless Valve Actuation, Variable Compression Ratio, Advanced CVT, and Mid-range Hybrid Vehicles.

Technology Application Algorithm

In order to understand how manufacturers might respond to changes in CAFE standards, we also developed an algorithm that applies technologies to different trucklines based on comparative estimated cost effectiveness. Having determined the applicability of each technology to each vehicle model, engine, and/or transmission, the compliance simulation algorithm begins the process of applying technologies based on the CAFE standards applicable during the current model year. This involves repeatedly evaluating the degree of noncompliance, identifying the "best next" technology available on each of the parallel technology paths mentioned above, and applying the best of these. If, considering all regulatory classes, the manufacturer owes no CAFE fines, the algorithm applies no technologies beyond any carried over from the previous model year. If the manufacturer does owe CAFE fines, the algorithm first finds the best next applicable technology in each of the technology groups (e.g., engine technologies), and applies the same criterion to select the best among these. If this manufacturer is assumed to be unwilling to pay CAFE fines (or, equivalently, if the user has set the system to exclude the possibility of paying fines as long as some technology can still be applied), the algorithm applies the technology to the affected vehicles. If the manufacturer is assumed to be willing to pay CAFE fines and applying this technology would have a lower "effective cost" (discussed below) than simply paying fines, the algorithm also applies the technology. In either case, the algorithm then reevaluates the manufacturer's degree of noncompliance. If, however, the manufacturer is assumed to be willing to pay CAFE fines and doing so would be less expensive than applying the best next technology, the algorithm stops applying technology to this manufacturer's products. Whether or not the manufacturer is assumed to be willing to pay CAFE fines, the algorithm uses CAFE fines not only to determine whether compliance has been achieved, but also to determine the relative attractiveness of different potential applications of technologies. For this analysis we assumed that paying fines, rather than applying technologies to improve fuel efficiency, would not be used by the manufacturers with the exception of BMW, Porsche, and Volkswagen. Whenever the algorithm is evaluating the potential application of a technology, it considers the effective cost of applying that technology to the group of vehicles in question, and chooses the option that yields the lowest effective cost. The effective cost is used for evaluating the relative attractiveness of different technology applications, not for actual cost accounting. The effective cost is defined as the change in total technology costs incurred by the manufacturer plus the change in CAFE fines incurred by the manufacturer minus the value of any reduction of fuel consumed by vehicles sold by the manufacturer:

Mathematically, this is expressed as follows:

$$COST_{eff} = \frac{\Delta TECHCOST + \Delta FINE - VALUE_{FUEL}}{N_j}$$

where *ΔTECHCOST* is simply the product of the unit cost of the technology and the total sales (*Nj*) of the affected cohort of vehicles (*j*). The value of the reduction in fuel consumption achieved by applying the technology in question to all vehicles *i* in cohort *j* is calculated as follows:[45]

[45] This is not necessarily the "actual" value of the fuel savings, but rather the increase in vehicle price the manufacturer is assumed to expect to be able to impose without losing sales.

$$VALUE_{FUEL} = \sum_{i \in j} \left[N_i \sum_{v=0}^{v=PB} \frac{SURV_v MI_v FUELPRICE_{MY+v}}{(1-gap)(1+r)^{v+0.5}} \left(\frac{1}{FE_i} - \frac{1}{FE_i'} \right) \right]$$

where MI_v is the number of miles driven in a year at a given vintage v, $SURV_v$ is the probability that a vehicle of that vintage will remain in service, FE_i and FE_i' are the vehicle's fuel economy prior to and after the pending application of technology, *gap* is the relative difference between on-road and laboratory fuel economy, N_i is the sales volume for model i in the current model year *MY*, $FUELPRICE_{MY+v}$ is the price of fuel in year $MY+v$, and *PB* is the "consumer time horizon", or number of years in the future the consumer is assumed to take into account when considering fuel savings.

We assumed a consumer time horizon of 4.5 years and a discount rate of seven percent or three percent. The consumer time horizon of 4.5 years is used in this technology application algorithm, however, it is not used when setting the socially optimum Reform CAFE proposal for MY 2011. In this case we use the fuel savings over the full 26-year lifetime of the vehicle. Our assumptions regarding fuel prices and age-specific vehicle survival and mileage accumulation rates are discussed in Chapter VIII.

The technologies in Table VI-4 were ranked primarily on the cost per percentage point improvement in fuel consumption (gallons per mile) and applied where available to each manufacturer's fleet in their order of rank. However, the ranking also reflects other factors, such as the logical order in which certain technologies must be applied. Beginning with the first technology listed in Table VI-4, the model repeatedly selects the appropriate technology application for a particular make/model based on cost-effectiveness (i.e., fuel savings per dollar). Once that technology has been applied to all models for that manufacturer, the evaluation process is repeated for the next technology in the list. Each time the algorithm applies a technology, it updates the technical description, incurred cost increase, and fuel economy of the relevant vehicle, as well as the manufacturer's CAFE. The algorithm continues applying technologies until each manufacturer either complies with the assumed CAFE standard or exhausts all technologies assumed to be available in the model year under consideration. As the technology application algorithm performs/repeats, it maintains running totals of cost increases (at the truckline and corporate level). Final calculated levels are outputs of the algorithm.

In order to estimate the potential net effects of the proposal, we applied the above-mentioned technology assumptions and technology application algorithm to the baseline CAFE levels. Not all of the manufacturers' fuel economy levels reached 22.2 mpg as shown in Table VI-1a. Therefore, for some of those manufacturers, technologies were applied to increase them up to the adjusted baseline of 22.2 mpg. The costs and benefits are included in the analysis only if those technologies were utilized to increase the manufacturer's fleet average from the adjusted baseline to the level of the proposal.

These estimates represent incremental changes if a technology is applied to a truckline to which other technologies have already been applied. We used the cost per percent improvement from Table VI-4 to determine the sequence that a manufacturer might follow when deciding which technologies to apply. This "application path" is not always chosen on a cost per percent improvement in mileage. First, we examined those technologies that are available in MY 2008 and ranked them. Cost per percent improvement could not be used for every case, because some technologies are either prerequisites for other technologies or would logically precede such other technologies. For example, a five speed automatic transmission would probably be introduced before a six speed automatic transmission. Also, a 42 Volt Electrical System was assumed to be necessary for an integrated starter/generator, and a multi-valve, overhead camshaft was assumed to logically precede variable valve timing and, subsequently, variable valve lift and timing. Variable valve lift and timing (VVLT) is considered as a potential incremental improvement beyond (and, in this case, replacement for) variable valve timing (VVT). Weight reduction was only applied to heavier vehicles in any manufacturer's fleet.

We also applied a few explicit technical constraints on the applicability of some technologies. When considering low-friction lubricants, we assumed that all light trucks will rely on 5W-30 or, where indicated by manufacturers, 5W-20. For engines that would otherwise rely on 5W-20, we reduced the expected available reduction in fuel consumption by half. We assumed that cylinder deactivation would not be applied to engines with fewer than six cylinders. We assumed that several technologies, including multivalve OHC, VVT, VVLT, supercharging and downsizing, intake valve throttling, camless valve actuation, variable compression ratio, would only apply to gasoline engines. We assumed that transmission improvements, 42 Volt electrical systems, and integrated starter/generators would not be available as improvements to hybrid electric vehicles (HEVs). We assumed that engine friction reduction would not be applicable to large pickups and SUVs, and that low-friction lubricants would not be applicable to rear-wheel drive (and derivative) vehicles.[46]

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[46] For the analysis using the technology application algorithm discussed below, we approximated this last constraint by not applying low-friction lubricants to pickups and large SUVs.

Stage Analysis for DaimlerChrysler, General Motors, Ford, Honda, Hyundai, Nissan, Subaru and Toyota

NHTSA's stage analysis relies heavily on the step-by-step application of different technologies at the truckline level, emphasizing particular technologies identified by the manufacturers in their detailed submissions given in response to the Request for Product Plan Information (68 FR 74931). The technologies applied in the stage analysis are over and above the manufacturers' product plans given in Table VI-1a. These detailed responses were received from DaimlerChrysler, General Motors, Ford, Honda, Hyundai, Nissan, Subaru and Toyota. These manufacturers have the largest share of the light truck market and many offer a full line of vehicles. Some of the technologies used in the stage analysis have been used for over a decade, e.g., OHC, engine friction reduction, and low friction lubricants. Some have only recently been incorporated on light trucks, e.g., 5-speed and 6-speed automatic transmissions and variable valve timing. Others have been under development for a number of years but have not been produced in quantity for an extended period, e.g., cylinder deactivation, variable valve lift and timing, continuously variable transmission (CVT), integrated starter generator and hybrid drivetrains.

The stage analysis utilizes engineering judgment to project fuel economy improvement on a nameplate-by-nameplate basis. For instance, NHTSA estimates that replacing an overhead valve engine with a multi-valve overhead camshaft engine of the same displacement and replacing a 4-speed automatic transmission with a 5- or 6-speed automatic transmission offer about the same potential level of improvement. One of them may be more attractive to a particular manufacturer because of its cost, ease of manufacturing, or the model lines to which it would apply. In applying the stage analysis, the agency projects the use of the most cost-effective technology for a given fuel economy improvement considering its appropriateness for the specific manufacturers' capabilities and general product plans. This analysis does not include the many minor types of improvements in electronic controls and engine valuing changes that could result in further fuel economy gains because it is difficult to precisely determine which of these technologies have been included in the models that manufacturers plan to produce in MY 2008 and beyond.

This analysis also includes the possibility that manufacturers could utilize some vehicle weight reduction as a fuel economy improvement technology on light trucks with curb weights over 3,900 pounds. Based on the results of Dr. Kahane's revised weight and safety analysis, the net weight-safety effect of removing 100 pounds from a light truck - if you hold footprint constant - is zero for all light trucks with curb weights above 3,900 pounds. This analysis examined opportunities for manufacturers to reduce the weight of their light trucks having curb weights over 3,900 pounds if it was determined that weight reduction was an economically logical choice for manufacturers after other more cost effective technologies were projected. In general, weight reduction was only applied to those vehicles with curb weights in excess of 5,000 pounds, which is 1,100 pounds heavier than the 3,900 pounds threshold, found in Dr. Kahane's study. Additionally, an attempt was made to apply weight reduction in conjunction with a planned vehicle redesign or freshening, sometimes in concert with a reduction in aerodynamic drag.

The analysis is divided into three stages: a more conservative application of technologies which are deemed to be available for use by MY 2008, which would not require significant changes in transmission and/or engine technology (Stage I); a more aggressive application of transmission and/or engine technology - classified as Production-Intent by the recent NAS study – which is added on top of those applied to the first stage (Stage II); and the application of diesel engines and hybrid powertrains to some products. (Stage III).

The Stage I analysis includes technologies that manufacturers state as being available for use by MY 2008 or earlier, but they are choosing not to use them in their product plans. Many of these technologies are currently being used in today's light duty truck fleet.

The Stage II analysis includes two major categories of technological improvements to the manufacturer's fleets, the timing of which is tied as nearly as possible to planned model change and engine introduction years. The first of these categories is transmission improvements, which consists of the introduction of 5-speed and 6-speed transmissions, and the introduction of CVTs to unibody SUVs and crossover vehicles. CVTs are restricted to these vehicles because they are not designed for rugged off-road applications and/or the need to haul heavy loads. Inherent in the design of CVTs is a reduced ability to deliver the low-end torque needed in such applications, thus the use of this technology is restricted to unibody SUVs and crossover vehicles.

The second category was engine improvements, and consists of gradually upgrading all light truck engines to include multi-valve overhead camshafts, introducing engines with more than 2-

valves per cylinder, applying variable valve timing or variable valve lift and timing to multi-valve overhead camshaft engines, and applying cylinder deactivation to 6 and 8-cylinder engines.

The Stage III analysis includes projections of the potential CAFE increase that could result from the application of diesel engines and hybrid powertrains to some products. Both diesel engines and hybrid powertrains appear in several manufacturers plans within the MY 2008 – 2010 timeframe, and other manufacturers have publicly indicated that they are looking seriously into both technologies.

DaimlerChrysler

In their submission, DaimlerChrysler described a variety of technologies that could be used to increase vehicle fuel economy. The description of each technology described included its estimated fuel economy benefit, the basis for that estimate, its potential applications, where it is currently employed in DaimlerChrysler's light truck fleets, where the technology could potentially be used, risks in employing the technology, and potential impacts on NVH, safety, emissions, cargo and towing capacity. DaimlerChrysler also provided a projected fleet description with projected CAFE levels for MYs 2002-2012.

(a) Stage I

To determine which Stage I technologies DaimlerChrysler could employ, on which vehicles and/or engines they could be employed, and when they could be employed, NHTSA relied heavily on the DaimlerChrysler-provided descriptions and on DaimlerChrysler's previous comments on the MY 2005-2007 light truck rule. Our analysis shows that DaimlerChrysler could employ [ ] by MY 2008 with [ ] employed by MY 2009. The [

] would carryover to MY 2009-2010, while the [ ] available for MY 2009 would carryover to MY 2010. NHTSA used the NAS report's mid-range numbers for percentage increase in fuel economy in calculating the possible fuel economy increase attributable to each of these technologies.

Starting with MY 2008, DaimlerChrysler could use [ ] on its [ ] models. These vehicles can utilize [ ] are currently in wide distribution. By MY 2006, some [ ] models will be manufactured with [ ]. The agency believes that there is more than sufficient lead-time for DaimlerChrysler to equip the [ ] models with these [ ] and to make arrangements with [ ] to purchase sufficient quantities.

Starting with MY 2008, DaimlerChrysler could include a [ ] This is a technology that can be used throughout DaimlerChrysler's light truck fleet and could be added to these vehicles within a relatively short leadtime.

Starting with MY 2008, DaimlerChrysler could use [ ] on all of its models that could utilize [ ]. Excluded from application is the [ ], for which this technology is already applied. [ ] can be applied to [ ]. The agency believes that there is more than sufficient lead-time for DaimlerChrysler to equip the [ ] models with these [ ] and to make arrangements with [ ] to purchase sufficient quantities.

Starting with MY 2008, DaimlerChrysler could use [ ]. The engines used in the [ ]. The remaining engines in DaimlerChrysler's light truck fleet use [ ]. This is a technology that can be used throughout DaimlerChrysler's light truck fleet could be added to these engines within a relatively short lead time.

Additionally, starting with MY 2009, DaimlerChrysler could employ [ ]. In MY 2009, the [ ]. In MY 2010, the [ ]. In MY 2010, the [ ]. Additionally, the agency believes that by 2010, the [ ]. The agency believes that DaimlerChrysler could incorporate a [ ] of these vehicles as part of its [ ] and that is quite feasible to have this technology included on these vehicles when they are [ ].

The Stage I improvements to the DaimlerChrysler light truck CAFE are summarized in the following table.

Table VI-5
DaimlerChrysler Stage I Technology CAFE Improvements, mpg
[Entire table Confidential

]

(b) Stage II

To determine which Stage II technologies DaimlerChrysler could employ, on which vehicles and/or engines they could be employed, and when they could be employed, NHTSA relied on its own engineering judgment, submissions from other manufacturers, and comments from DaimlerChrysler. Our analysis showed that DaimlerChrysler could employ [ ] by MY 2008, [ ] by MY 2009, with [ ] by MY 2010. All the MY 2008 and MY 2009 technologies would carry over into future model years. To determine the possible fuel economy increase attributable to each of these technologies, the agency looked at the NAS study's percentage increase in fuel economy for each technology and examined DaimlerChrysler submission and its fuel economy trends

Starting with MY 2008, DaimlerChrysler could use [ ]. Many of DaimlerChrysler's direct competitors for the small- and medium-size light truck market are introducing vehicles with [ ] during MY 2008-2010.

Starting with MY 2008, DaimlerChrysler could use a [ ]. This technology is used on [ ]. Since the [ ] it seems logical that the [ ] models could also utilize a [ ].

Starting with MY 2009 DaimlerChrysler could use [ ]. These are engines that are adaptable to the technology because of their [ ] configuration.

Starting with MY 2009, DaimlerChrysler could apply [ ]. In addition, starting with MY 2010, DaimlerChrysler could also apply [ ].

NHTSA projected the use of [ ] in the above vehicles for many reasons, including the fact that many of DaimlerChrysler's direct competitors for the mid-size and larger light truck market are introducing vehicles with [ ] during MY 2008-2010. DaimlerChrysler offers [ ] on some [ ] during MY 2008 -2010, thus [ ] are technically feasible for the above vehicles.

Starting with MY 2010, DaimlerChrysler could offer [ ]. These engines were chosen because of their [ ] design. DaimlerChrysler's current [ ] engines, the [ ] engines are [ ] engines, thus it's logical to assume that other [ ] engine designs could utilize [ ] technology as well.

(c) Stage III

The Stage III analysis includes projections of the potential CAFE increase that could result from the application of diesel engines and hybrid powertrains to some products. Our projection for DaimlerChrysler indicates that the company can meet the standards contained in this proposed rule without the agency applying any diesel engines and hybrid powertrains to DaimlerChrysler's product plans. Thus, we did not identify any CAFE increases resulting from Stage III for DaimlerChrysler.

The potential improvements to the DaimlerChrysler light truck CAFE – as projected by NHTSA - are summarized in the following table. Due to rounding, the individual improvements may not equal the potential CAFE for DaimlerChrysler.

Table VI-6
Potential Daimler CAFE Improvements, mpg

Model Year	Baseline Mpg	Stage I	Stage II	Stage III	Total	Potential CAFE, mpg
2008	[ ]	[ ]	[ ]	0	[ ]	22.523
2009	[ ]	[ ]	[ ]	0	[ ]	23.293
2010	[ ]	[ ]	[ ]	0	[ ]	23.570

Ford

(a) Stage I

In its submission, Ford described a variety of technologies that could be used to increase vehicle fuel economy. For each technology described, Ford included its estimated fuel economy benefit, the basis for that estimate, the baseline technology it is measured against, when the technology would be available for use, its potential applications, where it is currently employed in Ford's light truck fleets, where the technology could potentially be used, and potential reasons that limit the implementation rate of the technology.

To determine which Stage I technologies Ford could employ, on which vehicles and/or engines they could be employed, and when they could be employed, NHTSA relied heavily on the Ford-provided descriptions. Our analysis showed that Ford could employ [ ] by MY 2008, with an additional [ ] introduced by MY 2009. All the MY 2008/2009 technologies would carry over into future model years. NHTSA used the NAS study's mid-range numbers for the percentage increase in fuel economy that was used calculating the possible fuel economy increase attributable to each of these technologies.

Starting with MY 2008, Ford could use [ ] on all of its models that could utilize [ ]. Ford and other manufacturers have indicated that they are incorporating this cost-effective technology in other vehicle lines. By MY 2006, some [ ] models will be manufactured with [ ]. The agency believes that there is more than sufficient lead-time for Ford to equip the [ ] models with these [ ] and to make arrangements with [ ] to purchase sufficient quantities.

Starting with MY 2008, Ford could use a [ ]. Ford did not project the use of any [ ] on these vehicles during MY 2008 – 2010, however the agency believes that this technology is cost effective and can be implemented by MY 2008. Ford is currently using this technology in its truck fleet and should be able to incorporate it in its [ ] by MY 2008.

In MY 2008, Ford could use [ ] on all [ ]. Ford utilizes this technology on many other vehicles, especially those that are [ ], and the agency believes that this technology is applicable to a wide variety of vehicles.

Starting with MY 2008, Ford could include a [ ]. This technology is similar to one being introduced by a competitor and should be very applicable to these engines, especially when its used in conjunction with these [ ].

Starting with MY 2008, Ford could use [ ] on [ ]. In [ ], Ford is introducing new versions of the [ ]. Combined with the fact that the fuel economy of the base [ ] model is increasing, it appears that these vehicles will be undergoing a redesign/introduction in MY 2007. In MY 2010, the [ ] and the [ ]. In addition, Ford is introducing a [ ] which replaces the current [ ]. The agency believes that Ford could incorporate [ ] and that is quite feasible to have this technology included on these vehicles in when they are redesigned or introduced.

The effect of these technology changes is summarized in the following table.

Table VI-7
Ford Light Truck Stage I Improvements
[Entire Table Confidential

]

(b) Stage II

To determine which Stage II technologies Ford could employ, on which vehicles and/or engines they could be employed, and when they could be employed, NHTSA relied on its own engineering judgment and submissions from other manufacturers. In looking at these submissions, together with what Ford provided, NHTSA has analyzed which Stage II technologies could be applied to Ford's light truck fleet for MYs 2008-2010. Our analysis showed that in MY 2008, Ford could introduce or expand its application of [ ]. Our analysis also projected that the sales of one model would remain constant, if not increase, by MY 2009 and carry through to 2010.

Starting with MY 2008, Ford could use [ ]. These engines are [ ] and this technology would be a further technological advance on those engines. In addition to other Ford engines having this technology, most other light truck manufacturers employ this technology today.

Starting with MY 2008, Ford could use [ ]. This would be a further technological advance on engines that have [ ] today. Several other manufacturers employ this technology today.

Starting with MY 2008, Ford could update [ ]. The engines that could be updated are the [ ]. These engines would benefit by not only from being updated to [ ] but also by the addition of more [ ]. In addition to other Ford engines having this technology, most other light truck manufacturers employ this technology today.

Starting with MY 2009, Ford could equip all of its [ ]. In its submission, Ford projected the use of a [ ] on some [ ]. The agency believes that Ford has sufficient capacity to produce the quantity of [ ] that are projected that it is feasible and that there is sufficient lead-time for these [ ] could be used on [ ].

Starting with MY 2009, Ford could offer [ ]. These engines are the amongst the [ ] Ford uses in their light truck fleet, thus vehicles utilizing these engines could benefit the most from these engines having [ ]. Additionally, because these engines are used on some of Ford's best selling vehicles, Ford's CAFE could be raised significantly by the use of [ ] on these engines. Several other manufacturers employ this technology today, including DaimlerChrysler, GM and Honda.

Additionally, it is possible that the sales of the [ ] would remain constant through MY 2008-2010. Ford projects the sales of these vehicles to be [ ] in MY 2008, 2009 and 2010 respectively. NHTSA believes that due to the increased demand for and popularity of these vehicles, the sales of these vehicles, at the very least, would tend to be constant, if not increase from year to year. Thus, NHTSA returned the sales of the [ ] to [ ] units. Based on sales trends for [ ], NHTSA believes that the sales of the [ ] would increase during the period covered by this rulemaking.

(c) Stage III

The Stage III analysis includes projections of the potential CAFE increase that could result from the application of diesel engines and hybrid powertrains to some products. Our projection for Ford indicates that the company can meet the standards contained in this proposed rule without applying any additional diesel engines and hybrid powertrains. Thus, we did not identify any CAFE increases resulting from Stage III for Ford.

The potential improvements to the Ford light truck CAFE are summarized in the following table. Due to rounding, the individual improvements may not equal the potential CAFE for Ford.

Table VI-8
Potential Ford CAFE Improvements, mpg

Model Year	Baseline Mpg	Stage I Improvements	Stage II Improvements	Stage III Improvements	Total Increase	Potential CAFE, mpg.
2008	[ ]	[ ]	[ ]	[ ]	[ ]	22.497
2009	[ ]	[ ]	[ ]	[ ]	[ ]	23.214
2010	[ ]	[ ]	[ ]	[ ]	[ ]	23.610

GM

In their submission, GM described a variety of technologies that could be used to increase vehicle fuel economy. Each technology described included its estimated fuel economy benefit, the basis for that estimate, whether the benefit was direct or interactive, a description of how the technology works and how it increases fuel economy, when the technology would be available for use, its potential applications, where it is currently employed in GM 's light truck fleets, where the technology could potentially be used, risks in employing the technology, and potential impacts on NVH, safety, emissions, cargo and towing capacity. GM also provided a projected fleet description with projected CAFE levels for MYs 2003-2012.

(a) Stage I

To determine which Stage I technologies GM could employ, on which vehicles and/or engines they could be employed, and when they could be employed, NHTSA relied heavily on the GM-provided descriptions and on GM's previous comments on the MY 2005-2007 light truck rule regarding the technology applications used in the PRIA. Our analysis shows that GM could employ [ ] by MY 2008 with [ ] employed by MY 2009. The [ ] would carryover to MY 2009-2010, while [ ] available for MY 2009 would carryover to MY 2010. NHTSA used the NAS report's mid-range numbers for percentage increase in fuel economy in calculating the possible fuel economy increase attributable for most of these technologies. For [ ], NHTSA utilized higher percentage increases that were directly derived from GM data.

Starting with MY 2008, GM could use [ ] vehicles. GM utilizes this technology on several models, and the above models are [ ] designs which can utilize these [ ]. The agency believes that there is more than sufficient lead-time for GM to equip its models with these [ ] and to make arrangements with [ ] to purchase sufficient quantities.

Starting with MY 2008, GM could use [ ]. In reviewing GM's submission, this technology – which was first used by GM in MY 2005 – is used in most of GM's light trucks. GM has indicated its desire to use this technology on all vehicles that it produces. The agency has applied this technology to the only vehicles for which GM doesn't indicate it use in the projected project plan.

Starting with MY 2008, GM could use a [ ]. In examining GM's plans and the technology description provided, the agency has applied this technology to light trucks for which this technology is appropriate. GM uses this technology on related models beginning with MY 2007.

Starting with MY 2008, GM could use a [ ]. In examining GM's plans and the technology description provided, the agency has applied this technology to light trucks for which this technology is appropriate. GM first introduces this technology on passenger cars in MY 2005 and light trucks by MY 2006. By MY 2008, it is employed on over half of GM's light trucks.

Starting with MY 2008, GM could include an [ ]. This is a technology that can be used on all but [ ] (which have utilized this technology since MY 2004) and could be added to these vehicles within a relatively short lead time.

Starting with MY 2008, GM could include [ ]. This technology [ ] and can be applied on all vehicles and [ ]. This technology is currently used on the [ ].

Starting with MY 2009, GM could include an [ ]. GM's technology description states that the company hopes to utilize this technology widely.

Starting with MY 2009, GM could include a [ ]. GM's description states that this technology is being evaluated for introduction to engines in MY 2009, especially those with [ ].

Starting with MY 2008, GM could employ [ ]. The agency projected the possible use of [ ]. starting with MY 2008. For the [ ], the agency projected [ ] in conjunction with a [ ]. For almost all of the vehicles that the agency is projecting the use of [ ] possessing the same nameplate and attributes. GM attributes most of this [ ].

Additionally, starting with MY 2008, GM could employ [ ]. In MY 2008, the [ ]. In addition, GM is introducing the [ ] in MY 2008. In MY 2009, the [ ]. In MY 2010, the [ ]. The agency believes that GM could incorporate a [ ] of these vehicles as part of its [ ] and that is quite feasible to have this technology included on these vehicles when they are [ ].

The Stage I improvements to the GM light truck CAFE are summarized in the following table. Because many of the projected Stage I technologies can be classified under the heading of engine accessory technologies, the agency has grouped them under one heading below. The technologies included under this heading include [ ].

Table VI-9
GM Stage I Technology CAFE Improvements, mpg
[Entire Table Confidential

]

(b) Stage II

To determine which Stage II technologies GM could employ, on which vehicles and/or engines they could be employed, and when they could be employed, NHTSA relied on its own engineering judgment, submissions from other manufacturers, and comments from GM about the PEA. In looking at these submissions, together with what GM provided, NHTSA has analyzed which Stage II technologies could be applied to GM's light truck fleet for MYs 2008-2010. Our analysis showed that GM could employ [ ] by MY 2008, [ ] by MY 2009 and an [ ] by MY 2010. All the technologies would carry over into future model years. To determine the possible fuel economy increase attributable to each of these technologies, the agency looked at the NAS study's percentage increase in fuel economy for each technology and examined GM's submission and its fuel economy trends. For two technologies, it appears that GM's application of these technologies yields greater return for the company than the NAS average. The agency used these numbers for the purposes of projecting the use of these two specific technologies; [ ].

Starting with MY 2008, GM could use [ ]. These are engines that are adaptable to the technology because of their [valve-train] configuration. GM currently makes its [ ].

Starting with MY 2008, GM could use [ ]. GM's data shows that [ ] is currently used on [ ] engines. Combining the fact that the [ ] are of similar design to three engines having [ ] with the information provided by GM about [ ], leads the agency to believe that [ ] could be applied to these three engines.

Starting with MY 2008, GM could offer [ ]. These engines were chosen because of their [ ] design. GM currently widely uses this technology on the majority of [ ] engines and some [ ] engines. GM's current [ ] engines are [ ] engines, thus it's logical to assume that other [ ] engine designs could utilize the [ ] technology as well. The [ ] engine is a variant on the [ ] engine and is quite adaptable to this technology. GM is also currently offering the [ ] engine with [ ]. GM provided data supplied a fuel economy improvement number of [ ] a number which NHTSA verified through data analysis.

Starting with MY 2008, GM could use [ ]. Starting with MY 2010, could use [ ]. NHTSA analyzed data that GM provided to the agency regarding the fuel economy values for vehicles having [ ].

Starting with MY 2008, GM could use [ ]. Some [ ] models are scheduled to be manufactured with [ ].

NHTSA projected the use of [ ]. in the above vehicles for many reasons, including the fact that many of GM's direct competitors for the mid-size and larger light truck market are introducing vehicles with [ ] during MY 2008-2010. GM offers [ ] on some full-size trucks and SUVs during MY 2008 -2010, thus [ ] are technically feasible for these vehicles.

Starting with MY 2008, GM could use [ ]. Many of GM's direct competitors for the mid-size pickup market are introducing vehicles with [ ] during MY 2008-2010.

Starting with MY 2008, GM could use [ ] models. These are models that are similar in weight and overall design with the [ ]. Although some of these [ ] the agency notes that [ ].

Additionally, it is possible that the sales of the [ ] could double by 2009 and remain constant through MY 2010. GM projects the sales of these vehicles to be [ ] of the offerings for these model lines. Limited production of these vehicles began in [ ], and the [ ] in significantly larger quantities in [ ] in conjunction with [ ] of the [ ]. NHTSA believes that due to the increased demand for and popularity of these vehicles, the sales of these vehicles, at the very least, could double by 2009. Based on sales trends for [ ], NHTSA believes that the sales of the [ ] would increase during the period covered by this rulemaking.

Starting with MY 2010, GM could use [ ]. This would be a further technological advance on engines that have [ ] today. Several other manufacturers employ this technology today

(c) Stage III

The Stage III analysis includes projections of the potential CAFE increase that could result from the application of diesel engines and hybrid powertrains to some products over and above the manufacturer's plans.

Starting with MY 2010, GM could [ ]. The engines that could [ ] that GM uses in its [ ]. NHTSA projected that [ ]

The potential improvements to the GM light truck CAFE – as projected by NHTSA - are summarized in the following table. Due to rounding, the individual improvements may not equal the potential CAFE for GM.

Table VI-10
Potential GM CAFE Improvements, mpg

Model Year	Baseline Mpg	Stage I	Stage II	Stage III	Total	Potential CAFE, Mpg
2008	[ ]	[ ]	[ ]	0	[ ]	22.453
2009	[ ]	[ ]	[ ]	0	[ ]	23.143
2010	[ ]	[ ]	[ ]	[ ]	[ ]	23.543

HYUNDAI

(a) Stage I

To determine which Stage I technologies Hyundai could employ, on which vehicles and/or engines they could be employed, and when they could be employed, NHTSA relied heavily on the Hyundai provided descriptions. The light trucks included in Hyundai's plans include those made by Kia. Our analysis showed that, by MY 2008, Hyundai could employ [ ] on all of its vehicles. All of these technologies would carry forward to future years. All of the vehicles produced by Hyundai utilize unibody chasses and have characteristics similar to those of passenger cars, minivans and crossover vehicles. All of these technologies were carried forward into subsequent years. NHTSA used the NAS study's mid-range numbers for the percentage increase in fuel economy that was used calculating the possible fuel economy increase attributable to each of these technologies.

Starting with MY 2008, Hyundai could use [ ] on all of its vehicles. Other vehicle manufactures utilize this technology on many other vehicles, and the agency believes that this technology is applicable to the wide variety of light trucks that Hyundai produces.

Starting with MY 2008, Hyundai could use [ ] on all of its vehicles. This is a technology that can be used throughout Hyundai's light truck fleet could be added to these engines within a relatively short lead time.

In MY 2008, Hyundai could employ [ ]. Several other manufacturers have indicated that they are incorporating this cost-effective technology on their vehicles. The agency believes that there is more than sufficient lead-time for Hyundai to equip its models with these [ ] and to make arrangements with [ ] to purchase sufficient quantities.

The effect of these technology changes is summarized in the following table.

Table VI-11
Hyundai Light Truck Stage I Improvements
[Entire Table Confidential

]

(b) Stage II and Stage III

The Stage II analysis is a more aggressive application of transmission and/or engine technology - classified as Production-Intent by the recent NAS study – which is added on top of those applied to the first stage to develop the upper end of the range. The Stage III analysis includes projections of the potential CAFE increase that could result from the application of diesel engines and hybrid powertrains to some products. Due to the fact that Hyundai is projected to meet the CAFE levels for MY 2008, MY 2009 and MY 2010 with modifications included in the Stage I analysis, we do not project the need to apply Stage II or Stage III modifications.

Table VI-12
Potential Hyundai CAFE Improvements, mpg

Model Year	Baseline Mpg	Stage I	Stage II	Stage III	Total	Potential CAFE, mpg
2008	[ ]	[ ]	0	0	[ ]	22.758
2009	[ ]	[ ]	0	0	[ ]	24.150
2010	[ ]	[ ]	0	0	[ ]	24.766

NISSAN

(a) Stage I

To determine which Stage I technologies Nissan could employ, on which vehicles and/or engines they could be employed, and when they could be employed, NHTSA relied heavily on the Nissan-provided descriptions. Our analysis showed that, by MY 2008, Nissan could employ [ ] to its entire light truck fleet and [ ] to part of the vehicle fleet. By MY 2009, Nissan could employ [ ] to part of its fleet. All of these technologies were carried forward into subsequent years. NHTSA used the NAS study's mid-range numbers for the percentage increase in fuel economy that was used calculating the possible fuel economy increase attributable to each of these technologies.

Starting with MY 2008, Nissan could use [ ]. This is a technology that can be used throughout Nissan's light truck fleet could be added to these engines within a relatively short leadtime.

Starting with MY 2008, Nissan could use [ ] on all of its vehicles. Other vehicle manufactures utilize this technology on many other vehicles, and the agency believes that this technology is applicable to the wide variety of light trucks that Nissan produces and that Nissan would have sufficient lead time to add this technology to its light trucks.

Starting with MY 2008, Nissan could use [ ]. The agency was provided with limited information regarding the fuel saving technologies that will be utilized on these vehicles in the future. The agency believes that it is quite feasible that by MY 2008, a variety of [ ] could be applied to these vehicles, and thus is projecting their use on these vehicles.

Starting with MY 2008, Nissan could use [ ] on all of its models that could utilize [ ]. Several other manufacturers have indicated that they are incorporating this cost-effective technology on their vehicles. The agency believes that there is more than sufficient lead-time for Nissan to equip its models with these [ ] and to make arrangements with [ ] to purchase sufficient quantities.

Starting with MY 2008, Nissan could use [ ] on all of its front wheel drive vehicle models and on models that could [ ]. [ ] can be applied to [ ] The agency believes that there is more than sufficient lead-time for Nissan to equip the [ ] models with these [ ] and to make arrangements with [ ] to purchase sufficient quantities.

Additionally, starting with MY 2008, Nissan could employ [ ]. In MY 2008, the [ ]. In MY 2008, Nissan [ ] the [ ]. In MY 2009, the [ ]. In MY 2010, the [ ]. The agency believes that Nissan could incorporate a [ ] of these vehicles as part of its [ ] and that is quite feasible to have this technology included on these vehicles when they are [ ].

Starting with MY 2009, Nissan could include a [ ]. This technology is similar to one being introduced by a competitor and should be very applicable to these engines. With a relatively limited number of engines, Nissan should be able to incorporate this technology across its entire fleet without an undue burden.

The effect of these technology changes is summarized in the following table.

Table VI-13
Nissan Light Truck Stage I Improvements
[Entire Table Confidential

]

(b) Stage II

To determine which Stage II technologies Nissan could employ, on which vehicles and/or engines they could be employed, and when they could be employed, NHTSA relied on its own engineering judgment and submissions from other manufacturers. In looking at these submissions, together with what Nissan provided, NHTSA has analyzed which Stage II technologies could be applied to Nissan's light truck fleet for MYs 2008-2010.

Our analysis showed that, by MY 2008, Nissan could employ [ ] to part of its vehicle fleet, with [ ] employed by MY 2009. All of these technologies were carried forward into subsequent years. NHTSA used the NAS study's mid-range numbers for the percentage increase in fuel economy attributable to each of these technologies.

Starting with MY 2008, Nissan could use [ ] on all models with [ ]. This engine is the [ ] Nissan uses in their light truck fleet, thus vehicles utilizing this engine could benefit the most from having [ ]. Additionally, because this engine is used on some of Nissan's best selling vehicles, Nissan's CAFE could be raised significantly by the use of [

] on this engine. Several other manufacturers employ this technology today, including DaimlerChrysler, GM and Honda.

Starting with MY 2008, Nissan could use [ ] on all vehicles except [ ]. This would be a further technological advance on engines that have [ ] today. Several other manufacturers employ this technology today.

Beginning with MY 2009, Nissan could change [ ]. NHTSA projected the use of [ ] in the above vehicles for many reasons, including the fact that many of Nissan's direct competitors for the mid-size and larger light truck market are introducing vehicles with [ ] during MY 2008-2010.

Starting with MY 2009, Nissan could use [ ] on [ ]. The [ ] has similar architecture to the [ ], for which [ ] are projected in Nissan's projected plan.

(c) Stage III

The Stage III analysis includes projections of the potential CAFE increase that could result from the application of diesel engines and hybrid powertrains to some products. Our projection for Nissan indicates that the company can meet the standards contained in this proposed rule without applying any additional diesel engines and hybrid powertrains above and beyond what Nissan has already included in their projected plans. Thus, we did not identify any CAFE increases resulting from Stage III for Nissan.

The potential improvements to the Nissan light truck CAFE are summarized in the following table. Due to rounding, the individual improvements may not equal the potential CAFE for Nissan.

Table VI-14
Potential Nissan CAFE Improvements, mpg

Model Year	Baseline Mpg	Stage I	Stage II	Stage III	Total	Potential CAFE, Mpg
2008	[ ]	[ ]	[ ]	0	[ ]	22.515
2009	[ ]	[ ]	[ ]	0	[ ]	23.166
2010	[ ]	[ ]	[ ]	0	[ ]	23.824

TOYOTA

(a) Stage I

To determine which Stage I technologies Toyota could employ, on which vehicles and/or engines they could be employed, and when they could be employed, NHTSA relied heavily on the Toyota provided descriptions. Our analysis showed that, by MY 2009, Toyota could employ one technology to its entire light truck fleet. By MY 2010, Toyota could employ [ ] to all of its fleet and [ ] to part of its vehicle fleet. All of these technologies were carried forward into subsequent years. NHTSA used the NAS study's mid-range numbers for the percentage increase in fuel economy that was used calculating the possible fuel economy increase attributable to each of these technologies.

Starting with MY 2009, Toyota could use [ ] on all of its vehicles. Other vehicle manufactures utilize this technology on many other vehicles, and the agency believes that this technology is applicable to the wide variety of light trucks that Toyota produces.

Starting with MY 2010, Toyota could use [ ] on all of its vehicles. This is a technology that can be used throughout Toyota's light truck fleet could be added to these engines within a relatively short leadtime.

In MY 2010, Toyota could employ [ ]. Several other manufacturers have indicated that they are incorporating this cost-effective technology on their vehicles. The agency believes that there is more than sufficient lead-time for Toyota to equip its models with these [ ] and to make arrangements with [ ] to purchase sufficient quantities.

The effect of these technology changes is summarized in the following table.

Table VI-15
Toyota Light Truck Stage I Improvements
[Entire Table Confidential

]

(b) Stage II and III

The Stage II analysis is a more aggressive application of transmission and/or engine technology - classified as Production-Intent by the recent NAS study – which is added on top of those applied to the first stage to develop the upper end of the range. The Stage III analysis includes projections of the potential CAFE increase that could result from the application of diesel engines and hybrid powertrains to some products. Due to the fact that [ ] and can meet the CAFE levels for MY 2009 and MY 2010 with modifications included in the Stage I analysis, we do not project the need to apply Stage II or Stage III modifications.

Table VI-16
Potential Toyota CAFE Improvements, mpg

Model Year	**Baseline Mpg**	**Stage I**	**Stage II**	**Stage III**	**Total**	**Potential CAFE, Mpg**
2008	[ ]	[ ]	0	0	[ ]	22.915
2009	[ ]	[ ]	0	0	[ ]	23.373
2010	[ ]	[ ]	0	0	[ ]	23.688

VII. COST IMPACTS AND LEAD TIME

The technology application algorithm implemented with the Volpe model was used as the basis for estimating costs for the fleet. The stage analysis will predict different technological responses to CAFE standards and different estimates of costs. In the previous Final Economic Assessment for MY 2005-07[47], the agency compared the costs for Ford and GM using both the stage analysis and the technology application algorithm and showed that the stage analysis had costs that were on average 6 to 16 percent higher than the technology application algorithm. From a practical perspective, the stage analysis provides a basis for judging the general reasonableness of the technology application algorithm. However, because a myriad of responses are, in fact, plausible, NHTSA believes that the cost methodology utilized in the technology application algorithm will provide a reasonable estimate of the proposed CAFE standard under the given assumptions.

Table VI-3 presented potential retail price impacts and fuel consumption impacts of different technologies. We applied the technology application algorithm described in Chapter VI. Some manufacturers might achieve more benefit than others using similar technologies or on specific vehicles. However, because NHTSA believes that technology characteristics are subject to greater uncertainty on a manufacturer-specific basis, this analysis assumes an equal impact from specific technologies for all manufacturers and vehicles. The technologies were ranked based primarily on the cost per percentage point improvement in fuel economy and applied (where available) to each manufacturer's fleet in their order of rank.

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[47] "Final Economic Assessment, Corporate Average Fuel Economy Standards for MY 2005-2007 Light Trucks", April 2003, Docket No. 11419-18358, Page VII-7.

The first row of Table VII-1 shows the average baseline mpg for the industry resulting from the product plans submitted by the vehicle manufacturers. The second row shows the industry average fuel economy level obtained by adjusting upward the baseline mpg levels of those manufacturers whose product plans resulted in mpg levels below the MY 2007 standard of 22.2 mpg, called the "Adjusted Baseline" mpg level. The remaining rows of Table VII-1 report the estimated mpg level for the industry under the various scenarios. {Note that no level is proposed for MY 2011 in the Unreformed CAFE system, since the agency is proposing that Reformed CAFE must be used in MY 2011. The estimated fleet average under the Adjusted Baseline exceeds the current CAFE standard because the fuel economy levels resulting from some manufacturers' product plans exceed 22.2 mpg.

Table VII-1
Baseline and Estimated mpg Levels for the Proposed Rule

	MY 2008	**MY 2009**	**MY 2010**	**MY 2011**
Manufacturers' Production Plans Average	21.76	22.05	22.13	22.16
Adjusted Baseline With a 22.2 mpg Minimum	22.35	22.56	22.63	22.66
Estimated Levels after Applying Technology				
Unreformed CAFE, 2008- 2010	22.61	23.15	23.50	N.A.
Reformed CAFE 2008-2011	22.64	23.27	23.55	24.00

Tables VII-2 presents the estimated costs to bring those manufacturers that are not planning on meeting the current level of 22.2 mpg for MY 2008-11, without using fuel economy adjustments for alternative fueled vehicles, up to 22.2 mpg. These are the most cost- effective technologies available to the manufacturers. These costs have been estimated, but they are not considered to be part of the costs of meeting the proposed requirements. Those costs, and commensurate benefits, are considered part of the costs and benefits of complying with previously issued rules. These are average industry cost estimates over all vehicles sold, not just for those manufacturers with a baseline below 22.2 mpg. The reason for decreases in the latter model years are that some manufacturers are planning to make improvements in fuel economy in the later model years, resulting in bringing them closer to 22.2 mpg or above 22.2 mpg. These estimates represent the costs to bring the manufacturer's plans that are below 22.2 mpg back up to 22.2 mpg, for each model year individually.

Tables VII-3 and VII-4 show the costs (on an average cost per vehicle basis) of applying technology necessary to move each manufacturer's planned fuel economy levels up to the level of the proposal. Thus, if a manufacturer's product plans resulted in a fuel economy level of 22.2 mpg during each model year, these costs represents the cumulative cost of technologies necessary to bring that manufacturer's fleet average up to the proposed alternatives. The costs for BMW, Porsche and Volkswagen are the fines that these manufacturers would have to pay on an average vehicle basis. We assume that these costs will be passed on to consumers. Tables VII-3 and VII-4 show the costs of meeting the proposed standards as compared to the adjusted baseline.

The second part of each of these tables shows the estimated total manufacturer costs in millions. Since the manufacturer's plans for MY 2008, 2009, 2010, and 2011 are different, the baseline changes in each year (as shown in Table V-1). Each individual year is analyzed compared to the manufacturer's plans for that year (adjusted by bringing those manufacturers with an average mpg below 22.2 mpg, up to 22.2 mpg). Fines are not included in the second part of these tables, since these are transfer payments and not technology costs.

The agency is proposing to set reformed CAFÉ levels that result in costs that approximate the costs of unreformed CAFÉ during the transition period. A comparison of Tables VII-3 and VII-4 indicates that total costs are quite similar under each approach for 2008, 2009, and 2010. The cost estimates are not exactly equal due to some limitations of the Volpe model. For the final rule, we intend to set the cost of the two scenarios as close to equal as possible.

Table VII-2
Estimated Incremental Costs or Fines* over Manufacturer's Plans
To get to Adjusted Baseline - Average Cost per Vehicle
[Entire Page Confidential

Total Incremental Costs in Millions

	MY 2008	MY 2009	MY 2010	MY2011
BMW				
Daimler Chrysler	$91	$89	$88	$89
Ford	206	163	162	162
Fuji – Subaru				
General Motors	540	461	456	469
Honda				
Hyundai	18	7	14	14
Isuzu	28	31	33	33
Nissan	143	135	115	115
Porsche				
Suzuki	1	1	1	1
Toyota				
Volkswagen				
Total Fleet	$1,029	$888	$869	$883

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Table VII-3
Estimated Incremental Costs over Adjusted Baseline
For Unreformed CAFE in 2008-2010
Average Cost per Vehicle

	MY 2008	**MY 2009**	**MY 2010**
BMW	17	50	72
Daimler Chrysler	52	71	140
Ford	48	118	132
Fuji – Subaru	0	0	0
General Motors	80	234	338
Honda	0	0	0
Hyundai	57	70	47
Isuzu	62	226	347
Nissan	150	270	318
Porsche	17	50	72
Suzuki	198	235	298
Toyota	0	27	95
Volkswagen	17	50	72
Total Fleet Ave.	56	130	185

Estimated Incremental Costs over Adjusted Baseline
For Unreformed CAFE in 2008-2010
Total Incremental Cost in Millions

	MY 2008	MY 2009	MY 2010
BMW	0	0	0
Daimler Chrysler	97	137	272
Ford	107	276	317
Fuji – Subaru	0	0	0
General Motors	219	636	927
Honda	0	0	0
Hyundai	25	29	20
Isuzu	5	19	29
Nissan	65	111	135
Porsche	0	0	0
Suzuki	10	12	16
Toyota	0	23	82
Volkswagen	0	0	0
Total Fleet	528	1244	1798

Table VII-4
Estimated Incremental Costs over Adjusted Baseline
For Reformed CAFE 2008-2011
Average Cost per Vehicle

	MY 2008	**MY 2009**	**MY 2010**	**MY2011**
BMW	88	143	160	193
Daimler Chrysler	100	138	165	232
Ford	32	78	81	153
Fuji – Subaru	0	0	0	10
General Motors	0	156	260	376
Honda	0	0	0	66
Hyundai	416	433	472	581
Isuzu	5	182	274	421
Nissan	0	130	175	329
Porsche	6	72	99	127
Suzuki	787	981	1007	1274
Toyota	43	189	260	325
Volkswagen	28	94	116	143
Total Fleet Ave.	54	140	186	275

Estimated Incremental Costs over Adjusted Baseline
For Reformed CAFE 2008-2011
Total Incremental Cost in Millions

	MY 2008	MY 2009	MY 2010	MY2011
BMW	0	0	0	0
Daimler Chrysler	188	266	320	445
Ford	70	182	193	365
Fuji – Subaru	0	0	0	1
General Motors	0	423	711	1029
Honda	0	0	0	41
Hyundai	181	180	206	253
Isuzu	0	15	23	35
Nissan	0	53	74	140
Porsche	0	0	0	0
Suzuki	41	52	54	68
Toyota	36	160	222	278
Volkswagen	0	0	0	0
Total Fleet	505	1332	1,802	2656

The Impact of Higher Prices on Sales

The proposed fuel economy standards are expected to increase the price of light trucks. The potential impact of higher vehicle prices on sales was examined on a manufacturer specific basis, since the estimated cost of improving fuel economy and the mpg improvement is different for each manufacturer. There is a broad consensus in the economic literature that the price elasticity for demand for automobiles is approximately –1.0.[48,49,50] Thus, every one percent increase in the price of the vehicle would reduce sales by one percent. Elasticity estimates assume no perceived change in the quality of the product. However, in this case vehicle price increases result from adding technologies that improve fuel economy. If consumers do not value improved fuel economy at all, then the estimated impact on sales from price elasticity could be applied directly. However, we believe that consumers do value improved fuel economy, because they reduce the operating cost of the vehicles.

To estimate the average value consumers place on fuel savings at the time of purchase, we assume that the average purchaser considers the fuel savings they would receive over a 4.5 year time frame. We chose 4.5 years because this is the average length of time of a financing agreement. The present values of these savings were calculated using both a 3 percent and 7 percent discount rate. We used a fuel price forecast (see Table VIII-3) that included taxes, because the average consumer thinks about the price paid at the pump and doesn't consider externalities or transfer payments. Based on Table VIII-2, the average truck would travel 66,975

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[48] Kleit, A.N. (1990). "The Effect of Annual Changes in Automobile Fuel Economy Standards." *Journal of Regulatory Economics*, vol. 2, pp 151-172.

[49] Bordley, R. (1994). "An Overlapping Choice Set Model of Automotive Price Elasticities," *Transportation Research B*, vol 28B, no 6, pp 401-408.

[50] McCarthy , P.S. (1996). "Market Price and Income Elasticities of New Vehicle Demands," *The Review of Economics and Statistics*, vol. LXXVII, no. 3, pp. 543-547.

miles in 4.5 years out of the total weighted travel of 179,954. Fuel savings were recalculated over the first 4.5 years under the assumptions discussed above.

[ ].[51]

For example, the average price for BMW was $38,500, the average price for GM was $23,860, and the average price for Suzuki was $20,170. Average prices and estimated sales volumes are needed because price elasticity is an estimate of how a percent increase in price affects the percent decrease in sales. A sample calculation for General Motors under the unreformed alternative in MY 2008 is an estimated retail price increase of $80 and a fuel savings over the 4.5 years of $68 at a 3 percent discount rate and $62 at a 7 percent discount rate. The net cost is $12 at a 3 percent discount rate and $18 at a 7 percent discount rate. Comparing these to the $23,860 average price is about a 0.05 percent price increase at a 3 percent discount rate and a 0.0754 percent price increase at a 7 percent discount rate. GM sales were estimated to be 2,740,636 for MY 2008. With a price elasticity of –1.0, a 0.05 to 0.0754 percent decrease in sales could result in an estimated loss of sales of 1,378 at a 3 percent discount rate and 2,067 at a 7 percent discount rate.

Sales increases occur when the value of improved fuel economy exceeds the consumer cost of added technology. Overall, across all manufacturers combined, there would be a slight loss in sales under the Unformed CAFE and a slight gain in sales for the Reformed CAFE due to the value of fuel savings exceeding the added purchase price cost to the consumer. Some manufacturers would gain sales slightly and other would lose some sales. Table VII-5 shows the

[51] [ ].

estimated total impact on sales for Unreformed CAFE, if we assumed that consumers value an improvement in fuel economy for 4.5 years. A negative number means a decrease in sales and a positive number means an increase in sales.

Table VII-5a
Potential Impact on Sales by Manufacturer
Unreformed CAFE at 3 percent discount rate

	MY 2008	**MY 2009**	**MY 2010**
BMW	-31	-91	-132
Daimler Chrysler	1792	1938	4923
Ford	1298	2186	2237
Fuji – Subaru	0	0	0
General Motors	-1378	-4665	-6885
Honda	0	0	0
Hyundai	346	434	456
Isuzu	-48	-209	-340
Nissan	-1507	-1705	-1902
Porsche	-8	-23	-33
Suzuki	-245	-114	-61
Toyota	0	167	489
Volkswagen	-27	-82	-120
Total Fleet Ave.	192	-2163	-1369

Table VII-5b
Potential Impact on Sales by Manufacturer
Unreformed CAFE at a 7 percent discount rate

	MY 2008	MY 2009	MY 2010
BMW	-31	-91	-132
Daimler Chrysler	1195	1224	3385
Ford	908	1366	1398
Fuji – Subaru	0	0	0
General Motors	-2067	-6372	-9294
Honda	0	0	0
Hyundai	237	295	364
Isuzu	-61	-266	-434
Nissan	-1629	-1973	-2239
Porsche	-8	-23	-33
Suzuki	-263	-151	-117
Toyota	0	121	336
Volkswagen	-27	-82	-120
Total Fleet Ave.	-1746	-5951	-6887

Table VII-6a
Potential Impact on Sales by Manufacturer
Reformed CAFE at 3 percent discount rate

	MY 2008	MY 2009	MY 2010	MY 2011
BMW	-159	-262	-294	-363
Daimler Chrysler	3783	4387	5231	5385
Ford	714	1844	1957	2237
Fuji – Subaru	0	0	0	115
General Motors	0	-3072	-4819	-7109
Honda	0	0	0	165
Hyundai	-55	556	346	255
Isuzu	0	-151	-276	-492
Nissan	0	-287	-396	-1367
Porsche	-3	-33	-46	-61
Suzuki	-211	-365	-392	-656
Toyota	269	803	947	1178
Volkswagen	-45	-154	-193	-251
Total Fleet Ave.	4293	3266	2068	-965

Table VII-6b
Potential Impact on Sales by Manufacturer
Reformed CAFE at a 7 percent discount rate

	MY 2008	MY 2009	MY 2010	MY 2011
BMW	-159	-262	-294	-363
Daimler Chrysler	2688	3060	3487	3251
Ford	519	1298	1328	1258
Fuji – Subaru	0	0	0	104
General Motors	0	-4210	-6655	-9861
Honda	0	0	0	27
Hyundai	-619	52	346	547
Isuzu	-4	-204	-344	-595
Nissan	0	-460	-614	-1763
Porsche	-3	-33	-46	-61
Suzuki	-349	-534	-565	-864
Toyota	209	515	561	719
Volkswagen	-45	-154	-193	-251
Total Fleet Ave.	2237	-1035	-3677	-8945

Leadtime

The agency judiciously chose which technologies it believed could be added by the manufacturers by specific dates, having knowledge of their plans, and in some cases, knowledge of what other manufacturers are doing. Marginal cost/benefit is one of several rationales (applicability to the appropriate vehicles, lead time, capabilities, and competition) considered for choosing technologies that we thought the manufacturers could deploy.

The agency's technical analysis utilized its best engineering judgment to arrive at CAFE levels that it believes can be achieved by the light truck fleet within the time and design constraints that vehicle manufacturers operate under. This judgment represents the opinions of technical experts, but is still a projection of what technologies could be used to meet the CAFE standards.

Not all technologies can apply to every light truck due to the capability of the technology, vehicle utility and costs. For example, it appears that CVT application is limited to smaller vehicles, such as compact SUVs, crossover vehicles and compact pickups.

Two technologies, which are planned for introduction, were applied sparingly, above the manufacturer's plans, due to technology uncertainties and costs. Diesel engines, which are more efficient than gasoline engines and are included in a few manufacturer projections, were applied to only a few make/models because more cost-effective technologies were chosen first in the Volpe model.

Hybrid drivetrains, which are much more efficient than conventional technology and are included in a few manufacturers projections, have a cost premium. NHTSA is highly encouraged by the manufacturers' plans and believes that more light trucks will be equipped with hybrid drivetrains in the near future. NHTSA also believes that other vehicles currently included in manufacturers' plans could employ hybrid technology. However, due to lead time and cost considerations, the agency did not project the inclusion of hybrid drivetrains on any other vehicle models not in the manufacturers' plans. The Volpe model, given current inputs, finds hybrid drive trains to be a relatively cost-ineffective method of CAFE compliance.

VIII. BENEFITS

Economic Impacts from Higher CAFE Standards

Economic impacts from adopting a tighter CAFE standard for light trucks were estimated separately for each model year over its life span in the U.S. vehicle fleet, extending from the initial year when a model year is offered for sale through the year when nearly all vehicles from that model year have been retired or scrapped (assumed to be 26 years in this analysis). The underlying source of the economic and environmental impacts considered in this analysis is the reduction in gasoline use resulting from the improvement in fuel economy of new light-duty trucks produced. Each of these impacts is measured by the *difference* between a measure (for example, total gallons of fuel consumed by light trucks produced during a model year over its entire 26-year life span in the fleet) with the adjusted baseline, and with the two alternatives for model years 2008 to 2011. Future impacts are estimated after discounting to the year the vehicle is sold to determine their present value, using a 3 and 7 percent discount rate.[52]

The Discount Rate

OMB Circular A-4 provides guidance to agencies on discounting costs and benefits in the context of regulatory analysis. Circular A-4 states that agencies should provide estimates of net benefits using both 3 percent and 7 percent and recommends using other discount rates to show the sensitivity of the estimates to the discount rate assumption. In particular, Circular A-4 points out that in some instances there is reason to expect that the regulation may cause resources to be reallocated in a manner which has an opportunity cost that lies outside the range of 3 to 7

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[52] Discounting to the year when each model year was produced allows future economic benefits from improving each model year's fuel economy to be compared to added production costs for making those vehicles more fuel-efficient, which are assumed to be incurred at the time those vehicles are manufactured.

percent. In this case, Circular A-4 directs agencies to conduct regulatory analysis using a higher discount rate as a further sensitivity analysis in addition to using the 3 and 7 percent rates.

The rationale for using a particular range of discount rates in the context of a particular rulemaking should reflect the opportunity cost over time of the cost and benefit effects of that rule. It is well known that this opportunity cost can differ widely depending on who bears the incidence of the costs and benefits, and there is often uncertainty about that incidence. The 7 percent rate is an estimate of the average before-tax rate of return to private capital in the U.S. economy, reflecting the returns to real estate, small business, and corporate capital. It approximates the opportunity cost of capital, and it is the appropriate discount rate whenever the main effect of a regulation is to displace or alter the use of capital in the private sector.

As Circular A-4 points out, however, the effects of regulation do not always fall exclusively or primarily on the allocation of capital. When regulation primarily and directly affects private consumption (e.g., through higher consumer prices for goods and services), a lower discount rate may be appropriate. The alternative most often used is sometimes called the social rate of time preference. This simply means the rate at which society discounts future consumption flows to their present value. If we take the rate that the average saver uses to discount future consumption as our measure of the social rate of time preference, then the real rate of return on long-term government debt may provide a fair approximation. Over the last thirty years, this rate has averaged around 3 percent in real terms on a pre-tax basis.

In the context of CAFE standards, an argument can thus be made for using a range of discount rates depending on one's view of the likely incidence of the costs and benefits of fuel economy improvements. In addition to the 3 and 7 percent rates, the interest rate likely to be paid by consumers to finance vehicle purchases is relevant because the majority of new vehicle purchases are financed and the majority of net benefits of this rulemaking accrue to vehicle purchasers. The interest rate on vehicle loans in this case directly reflects the opportunity cost that vehicle purchasers face when buying vehicles with greater fuel economy and a higher purchase price. Based on historical interest rates for new and used car loans, and relevant interest rate and inflation rate forecasts for the period of this rulemaking, an appropriate discount rate from this point of view is 5 to 10 percent real. Evidence of implicit discount rates even higher than 10 percent has been found by studies examining the tradeoffs between energy efficiency and purchase price that consumers implicitly make in the context of purchasing decisions for energy using durables, including passenger vehicles.

For this proposed rule, we have used a rate of 7 percent in the process of determining the standards and have computed the net benefits of the resultant standards at a rate of both 7 percent and 3 percent, as described in the Preliminary Regulatory Impact Analysis. We ask for comment on what discount rates are appropriate for this rulemaking, including the use of 3, 7, and 10 percent.

Sales Projections

A critical variable affecting the total economic benefits from improving light truck fuel economy is the number of vehicles likely to be produced under stricter CAFE standards. Forecasts of total light truck sales for future years (see Table VIII-1) were obtained from the Energy Information

Administration's (EIA) *Annual Energy Outlook 2005* (*AEO 2005*), a standard government reference for forecasts of energy production and consumption in different sectors of the U.S. economy.[53] Actual fuel economy levels for each future model year's light trucks under the current CAFE standard and with alternative scenarios in effect were estimated using the model of fuel economy technology application described in Chapter VI. Under current standards, the average actual fuel economy for all new light trucks manufactured during each model year is expected to slightly exceed the prevailing standards on an industry–wide basis. However, the actual fuel economy levels achieved by light trucks in on-road driving falls significantly short of the level measured under test conditions, and the actual fuel economy performance of each future model year is adjusted to reflect the expected size of the fuel economy "gap" of 15 percent.

[53] U.S. Department of Energy, Energy Information Administration, *Annual Energy Outlook 2005*, Table 45,. http://www.eia.doe.gov/oiaf/aeo/index.html.

Table VIII-1
Sales Projections

	MY 2008	MY 2009	MY 2010	MY 2011
BMW	69,736	70,431	70,797	72,501
Daimler Chrysler	1,883,520	1,929,947	1,940,467	1,922,192
Ford	2,216,169	2,333,458	2,387,582	2,387,571
Fuji – Subaru	73,377	89,027	94,837	94,837
General Motors	2,740,636	2,714,945	2,737,919	2,735,895
Honda	608,434	617,553	622,371	623,497
Hyundai	435,569	415,172	435,635	435,634
Isuzu	82,088	83,352	84,018	84,018
Nissan	436,890	411,010	425,102	425,101
Porsche	10,334	10,556	10,694	11,086
Suzuki	52,282	53,087	53,514	53,513
Toyota	834,616	847,186	853,819	855,096
Volkswagen	36,506	37,388	37,968	40,053
Fleet Total	9,480,157	9,613,112	9,754,723	9,740,994

The number of light trucks manufactured during each model year that remains in service during each subsequent calendar year is estimated by applying estimates of the proportion of vehicles surviving to each age up to 26 years (see Table VIII-2). These "survival rates," which are estimated from experience with recent model-year light trucks, are slightly different than the survival rates used in past NHTSA analyses since they reflect recent increases in durability and usage of more recent light truck models.[54] Updated estimates of average annual miles driven by vehicle age were developed from the Federal Highway Administration's 2001 National Household Transportation Survey, and also differ from those employed in past NHTSA analyses (see Table VIII-2).[55] The total number of miles driven by light trucks of a single model year

[54] The survival rates were calculated from R.L. Polk, National Vehicle Population Profile, 1977-2002; see NHTSA, "Vehicle Survivability and Travel Mileage Schedules," Office of Regulatory Analysis and Evaluation, January 2005, pp. 9-11.

[55] See NHTSA, "Vehicle Survivability and Travel Mileage Schedules," Office of Regulatory Analysis and Evaluation, January 2005, pp. 15-17.

during each year of its life span in the fleet with the base CAFE standard of 20.7 mpg in effect is estimated by multiplying these age-specific estimates of annual miles driven per vehicle by the number of vehicles projected to remain in service at each age (see Table VIII-2).

Benefits from Fuel Savings

The main source of economic benefits from the proposal for light truck CAFE standards is the value of the resulting fuel savings over the lifetimes of vehicles that are required to comply with the stricter standards. These fuel savings for each scenario are measured by the difference between total lifetime fuel use by light trucks of each model year at 22.2 mpg or the values supplied for each model in manufacturers' product plans if those are higher, and with the fuel economy levels corresponding to that scenario in effect. The sum of these annual fuel savings over each calendar year that light trucks from a model year remain in service represents the cumulative fuel savings resulting from applying the proposed rule to vehicles produced during that model year.

Table VIII-2 provides new schedules of vehicle miles traveled and survivability based on updated analyses performed by NHTSA. Vehicle survivability and vehicle miles traveled (VMT) schedules for light trucks were developed from 1977 to 2002 registration and 2001 mileage survey data. In this analysis, vehicle age was cut off for passenger cars and light trucks when the Estimated Survival Rate reached 26 years. Thus, the lifetime of a light truck was extended to 26 years to arrive at 176,868 miles, and benefits are calculated over this 26-year lifetime. The previous lifetime VMT estimate was 153,698 (25 years) for light trucks.

The primary source of data for determining vehicles in operation is the National Vehicle Population Profile (NVPP) compiled by R.L. Polk and Company. The NVPP is an annual census, as of July 1 of each year, of passenger cars and light trucks registered for on-road operation in the United States. NVPP registration data was utilized from vehicle model years 1977 to 2003. Survival rates were averaged for the five most recent model years for vehicles up to 20 years old.

The 2001 National Household Travel Survey (NHTS)—previously called the Nationwide Personal Transportation Survey (NPTS)—sponsored by the Federal Highway Administration, Bureau of Transportation Statistics, and the National Highway Traffic Safety Administration attempted to develop up-to-date VMT schedules. The NHTS is the integration of two national travel surveys: the Federal Highway Administration-sponsored Nationwide Personal Transportation Survey (NPTS) and the Bureau of Transportation Statistics-sponsored American Travel Survey (ATS). The 2001 NHTS was the source of updated VMT information.

Table VIII-2

Vehicle Miles Traveled and Survival Rates
by Age for Light Trucks

Vehicle Age (years)	**Annual Vehicle Miles Traveled**	**Proportion Surviving to Age**	**"Expected" Annual Vehicle Miles raveled**
1	16,085	0.974	15,665
2	15,782	0.960	15,157
3	15,442	0.943	14,556
4	15,069	0.920	13,867
5	14,667	0.893	13,102
6	14,239	0.862	12,274
7	13,790	0.827	11,398
8	13,323	0.788	10,497
9	12,844	0.747	9,588
10	12,356	0.703	8,689
11	11,863	0.659	7,814
12	11,369	0.629	7,156
13	10,879	0.572	6,226
14	10,396	0.516	5,368
15	9,924	0.463	4,593
16	9,468	0.412	3,904
17	9,032	0.365	3,300
18	8,619	0.322	2,778
19	8,234	0.283	2,330
20	7,881	0.248	1,952
21	7,565	0.216	1,635
22	7,288	0.188	1,370
23	7,055	0.163	1,151
24	6,871	0.141	972
25	6,739	0.122	823
26	6,663	0.106	703
			176,868
			Lifetime VMT

With the current CAFE standard assumed to remain in effect, total fuel consumption by each model year's light trucks during each calendar year they remain in service is calculated by dividing the total number of miles they are driven during that year by the average on-road fuel economy level they would achieve under the 22.2 mpg standard. With the proposed rule in effect, total fuel consumption by each model year's light trucks during each future calendar year is calculated by dividing the total number of miles they are driven by the higher on-road fuel economy level associated with that stricter CAFE standard. The total number of miles that light trucks are driven each year is slightly higher under the proposed rule than with the current 22.2 mpg standard remaining in effect as a result of the fuel economy "rebound effect," which is discussed in detail later in this chapter.

The economic benefits to vehicle owners that result from future fuel savings are valued in this analysis over the complete expected lifetimes of the vehicles affected by the proposed rule. This reflects the assumption that while the purchaser and first owner of a new vehicle might not realize the full lifetime benefits of improved fuel economy, subsequent owners of that same vehicle will continue to experience the resulting fuel savings until the vehicle is retired from service. It is important to note, however, that not all vehicles produced during a model year remain in service for the complete 26-year lifetime of each model year assumed in this analysis. Due to the pattern of vehicle retirement over this period, the expected or average lifetime of a representative vehicle is approximately half of that figure.

The economic value of fuel savings resulting from the proposed rule is estimated by applying the forecast of future fuel prices from the Energy Information Administration's *Annual Energy*

Outlook 2005 to each future year's estimated fuel savings.[56] These future fuel prices, which are reported in Table VIII-3, represent the retail price of fuel per gallon including federal and state taxes. While the retail price of fuel is the proper measure for valuing fuel savings from the perspective of vehicle owners, two adjustments to the retail price are necessary in order to reflect the economic value of fuel savings to society as a whole. First, Federal and state taxes are excluded from the social value of fuel savings because these do not reflect costs of resources used in fuel production, and thus do not reflect resource savings that would result from reducing fuel consumption. In other words, we assume that any reduction in state and federal fuel tax payments by consumers will reduce government revenues by the same amount.

Second, the economic cost of externalities generated by imports and consumption of petroleum products will be reduced in proportion to gasoline savings resulting from the proposed rule. The estimated economic value of these externalities is converted into its per-gallon equivalent and added to the pre-tax price of gasoline in order to measure this additional benefit to society for each gallon of fuel saved. This also allows the magnitude of these externalities to be easily compared to the value of the resources saved from reduced fuel production and use, which represent the most important component of the social benefits from saving gasoline. Table VIII-3 illustrates the adjustment of forecast retail fuel prices to remove the value of fuel taxes and add the value of economic externalities from petroleum imports and use. The derivation of the estimated value of reduced economic externalities from petroleum use shown in the table is explained in detail in the following section.

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[56] U.S. Department of Energy, Energy Information Administration, *Annual Energy Outlook 2005*, Table 12, http://www.eia.doe.gov/oiaf/aeo/index.html.

The agency realizes that there has been a recent surge in the price of gasoline. The main question for this analysis is whether gasoline prices will be higher than the forecast shown in Table VIII-3 in 2008 and beyond. Currently available projections from the Department of Energy do not forecast higher prices in the future. We will include newer predictions from the Department of Energy when they are available. The uncertainty analysis uses two other fuel price scenarios.

Table VIII-3
Adjustment of Forecast Retail Gasoline Price
to Reflect Social Value of Fuel Savings
(all figures in year 2003 dollars)

Year	**AE0 2005 Fuel Price Forecast (2003$/gallon)**	**Total Federal and State Taxes (2003$/gallon)**	**Fuel Price Excluding Taxes (2003$/gallon)**	**Value of Oil Import Externalities (2003$/gallon)**	**Social Value of Fuel Savings (2003$/gallon)**
			Yr 1 = 2008		
2008	$1.572	$0.375	$1.197	$0.106	$1.304
2009	$1.538	$0.375	$1.163	$0.106	$1.269
2010	$1.522	$0.375	$1.147	$0.106	$1.253
2011	$1.524	$0.375	$1.149	$0.106	$1.255
2012	$1.511	$0.375	$1.136	$0.106	$1.242
2013	$1.511	$0.375	$1.136	$0.106	$1.242
2014	$1.512	$0.375	$1.137	$0.106	$1.243
2015	$1.515	$0.375	$1.140	$0.106	$1.246
2016	$1.523	$0.375	$1.148	$0.106	$1.254
2017	$1.531	$0.375	$1.156	$0.106	$1.262
2018	$1.534	$0.375	$1.159	$0.106	$1.265
2019	$1.539	$0.375	$1.164	$0.106	$1.270
2020	$1.548	$0.375	$1.173	$0.106	$1.279
2021	$1.552	$0.375	$1.177	$0.106	$1.283
2022	$1.560	$0.375	$1.185	$0.106	$1.291
2023	$1.572	$0.375	$1.197	$0.106	$1.304
2024	$1.572	$0.375	$1.197	$0.106	$1.303
2025	$1.584	$0.375	$1.209	$0.106	$1.315
2026	$1.584	$0.375	$1.209	$0.106	$1.315
2027	$1.584	$0.375	$1.209	$0.106	$1.315
2028	$1.584	$0.375	$1.209	$0.106	$1.315
2029	$1.584	$0.375	$1.209	$0.106	$1.315
2030	$1.584	$0.375	$1.209	$0.106	$1.315
Beyond 2030	$1.584	$0.375	$1.209	$0.106	$1.315

Other Economic Benefits from Reducing Petroleum Use

U.S. consumption and imports of petroleum products may impose costs on households and businesses that are not reflected in the market price for imported oil or by consumers of petroleum products. Increasing imports of crude oil or refined petroleum products into the U.S. may increase the magnitude of these external economic costs, thus increasing the true cost of importing additional oil supplies by an amount that exceeds the market price of increased oil purchases themselves. More broadly, increasing U.S. consumption of petroleum products may increase these costs regardless of whether they are imported or refined domestically. In either case, gasoline savings resulting from the proposed rule may produce additional benefits in the form of reductions in these external costs from petroleum use that are not reflected in the market price of gasoline, and thus must be accounted for separately from the savings in resources for producing gasoline itself.

The full economic cost of importing petroleum into the U.S. is often defined to include three components in addition to the purchase price of petroleum itself. These are (1) higher costs for oil imports resulting from the combined effect of U.S. import demand and OPEC market power on the world oil price; (2) the risk of reductions in U.S. economic output and disruption of the domestic economy caused by sudden reductions in the supply of imported oil to the U.S.; and (3) costs 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. The following discussion reviews the nature of each of these costs, assesses the degree to which they are likely to vary in response to changes in the level of oil imports, and provides empirical estimates of each component drawn from recent research.

Demand Costs

Demand costs for imported oil (often termed market power or "monopsony" costs) arise because the U.S. is a sufficiently large purchaser of foreign oil supplies that its purchases can affect the world price. U.S. "monopsony" power means that increasing domestic petroleum demand that is met through higher oil imports can cause the world price of oil to rise, and conversely that declining U.S. imports can reduce the world price of oil. Thus one consequence of increasing U.S. oil imports is an increase in the price paid for all oil consumed by the U.S., which is borne not only by purchasers of the additional imports, but also by all oil purchasers of imported and domestically-produced petroleum, since changes in the world oil price also affect the price of domestically-produced oil.

This demand or price effect can be readily illustrated with an example. If the U.S. imports 10 million barrels per day at a world oil price of $20 per barrel, its total daily import bill is $200 million. If increasing imports to 11 million barrels per day causes the world oil price to rise to $21 per barrel, the daily U.S. import bill rises to $231 million. The resulting increase of $31 million per day is attributable to increasing daily imports by only 1 million barrels, which 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 the cost imposed on all users of imported oil by those demanding the increased level of imports, a cost in excess of the price they pay to obtain those additional imports. Note, however, that this additional cost arises only because the increase in U.S. oil imports affects the world oil price. The key determinants of the magnitude of this demand or price effect are the degree of monopoly power over foreign oil supplies that are exercised by the OPEC cartel, and the degree of monopsony power over world oil prices exerted by the U.S. if OPEC exercises its monopoly power over international oil supplies and U.S. import demand can affect the world price will changes in the level of U.S. petroleum imports influence world prices, thus creating the demand component of the economic cost of importing additional oil into the U.S. Under these same conditions, of course, reductions in U.S. demand for imported petroleum would reduce the world oil price, thus creating additional benefits for all domestic oil consumers beyond the savings they experience simply from purchasing less oil.

The degree of current OPEC monopoly power is subject to considerable debate, but appears to have declined somewhat since the 1970s. Nevertheless, 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 competitively. 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.

Empirical estimates have been made of the demand component of the economic cost of importing additional petroleum into the U.S. A particularly detailed and careful analysis by Leiby et al. (1997) estimated a range of values for this cost corresponding to approximately \$1.50-3.50 per barrel at year 2003 dollars.[57] The Leiby study says that at current import levels, reducing U.S. demand by one barrel saves a total of about \$2.50 (using the midpoint of this

[57] 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.

range) by reducing the price of all other oil we purchase. Thus reducing the level of U.S. oil imports by tightening the CAFE standard to lower future gasoline use by light trucks would result in "social" cost savings to the U.S. economy of approximately $2.50 per barrel beyond the direct savings in gasoline costs. This figure is equivalent to about $0.061 per gallon of gasoline saved by a more stringent light truck CAFE standard that is assumed to result in reduced domestic gasoline refining and lower imports of foreign oil. This assumes that OPEC will not respond to changes in CAFE. Depending on the extent to which OPEC were to respond to a decline in U.S. demand by reducing its output, the effect of CAFE on the world oil price would be lower and could be zero.

Disruption and Adjustment Costs

The second component of the external economic costs of importing oil arises partly because the 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 using its available resources. The resulting reduction in potential economic output depends on the extent and duration of any disruption in the supply of imported oil to the U.S., since these in turn determine the magnitude of the resulting increase in prices for petroleum products, as well as whether and how rapidly these prices return to their pre-disruption levels. Even if the price for imported oil returns to its original level, however, the nation's economic output will be at least temporarily reduced compared to the level that would have been possible without the disruption in oil supplies and consequent increase in energy prices.

Because supply disruptions and resulting price increases occur suddenly rather than gradually, they impose additional costs on businesses and households for adjusting their use of petroleum products and other sources of energy more rapidly than if the same price increase had occurred gradually over time. These adjustments temporarily reduce the level of economic output that can be achieved even below the level that would ultimately be reached once the economy's adaptation of output levels and energy use to higher petroleum prices was complete. The additional costs imposed on businesses and households for making these adjustments 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 two components of the disruption cost must be weighted or adjusted for the probability that the supply of imported oil to the U.S. will actually be disrupted. Thus the "expected value" of these costs – the product of the probability that an oil import disruption will occur and the sum of costs from reduced economic output and the economy's abrupt adjustment to sharply higher petroleum prices -- is the relevant measure of their magnitude. Further, only the *change* in their expected value that results from lowering the normal (pre-disruption) level of oil imports through a policy such as tightening CAFE standards is relevant when assessing its effect on the "true" cost of importing oil into the U.S.

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 the price increase resulting from any 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 resulting price increase or the probability that U.S. oil imports will be disrupted is affected by the pre-disruption level of oil imports, the expected value of the costs stemming from supply disruptions will also vary in response to the level of oil imports.

A variety of market mechanisms, including oil futures markets, energy conservation measures, and technologies that permit rapid fuel switching– are now available within the U.S. economy for businesses and households to anticipate and "insure" themselves against the effects of petroleum price increases. By employing these mechanisms – for example, by investing in energy conservation measures or installing technologies that can operate using multiple fuel sources – business and households can reduce their costs for adjusting to sudden increases in oil prices. While their availability has undoubtedly reduced the potential costs that could be imposed by disruptions in the supply of imported oil, the remaining value of these costs is probably not reflected in the market price of imported oil. This is because consumers of petroleum products are unlikely to take account of the potential costs that a disruption in imported oil supplies imposes on other sectors of the U.S. economy. Thus changes in oil import levels probably continue to affect the expected cost to the U.S. economy from potential oil supply disruptions, although the value of this component of oil import costs is likely to be significantly smaller than those estimated by studies conducted in the wake of the oil supply disruptions that occurred during the 1970s.

Leiby et al. (1997) estimate that under reasonable assumptions about the probability that import supplies will be disrupted to varying degrees in the future, this component of the social cost of oil imports ranges from well under $1.00 to approximately $2.50 per additional barrel of oil imported by the U.S., with adjustment costs accounting for the largest share of this total. Less recent studies of expected costs from prospective oil supply disruptions generally reported somewhat higher estimates, ranging from $2.00-3.00 per additional barrel at current import levels, but as indicated previously these costs are likely to have declined over time.

Most other recent research focuses on the historical costs to the U.S. economy from actual supply disruptions, which seems unlikely to provide relevant evidence on the disruption costs associated with future variation in oil imports. While some recent studies estimate costs to the U.S. economy from hypothetical future oil supply disruptions that imply higher values, these studies generally do not estimate the changes in these costs that would result from higher or lower levels of oil imports.

Updated to year-2003 dollars, an estimate of approximately $2.00 per barrel seems appropriate for the incremental disruption cost component of the full incremental cost of imported petroleum. Specifically, this implies that reductions in the level of oil imports resulting from gasoline savings in response to a tighter CAFE standard for light-duty trucks would reduce disruption costs by this amount, in addition to the value of savings in gasoline use itself. This figure is equivalent to about $0.045 per gallon ($2.00 per barrel/42 gallons per barrel) of gasoline saved that is assumed to be reflected in lower U.S. oil imports of crude petroleum.

Military Security and Strategic Petroleum Reserve Costs

The third component of the external economic costs of importing oil into the U.S. is usually identified as the costs to the U.S. taxpayers for maintaining a military presence to secure the supply of oil imports from potentially unstable regions of the world and protect the nation against their interruption. Some analysts also include the costs to federal taxpayers 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 such oil supply disruptions. Thus many analyses include part or all of the annual cost for U.S. military operations in the Persian Gulf (and occasionally other regions of the world), together with the full costs of stocking and maintaining the SPR, as additional economic costs associated with importing oil into the U.S.

The overall costs for U.S. military security and for maintaining the SPR may vary over time in response to long-term changes in the actual level of oil imports into the U.S., but these costs seem unlikely to decline from their current threshold level to a lower level in response to the reduction in the level of U.S. oil imports that would result from this particular rulemaking. In addition, military activities even in world regions that represent vital sources of oil imports undoubtedly serve a range of security and foreign policy objectives that is considerably broader than simply protecting oil supplies. Further, the scope and duration of any specific U.S. military activities that were undertaken for the purpose of protecting imported oil supplies seem unlikely to be tailored to the actual volume of petroleum imports from the regions where they take place. As a consequence, annual expenses to support U.S. military activities do not seem likely to vary closely in response to changes in the level of oil imports prompted by conservation efforts or other policies. More specifically, reductions in gasoline use resulting from stricter CAFE standards seem unlikely to result in savings in the military budget that could be included as additional benefits.

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 the volume of 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 have not varied in response to changes in oil import levels (although in theory they might ideally do so). As a result, this analysis does not include any cost savings from maintaining a smaller SPR among the external benefits of reducing gasoline consumption and petroleum imports by means of a tighter CAFE standard for light-duty trucks.

The "Rebound Effect"

By reducing the cost of gasoline per mile driven, tighter CAFE standards are expected to result in a slight increase in annual miles driven per vehicle from the levels of annual vehicle use if the MY 2007 standard of 22.2 mpg remained in effect. This increase in the annual number of miles each vehicle is driven, usually referred to as the "rebound effect," also results in a corresponding increase in the *total* number of miles driven by light trucks of each model year throughout the time they remain in service. As a consequence, the rebound effect also reduces the fuel savings that would have resulted from stricter CAFE standards if the number of miles driven did not change.

In this analysis, the magnitude of the rebound effect is estimated by applying a representative estimate of the elasticity of vehicle use with respect to fuel cost per mile driven to the reduction in that cost that would result from the stricter CAFE standard. With both the current or baseline standard and the higher CAFE standard in effect, the average fuel cost per mile for operating light trucks of any model year during each future calendar year is calculated by the forecast retail price of gasoline during that future calendar year, divided by the average actual on-road fuel economy level achieved by light trucks of that model year.[58] The reduction in fuel cost per mile driven resulting from adopting the higher CAFE standard is equal to the difference between this calculated fuel cost per mile under the base standard and with the stricter standard in effect. The increase in the number of miles that vehicles are driven in response to this reduction in fuel costs – and the partial offset of the fuel savings from improved fuel economy – represent the rebound effect.

When federal fuel economy standards first took effect, the overall fuel efficiency of the nation's light-duty vehicle fleet was low by comparison to today's levels, while gasoline prices were considerably higher (in "real" or constant-dollar terms). As a consequence, gasoline costs per mile driven – which are equal to the price of gasoline per gallon divided by the number of miles driven per gallon -- were quite high, and rapidly increasing fuel economy levels required by the CAFE standards resulted in significant declines in gasoline costs per mile driven. Some

[58] Gasoline price forecasts are also obtained from U.S. Department of Energy, Energy Information Administration, *Annual Energy Outlook 2005*, Table 12, http://www.eia.doe.gov/oiaf/aeo/supplement/index.html.

empirical estimates of the rebound effect derived from this experience thus concluded that it could offset a significant fraction – perhaps as much as half -- of the gasoline savings resulting directly from tighter fuel economy standards.

Up until 2004, the combination of relatively low fuel prices (compared to when fuel economy standards first took effect) and significantly improved fuel economy levels, resulted in gasoline costs per mile driven being quite low by historical standards. At the same time, household incomes have increased significantly over the past two decades, thus raising the value that household members attach to time spent traveling. As a consequence of these developments, up until 2004 the share of gasoline costs in the total costs of driving has declined sharply, so that improving fuel economy would not have produced a major reduction in the costs of motor vehicle travel. Hence it seems reasonable to expect that the rebound effect resulting from improvements in light-duty vehicle fuel economy is likely to be smaller in the 2000 to 2003 environment than in the 1980s and 1990s.

The magnitude of the rebound effect from higher fuel economy standards for light-duty vehicles is typically derived from econometric estimates of the elasticity of vehicle use (per vehicle or for an entire fleet) with respect to either fuel cost per mile driven or fuel efficiency measured in miles per gallon. Most recent estimates of the magnitude of the rebound effect for light-duty vehicles fall in the range of 10% to 30%, which imply that increasing vehicle use will offset 10-

30% of the fuel savings resulting directly from an improvement in fuel economy.[59] In the analysis of benefits from tighter CAFE standards for light-duty trucks, a rebound effect of 20% is employed.

Because the increase in light truck fuel economy differs among the proposed scenarios, the resulting increase in total light truck usage from the rebound effect differs as well. Under the Unreformed Alternative, the expected additional number of miles each vehicle is driven over its lifetime as a result of the rebound effect is 372 miles for light trucks produced during MY 2008, 871 miles for MY 2009 vehicles, and 1,224 miles for MY 2010 light trucks. Multiplying these figures by forecast light truck sales for each of those model years results in a total of 3.5 billion additional miles for all MY 2008 light trucks over their expected lifetimes, with corresponding figures of 8.4 and 11.9 billion additional miles for MY 2009 and 2010 vehicles. Under the Reformed Alternative, the expected additional number of miles each vehicle is driven over its lifetime as a result of the rebound effect is 438 miles for light trucks produced during MY 2008, 1,036 miles for MY 2009 vehicles, 1,322 for MY 2010 and 1,916 miles for MY 2011 light

[59] Recent estimates of the rebound effect resulting from higher fuel economy standards for light-duty vehicles indicate that a 10% reduction in fuel costs per mile results in a 1-2% increase in the number of miles driven. These estimates are derived from statistical estimates of the elasticity of miles driven per vehicle with respect to fuel cost per mile that range from approximately –0.10 to –0.20; see for example David L. Greene, "Vehicle Use and Fuel Economy: How Big is the Rebound Effect?" *The Energy Journal*, 13:1 (1992), 117-143; 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; Jonathan Haughton and Soumodip Sarkar, "Gasoline Tax as a Corrective Tax: Estimates for the United States," *The Energy Journal*, 17:2, pp. 103-126; and S.L. Puller and L.A. Greening, "Household Adjustment to Gasoline Price Changes: An Analysis Using Nine Years of U.S. Survey Data," *Energy Economics*, 21:1, pp. 37-52. This study employs an elasticity of miles driven per vehicle with respect to fuel cost per mile of –0.20, approximately the upper end of the range suggested by recent research, to estimate the rebound effect from tightening CAFE standards for light-duty trucks. Small, K.A. and VanDender, K. (2005) "A Study to Evaluate the Effect of Reduced Greenhouse Gas Emissions on Vehicle Miles Traveled, State of California Air Resources Board, California Environmental Protection Agency, and the California Energy Commission.

trucks. Multiplying these figures by forecast light truck sales for each of those model years results in a total of 4.1 billion additional miles for all MY 2008 light trucks over their expected lifetimes, with corresponding figures of 10.0, 12.9, and 18.7 billion additional miles for MY 2009, 2010, and 2011 vehicles. These estimates increase over the four model years because the increase in the required CAFE levels from the adjusted baseline is progressively larger; in turn, this causes the decline in fuel cost per mile driven and resulting increase in average miles driven per vehicle to be larger.

Other Impacts of the Rebound Effect

The rebound effect also produces additional benefits to vehicle owners in the form of consumer surplus from the increase in vehicle-miles driven, but may also increase the costs associated with traffic congestion, motor vehicle crashes, and noise. These effects are likely to be relatively small by comparison to the value of fuel saved as a result of raising CAFE standards, but they are nevertheless important to include, and the following discussions analyze each of these effects in detail.

Consumer Benefits from Additional Driving

The rebound effect produces additional benefits to vehicle owners in the form of consumer surplus from the increase in vehicle-miles driven. These benefits arise from the value to drivers and other vehicle occupants of the social and economic opportunities made available to them by additional traveling. As evidenced by the fact that they elect to make more frequent or longer trips when the cost of driving declines, the benefits from this additional travel must exceed the costs drivers and their passengers incur in making more or longer trips. The amount by which these benefits from additional travel exceed its (now lower) costs represents the increase in consumer surplus associated with additional rebound effect driving. Our analysis estimates the value of these benefits using the conventional approximation, which is one half of the product of the decline in light truck operating costs per vehicle-mile and the resulting increase in the annual number of miles driven. The resulting estimate is extremely small by comparison to most other economic impacts of raising CAFE standards.

There may be additional consumer surplus benefits that we did not quantify, relating to second tier effects for businesses from spending by those driving additional miles due to the rebound effect. We believe these effects would be small compared to the quantified consumer surplus.

Added Costs from Congestion, Crashes, and Noise

While it provides some benefits to drivers, increased vehicle use associated with the fuel economy rebound effect can also contribute to increased traffic congestion, motor vehicle crashes, and highway noise. Additional vehicle use can contribute to traffic congestion and delays by increasing recurring congestion on heavily-traveled facilities during peak travel periods, depending on how the additional travel is distributed over the day and on where it occurs. By increasing the number of crashes and disabled vehicles, added driving can also increase the delays that often result from these incidents, although the extent to which it actually does so again depends on when and where the added travel occurs. In either case, any added delays impose higher costs on drivers and other vehicle occupants in the form of increased travel time and operating expenses, and these should be considered as an additional economic cost associated with the rebound effect. Because drivers do not take these added costs into account in deciding when to make trips or where they travel, they must be accounted for separately as a cost of the added driving associated with the rebound effect.

Increased light truck use due to the rebound effect may also increase the costs associated with traffic crashes. Drivers presumably take account of the potential costs they (and the other occupants of their vehicles) face from the possibility of being involved in a crash 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 crashes occur, so any increase in these "external" crash costs must be considered as another cost of additional rebound-effect driving. Like increased delay costs, any increase in these external crash costs caused by added driving is likely to depend on the traffic conditions under which it takes place, since crashes are more frequent in heavier traffic, but their severity may be reduced by the slower speeds at which heavier traffic typically moves. Thus estimates of the increase in external crash costs from the rebound effect also need to account for when and where the added driving occurs.

Finally, added light truck 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 none of these effects are likely 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 estimating its value, the added inconvenience and irritation caused by increased traffic noise imposes economic costs on those it affects, and these added costs are unlikely to be taken into account by drivers of the vehicles that cause it. Thus any increase in noise costs resulting from added light truck use must be included together with other increased external costs from the rebound effect.

Our analysis uses estimates of the congestion costs, crash costs, and noise costs for pickup trucks and vans developed by the Federal Highway Administration to estimate the increased external costs caused by added light truck use from the rebound effect.[60] These estimates are intended to measure the increases in external costs – that is, the marginal external costs – from added congestion, property damages and injuries in traffic crashes, and noise levels caused by additional usage of light trucks that are borne by persons other than their drivers. FHWA's "Middle" estimates for congestion, crash, and noise costs imposed by pickup trucks and vans are 4.0 cents, 2.15 cents, and 0.06 cents per vehicle-mile, respectively, at year-2000 prices.[61] Updated to 2003 dollars, these values are 4.27 cents for congestion, 2.30 cents for crashes, and 0.06 cents for noise. These costs are multiplied by the estimated increases in light truck use from the rebound effect during each year of the affected model years' lifetimes in the fleet to yield the estimated increases in congestion, crash, and noise externality costs during that year. The resulting estimates are discounted to their present values as of the date each model year is sold and summed to obtain their total values.

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 crash costs for increased light-duty vehicle use

[60] These estimates were developed by FHWA for use in its 1997 *Federal Highway Cost Allocation Study*.

[61] Federal Highway Administration, 1997 *Federal Highway Cost Allocation Study*, Tables V-22, V-23, and V-24.

in the U.S. to be 3.5 and 3.0 cents per vehicle-mile in year-2002 dollars.[62] These estimates incorporate careful adjustments of congestion and crash costs that are intended to reflect the traffic conditions under which additional driving is likely to take place, as well as its likely effects on both the frequency and severity of motor vehicle crashes. While both the FHWA and RFF estimates of congestion crash costs are considerably lower than those cited by some commenters on the proposed rule, we regard them as more credible estimates of the likely magnitude of these costs.

Costs from Increased Air Pollutant Emissions

Finally, additional light truck use associated with the rebound effect will increase emissions of air pollutants that occur as motor vehicles are driven (air pollutant emissions from gasoline production are discussed in a later section). Air pollutants emitted in significant quantities by light-duty motor vehicles such as the light trucks affected by the proposed rule include hydrocarbon compounds (usually referred to as "volatile organic compounds," or VOC), nitrogen oxides (NOx), fine particulate matter (PM), and sulfur dioxide (SO_2). The increased use of light trucks that occurs through the rebound effect causes higher emissions of these "criteria" pollutants, since federal standards limit their permissible emissions by motor vehicles on a per-mile basis. The increase in emissions of these pollutants from additional light truck use is estimated by multiplying the increase in total miles driven by light trucks of each model year and age during a calendar year by age-specific emission rates per vehicle-mile developed using the

[62] 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, March 2002, pp. 19 and Table 1, http://www.rff.org/rff/Documents/RFF-DP-02-12.pdf.

U.S. Environmental Protection Agency's MOBILE6.2 motor vehicle emissions factor model[63]. The resulting increases in emissions are converted to economic values using estimates of the economic costs (primarily from damages to human health) reported by the federal Office of Management and Budget.[64]

Emissions Reductions Resulting from Fuel Savings

While added driving caused by the rebound effect can increase air pollutant emissions, the fuel savings resulting from the proposed rule will reduce emissions of these same pollutants that are generated during the production and distribution of gasoline. Since these emissions occur during crude oil extraction and transportation, gasoline refining, and gasoline storage and distribution, the reduction in emissions from each of these sources depends on whether fuel savings result in lower imports of refined gasoline or in reduced domestic gasoline refining.[65] Based on a detailed examination of historical and forecast changes in U.S. gasoline imports in relation to changes in domestic gasoline consumption, this analysis assumes that 50 percent of fuel savings resulting from the proposed rule will be reflected in reduced gasoline imports, and that the remaining 50

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[63] U.S. Environmental Protection Agency, MOBILE6 Vehicle Emission Modeling Software, http://www.epa.gov/otaq/m6.htm#m60

[64] White House Office of Management and Budget, Office of Information and Regulatory Affairs, "Progress in Regulatory Reform: 2004 Report to Congress on the Costs and Benefits of Federal Regulations and Unfunded Mandates on State, Local, and Tribal Entities," December 2004, p. 134, http://www.whitehouse.gov/omb/inforeg/regpol-reports_congress.html The values used for VOC, NOx, and SO2 are the midpoints of the ranges used by OMB, adjusted to 2003 dollars. However, OMB does not provide a damage cost estimate for carbon monoxide (CO); the value used here was derived from Donald R. McCubbin and Mark A. Delucchi, "The Health Costs of Motor-Vehicle-Related Air Pollution," Journal of Transport Economics and Policy, September 1999, Volume 33, part 3, pp. 253-86.

[65] 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.

percent will reduce domestic refining.[66] The resulting reduction in domestic refining is assumed to leave the mix of imported and domestic crude petroleum feedstocks currently utilized in domestic refining unchanged.

This analysis estimates 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.[67] The GREET model provides separate estimates of air pollutant emissions that occur in four separate activities entailed in gasoline production and distribution: crude oil extraction, crude oil transportation and storage, gasoline refining, and gasoline distribution and storage.[68] Our calculations assume that reductions in imports of gasoline in response to fuel savings from the proposed rule would reduce air pollutant emissions during gasoline storage and distribution only. Reductions in domestic refining of gasoline using imported crude oil as a feedstock are assumed to reduce emissions that occur during crude oil transportation and storage, and during gasoline refining, distribution, and storage. Finally, lower domestic refining using domestically-produced crude oil as a feedstock is assumed to reduce emissions during all four phases of gasoline production and

[66] Estimates of the response of gasoline imports and domestic refining to fuel savings from stricter CAFE standards are variable and highly uncertain, but our 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.

[67] Argonne National Laboratories, *The Greenhouse Gas and Regulated Emissions from Transportation (GREET) Model*, Version 1.6, April 2005, http://www.transportation.anl.gov/software/GREET/index.html

[68] 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; we convert these factors to mass per gallon of gasoline using the average energy content of gasoline. We assume that the current mix of approximately 60% conventional gasoline, 30% federal "reformulated" gasoline (FRFG2), and 10% California reformulated gasoline will continue to be refined over the period covered by our analysis.

distribution.[69] The resulting reductions in air pollutant emissions from gasoline production and distribution are converted to economic values using the same economic damage costs used to value emissions increases resulting from additional driving.

Fuel savings from stricter light truck CAFE standards also result in lower emissions of carbon dioxide, the main greenhouse gas emitted as a result of refining, distribution, and use of transportation fuels.[70] Lowering fuel consumption reduces carbon dioxide emissions directly, because the primary source of transportation-related greenhouse gas emissions is fuel combustion in internal combustion engines. Reductions in carbon dioxide emissions from vehicle operation are estimated by assuming that the entire carbon content of gasoline is converted to carbon dioxide in the combustion process.[71] Reduced gasoline consumption also reduces carbon dioxide emissions that result from fuel combustion, as well as from other energy use that occurs during the production and distribution of gasoline. Reductions in emissions from petroleum extraction and transportation, refining, and distribution are calculated using estimates of carbon dioxide emission rates in those activities obtained from Argonne National Laboratories' GREET model.

The Value of Increased Driving Range

Improving the fuel economy of light-duty trucks will also increase their driving range between refueling. By reducing the frequency with which drivers typically refuel their vehicles, and by

[69] 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.

[70] Carbon dioxide emissions account for more than 97% of total greenhouse gas emissions from the refining and use of transportation fuels; see U.S. Environmental Protection Agency, *Draft Inventory of GHG Emissions and Sinks (1990-1999)*, Tables ES-1 and ES-4, http://www.epa.gov/globalwarming/publications/emissions/us2001/energy.pdf.

[71] This assumption results is an 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.

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 savings in costs will presumably be reflected in lower vehicle sales prices.) No direct estimates of the value of extended vehicle range were readily available, so our 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[72]. The estimated change in required refueling frequency reflects the increased light truck use associated with the rebound effect, as well as the increased driving range stemming from higher fuel economy.

The following example illustrates how the economic value of extended refueling range is estimated in this analysis. Smaller light trucks have an average fuel tank size of approximately 20 gallons, and increasing the CAFE standard for model year 2008from 22.2 to 22.5 mpg for the unreformed alternative is estimated to increase the average CAFE rating for these models from the adjusted baseline of 22.35 to 22.61 mpg, which raises their actual on-road fuel economy from 19.00 to 19.22 mpg. Assuming that drivers typically refuel when their tanks are 20 percent full (i.e., 4 gallons in reserve), this increase in fuel economy raises the driving range for these vehicles from 19.00 x 16 = 304 to 19.22 x 16 = 307.5 miles. For a light truck driven 12,000 miles/year, this reduces the number of required refuelings from 12,000/304 = 39.5 to 12,000/307.5 = 39.0, or by one half refueling per year.

72 See http://ostpxweb.dot.gov/policy/Data/VOT97guid.pdf and http://ostpxweb.dot.gov/policy/Data/VOTrevision1_2-11-03.pdf

Weighted by the actual mix of urban (about 2/3) and rural (about 1/3) travel and average vehicle occupancy (1.6 persons), the DOT-recommended value of travel time per vehicle-hour is $21.90 (in year 2003 dollars)[73]. Assuming that locating a station and filling up takes five minutes, the value of time savings resulting from less frequent refueling amounts to $0.91 (calculated as 5/60 x 0.5 x $21.90) per vehicle per year for MY 2008 light trucks. This calculation is repeated for each calendar year that light trucks of each model year affected by the proposed rule would remain in the fleet, although its results differ for each year because different numbers of these vehicles remain in service during each year and their average use (and thus the number of fillups saved) varies with their age as well. As with the other future benefits (and costs) of improved fuel economy, these annual values are discounted to their present values as of the date each model year is produced and sold, and the results summed for each model year. This is considered an upper bound of savings, since not all drivers would wait until they have as little as a quarter tank of gas before they fill up again.

Summary of Benefits

The societal impacts from the proposed rule are summarized for each model year and compliance option (reformed and unreformed) in Tables VII-4 through VII-10. These tables include undiscounted values as well as present value calculations at 3% and 7%. They also show changes in the physical units of measure that produced these values. Negative values in these tables reflect net reductions in fuel consumption or emissions and their resulting economic damages, which represent benefits from the proposal, while positive values represent increasing

[73] The hourly wage rate during 2003 is estimated to be $21.90. Personal travel (94.4% of urban travel) is valued at 50 percent of the hourly wage rate. Business travel (5.6% or urban travel) is valued at 100 percent of the hourly wage rate. For intercity travel, personal travel (87%) is valued at 70 percent of the wage rate, while business travel (13%) is valued at 100 percent of the wage rate. The resulting values of travel time are $11.57 for urban travel and $16.12 for intercity travel, and must be multiplied by vehicle occupancy (1.6) to obtain the estimate value of time per vehicle hour.

emissions, congestion, noise or crash severity and their added costs. The net social benefit from these societal impacts is shown on the Total line in each table.

Highlights from Tables VIII 4-VIII-10 are shown in Tables VIII-11 and VIII-12. Table V-11 summarizes the total savings in gallons of fuel over the lifetime of the light trucks manufactured during each model year and scenario. There is a steady increase in fuel savings with each model year. The savings for MY 2011 are roughly 4 times those in MY 2008. Savings from both the Unreformed and Reformed scenarios are of similar magnitude during the 3 MY transition period.

Table VIII-12 summarizes the total social benefits for each scenario, discounted at 3 and 7 percent. The value of these impacts also increases steadily to a level that is roughly 4 times as high by 2011. The values for both Unreformed and Reformed CAFE also exhibit similar magnitudes during the transition period.

Table VIII-4
Lifetime Monetized Societal Impacts, Unreformed CAFE, 2008 MY

Societal Effect	**Physical Units**	**Undiscounted Value (2003$ k)**	**Present Discounted Value @ 3%**	**Present Discounted Value @ 7%**
Lifetime Fuel Expenditures	-825,960 (k gal)	-938,071	-756,980	-612,709
Value of Additional Driving	3,569,632 (kmiles)	-6,216	-5,307	-4,091
Refueling Time Value	2,974,300 hours	-65,137	-54,007	-42,913
Petroleum Market Externalities	-825,960 (k gal)	-74,252	-47,513	-28,481
Congestion Costs	3,569,632 (kmiles)	152,570	97,475	58,521
Noise Costs	3,569,632 (kmiles)	2,289	1,462	878
Crash Costs	3,569,632 (kmiles)	82,007	52,393	31,455
VOC	467 (tons)	800	260	0
NOX	-110 (tons)	-583	-1,152	-1,176
PM	-121 (tons)	-6,895	-4,415	-2,645
SOX	-1057 (tons)	-8,838	-5,656	-3,390
Total		-862,327	-723,441	-604,552

Table VIII-5
Lifetime Monetized Societal Impacts,
Unreformed CAFE 2009 MY

Societal Effect	**Physical Units**	**Undiscounted Value (2003$ k)**	**Present Discounted Value @ 3%**	**Present Discounted Value @ 7%**
Lifetime Fuel Expenditures	-1,860,377 (k gal)	-2,114,055	-1,775,279	-1,380,590
Value of Additional Driving	8,218,113 (kmiles)	-14,637	-14,086	-9,631
Refueling Time Value	6,685,662 hours	-146,416	-122,472	-96,614
Petroleum Market Externalities	-1,860,377 (k gal)	-167,243	-108,201	-60,040
Congestion Costs	8,218,113 (kmiles)	351,252	225,116	126,101
Noise Costs	8,218,113 (kmiles)	5,269	3,377	1,892
Crash Costs	8,218,113 (kmiles)	188,798	121,000	67,780
VOC	872 (tons)	1,494	417	-64*
NOX	-187 (tons)	-993	-2,397	-2,340*
PM	-270 (tons)	-15,401	-9,999	-5.529
SOX	-2376 (tons)	-19,874	-12,860	-7,135
Total		-1,931,806	-1,695,385	-1,366,170

* Because there are two streams of benefits, some values are positive and some values negative, and discounting affects the first few years in the stream less than the last years, the discounted values can actually change signs after discounting, as with the volatile organic compounds (VOC) values, or get larger after discounting as with the nitrogen oxides (NOx).

Table VIII-6
Lifetime Monetized Societal Impacts, Unreformed CAFE, 2010 MY

Societal Effect	**Physical Units**	**Undiscounted Value (2003$ k)**	**Present Discounted Value @ 3%**	**Present Discounted Value @ 7%**
Lifetime Fuel Expenditures	-2,714,912 (k gal)	-3,092,733	-2,508,449	-2,017,573
Value of Additional Driving	12,147,556(kmiles)	-25,391	-20,865	-16,684
Refueling Time Value	9,742,146 hours	-213,353	-171,837	-140,703
Petroleum Market Externalities	-2,714,912 (k gal)	-244,064	-148,100	-81,850
Congestion Costs	12,147,556(kmiles)	519,201	311,727	174,123
Noise Costs	12,147,556(kmiles)	7,788	4,676	2,612
Crash Costs	12,147,556(kmiles)	279,071	167,554	93,591
VOC	1,097(tons)	1,881	444	-136
NOX	-498 (tons)	-2,637	-3,821	-3,454
PM	-391 (tons)	-22,364	-13,626	-7,500
SOX	-3,469 (tons)	-29,016	-17,609	-9,731
Total		-2,821,617	-2,399,906	-2,007,305

Table VIII-7
Lifetime Monetized Societal Impacts, Reformed CAFE, 2008 MY

Societal Effect	**Physical Units**	**Undiscounted Value (2003$ k)**	**Present Discounted Value @ 3%**	**Present Discounted Value @ 7%**
Lifetime Fuel Expenditures	-941,967 (k gal)	-1,069724	-871,579	-698,856
Value of Additional Driving	4,155,821(k miles)	-9,736	-7,909	-6,399
Refueling Time Value	3,741,233 hours	-81,933	-67,012	-53,997
Petroleum Market Externalities	-941,967 (k gal)	-84,680	-54,713	-32,487
Congestion Costs	4,155,821(k miles)	177,625	114,802	68,153
Noise Costs	4,155,821(k miles)	2,664	1,722	1,022
Crash Costs	4,155,821(k miles)	95,473	61,706	36,632
VOC	479(tons)	822	246	-33
NOX	-268 (tons)	-1,418	-1,758	-1,590
PM	-137 (tons)	-7,804	-5,041	-2,994
SOX	-1,208 (tons)	-10,102	-6,527	-3,875
Total		-988,813	-836,062	-694,423

Table VIII-8
Lifetime Monetized Societal Impacts, Reformed CAFE, 2009 MY

Societal Effect	**Physical Units**	**Undiscounted Value (2003$ k)**	**Present Discounted Value @ 3%**	**Present Discounted Value @ 7%**
Lifetime Fuel Expenditures	-2,217,597 (k gal)	-2,519,261	-2,065,625	-1,646,093
Value of Additional Driving	9,974,034(k miles)	-20,262	-18,047	-13,329
Refueling Time Value	8,421,507 hours	-184,431	-151,159	-121,687
Petroleum Market Externalities	-2,217,597 (k gal)	-199,356	-125,899	-71,562
Congestion Costs	9,974,034(k miles)	426,302	267,813	153,039
Noise Costs	9,974,034(k miles)	6,395	4,017	2,296
Crash Costs	9,974,034(k miles)	229,137	143,949	82,258
VOC	976(tons)	1,673	431	-115
NOX	-484 (tons)	-2,563	-3,579	-3,220
PM	-319 (tons)	-18,234	-11,538	-6,545
SOX	-2,837 (tons)	-23,727	-14,986	-8,517
Total		-2,304,326	-1,974,622	-1,633,476

Table VIII-9
Lifetime Monetized Societal Impacts, Reformed CAFE, 2010 MY

Societal Effect	**Physical Units**	**Undiscounted Value (2003$ k)**	**Present Discounted Value @ 3%**	**Present Discounted Value @ 7%**
Lifetime Fuel Expenditures	-2,892,020 (k gal)	-3,291,245	-2,682,142	-2,149,527
Value of Additional Driving	13,049,740(kmiles)	-28,964	-25,556	-19,058
Refueling Time Value	10,831,781 hours	-237,216	-192,219	-156,516
Petroleum Market Externalities	-2,892,020 (k gal)	-259,985	-158,422	-87,232
Congestion Costs	13,049,740(kmiles)	557,762	336,491	187,144
Noise Costs	13,049,740(kmiles)	8,366	5,047	2,807
Crash Costs	13,049,740(kmiles)	299,797	180,864	100,590
VOC	1,110 (tons)	1,902	41	-176
NOX	-724 (tons)	-3,835	-5,881	-3,977
PM	-416 (tons)	-23,743	-14,391	-7,967
SOX	-3,699 (tons)	-30,936	-18,919	-10,380
Total		-3,008,098	-2,575,080	-2,144,291

Table VIII-10
Lifetime Monetized Societal Impacts, Reformed CAFE, 2011 MY

Societal Effect	**Physical Units**	**Undiscounted Value (2003$ k)**	**Present Discounted Value @ 3%**	**Present Discounted Value @ 7%**
Lifetime Fuel Expenditures	-4,110,494 (k gal)	-4,689,719	-3,828,244	-3,060,319
Value of Additional Driving	18,807,636(kmiles)	-46,710	-39,223	-30,695
Refueling Time Value	15,464,658 hours	-338,676	-276,831	-223,386
Petroleum Market Externalities	-4,110,494 (k gal)	-369,523	-219,039	-115,832
Congestion Costs	18,807,636(kmiles)	803,861	472,880	251,981
Noise Costs	18,807,636(kmiles)	12,058	7,093	3,780
Crash Costs	18,807,636(kmiles)	432,075	254,173	135,440
VOC	1,410 (tons)	2,417	135	-254
NOX	-1,119 (tons)	-5,929	-7,678	-5,294
PM	-588 (tons)	-33,574	-19,834	-10,524
SOX	-5,255 (tons)	-43,950	-26,126	-13,777
Total		-4,277,671	-3,682,694	-3,068,881

Table VIII-11
Savings in Millions of Gallons of Fuel
Undiscounted over the Lifetime of the Model Year Fleet

	MY 2008	MY 2009	MY 2010	MY 2011
Unreformed CAFE in 2008-2010,	826	1,860	2,715	NA
Reformed CAFE	942	2,218	2,892	4,110

Table VIII-12
Present Value of Lifetime Social Benefits by Alternative
(Millions of $2003)

Discounted 3%	MY 2008	MY 2009	MY 2010	MY 2011
Unreformed CAFE in 2008-2010	723	1,695	2,400	NA
Reformed CAFE 2008-2011	836	1,975	2,575	3,684
Discounted 7%				
Unreformed CAFE in 2008-2010	605	1,366	2,007	NA
Reformed CAFE 2008-2011	694	1,633	2,144	3,069

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IX. NET BENEFITS

This chapter compare the costs of technologies needed to make improvements in fuel economy to meet the proposed scenarios with the potential benefits, expressed on a per vehicle basis and in total (millions of dollars) per year. The following tables combine the estimated costs and benefits from Chapters VII and VIII. These are incremental costs and benefits compared to an adjusted baseline of manufacturers' production plans. Tables utilizing a 3 percent discount rate and 7 percent discount rate are presented.

Table IX-1 provides the costs on a per vehicle basis. Table IX-2 provides the average net benefits per vehicle at a 3 and 7 percent discount rate from a societal perspective for all light trucks produced during each model year to which the standard is applicable.

Table IX-1
Incremental Cost Analysis
Per Vehicle
(In Year 2003 Dollars)

	MY 2008	**MY 2009**	**MY 2010**	**MY 2011**
Unreformed CAFE in 2008-2010	56	130	185	NA
Reformed CAFE 2008-2011	54*	142*	186*	275

* By policy design, the proposed mpg levels under Reformed CAFE are set so that the industry-wide costs of Reformed CAFE are roughly equal to the industry-wide costs of Unreformed CAFE for MY 2008-2010.

Table IX-2
Incremental Societal Benefits per Vehicle
Over the Vehicle's Lifetime – Present Value
(Discounted 3% and 7%, In Year 2003 Dollars)

	MY 2008	MY 2009	MY 2010	MY 2011
Discounted 3%				
Unreformed CAFE in 2008-2010	76	176	246	NA
Reformed CAFE 2008-2011	88	205	264	378
Discounted 7%				
Unreformed CAFE in 2008-2010	64	142	206	NA
Reformed CAFE 2008-2011	73	170	220	315

Table IX-3 provides the net benefits per vehicle at a 3 percent and 7 percent discount rate.

Table IX-3
Net Benefits per Vehicle
Over the Vehicle's Lifetime – Present Value
(Discounted 3% and 7%, In Year 2003 Dollars)

	MY 2008	**MY 2009**	**MY 2010**	**MY 2011**
Discounted 3%				
Unreformed CAFE in 2008-2010	20	46	61	NA
Reformed CAFE 2008-2011	34	63	78	103
Discounted 7%				
Unreformed CAFE in 2008-2010	8	12	21	NA
Reformed CAFE 2008-2011	19	28	34	40

Table IX-4 shows the total costs, Table IX-5 shows the total benefits and Table IX-6 shows the total net benefits in millions of dollars at a 3 and 7 percent discount rate for the projected fleet of sales for each model year.

Table IX-4
Incremental Total Cost
(In Millions of Year 2003 Dollars)

	MY 2008	**MY 2009**	**MY 2010**	**MY 2011**
Unreformed CAFE in 2008-2010	528	1,244	1,798	NA
Reformed CAFE 2008-2011	505*	1,332*	1,802*	2,656

* By policy design, the proposed mpg levels under Reformed CAFE are set so that the industry-wide costs of Reformed CAFE are roughly equal to the industry-wide costs of Unreformed CAFE for MY 2008-2010.

Table IX-5
Incremental Total Societal Benefits
Over the Vehicle's Lifetime – Present Value
(Discounted 3% and 7%, In Millions of Year 2003 Dollars)

	MY 2008	**MY 2009**	**MY 2010**	**MY 2011**
Discounted 3%				
Unreformed CAFE in 2008-2010	723	1,695	2,400	NA
Reformed CAFE 2008-2011	836	1,975	2,575	3,683
Discounted 7%				
Unreformed CAFE in 2008-2010	605	1,366	2,007	NA
Reformed CAFE 2008-2011	694	1,633	2,144	3,069

Table IX-6
Net Total Benefits
Over the Vehicle's Lifetime – Present Value
(Discounted 3% and 7%, In Millions of Year 2003 Dollars)

	MY 2008	MY 2009	MY 2010	MY 2011
Discounted 3%				
Unreformed CAFE in 2008-2010	195	451	602	NA
Reformed CAFE 2008-2011	331	643	773	1,027
Discounted 7%				
Unreformed CAFE in 2008-2010	77	122	209	NA
Reformed CAFE 2008-2011	189	301	342	413

Both Scenarios examined provide net benefits for society. For MY 2008-10, the Reformed CAFE scenarios provide more benefits and more net benefits than the Unreformed Scenarios at roughly equal costs.

Payback Period

The payback period represents the length of time required for a vehicle buyer to recoup, through savings in fuel use, the higher cost of purchasing a more fuel-efficient vehicle. When a higher CAFE standard requires a manufacturer to improve the fuel economy of some of its vehicle models, the manufacturer's added costs for doing so are reflected in higher prices for these models. While buyers of these models pay higher prices to purchase these vehicles, their improved fuel economy lowers theconsumer's costs for purchasing fuel to operate them. Over time, buyers will recoup the higher purchase prices they pay for these vehicles in the form of savings in outlays for fuel. The length of time required to repay the higher cost of buying a more fuel-efficient vehicle is referred to as the buyer's payback period.

The length of this payback period depends on the initial increase in a vehicle's purchase price, the improvement in its fuel economy, the number of miles it is driven each year, and the retail price of fuel. We calculated payback periods using the fuel economy improvement and average price increase for each manufacturer's vehicles estimated to result from the proposed standard, the future retail gasoline prices, and estimates of the number of miles light trucks are driven each year as they age. These calculations are taken from a consumer's perspective, not a societal perspective. Thus, only gasoline savings are included on the benefits side of the equation, the price of gasoline includes fuel taxes (since consumers don't think about transfer payments but look at what they pay at the pump, and future savings are not discounted to present value (since the average consumer doesn't think in these terms). The payback periods for individual manufacturer's fleets ranged from 31 months to 100 months. The average for all manufacturers ranged from 38 to 52 months. In other words, the average consumer can expect to save enough fuel in 3.2 to 4.3 years to equal their incremental price increase. The averages presented in the table are only for those manufacturers that had costs for the model year (in other words, when a manufacturer already met the proposed level of the standard, the 0 months for payback was not averaged in with the other manufacturers that had costs and a real payback period).

Table IX-7
Payback Periods for the Consumer
(In months)

	MY 2008	MY 2009	MY 2010	MY 2011
Unreformed CAFE Average (Range)	52 (34 to 100)	47 (34 to 74)	48 (31 to 72)	NA
Reformed CAFE Average (Range)	38 (33 to 48)	45 (37 to 59)	47 (36 to 61)	47.0 (38 to 62)

X. PROBABILISTIC UNCERTAINTY ANALYSIS

This chapter identifies and quantifies the major uncertainties in the preliminary regulatory impact analysis and estimates how those uncertainties affect the net benefits of the proposed scenarios. Throughout the course of the analysis, many assumptions were made and diverse data sources were used. The uncertainty of these assumptions and data sources potentially could impact the net benefits of the standards. These assumptions and data sources all can be considered as uncertainty factors for the regulatory analysis. Some of these uncertainty factors contributed less to the overall variations of the outcomes, and thus are less significant. Some uncertainty factors depend on others or are closely related (oil import externalities), and thus can be combined. With the vast number of uncertainties imbedded in this regulatory analysis, the uncertainty analysis identifies only the major independent uncertainty factors having appreciable variability and impact on the end results and quantifies them by their probability distributions. These newly defined values are then randomly selected and fed back into the model to determine the net benefits using the Monte Carlo statistical simulation technique[74]. The simulation technique induces the probabilistic outcomes accompanied with degrees of probability or plausibility. This facilitates a more informed decision-making process.

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[74] See any statistics books describing the Monte Carlo simulation theory. For example,
"Uncertainty : A Guide to Dealing with Uncertainty in Quantitative Risk and Policy Analysis", Millett Granger Morgan and Max Henrion ,
"Making Hard Decisions: An Introduction to Decision Analysis", Robert T. Clemen,

The analysis is based on the actual processes used to derive net benefits as described in the previous chapters. Each variable (e.g., cost of technology) in the mathematical model represents an uncertainty factor that would potentially alter the modeling outcomes if its value were changed. We implicitly assume that these variables are independent of each other, although it is probable that the costs and effectiveness of fuel saving technology are not independent. The agency has no method of linking variables when they are dependent upon each other. The uncertainty of these variables are described by an appropriate probability distribution function based on available data. If data are not sufficient or not available, professional judgments are used to estimate the probability distributions of these uncertainty factors. A complete description of the formulas and methods used in the CAFE model is available in the public docket[75].

After defining and quantifying the major uncertainty factors, the next step is to simulate the model to obtain probabilistic results rather than single-value estimates. The proposed CAFE levels were kept constant, we did not change the reformed CAFE standards for each run based on net benefits. The simulation process was run repeatedly for 1,756 trials. Each complete run is a trial. For each trial, the simulation first randomly selects a value for each of the uncertainty factors based on their probability distributions. The selected values are then fit into the models to forecast results. In addition to the simulation results, the program also estimates the degree of certainty (or confidence, credibility). The degree of certainty provides the decision-maker an additional piece of important information to evaluate the forecast results.

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[75] CAFE Compliance and Effects Modeling System Documentation, Volpe Center, U.S. Dept. of Transportation, July 2005, pp. 27-46 and C-22 to C-35. Docket No. 21974.

Simulation Models and Uncertainty Factors

A Monte Carlo simulation was conducted using the CAFE modeling system that was developed to estimate the impacts of higher CAFE requirements described in previous chapters. The focus of the simulation model was variation around the chosen uncertainty parameters and their resulting impact on the key output parameters, fuel savings and net benefits. Net benefits measures the difference between the total dollar value that would be saved in fuel and other benefits and the total costs of the rule.

The agency reviewed the inputs and relationships that drive the CAFE model to determine the factors that are the major sources of uncertainty. Five factors were identified as contributing the most uncertainty to the estimated impacts of higher CAFE standards:

Technology costs

Technology effectiveness

Fuel prices

The value of oil import externalities

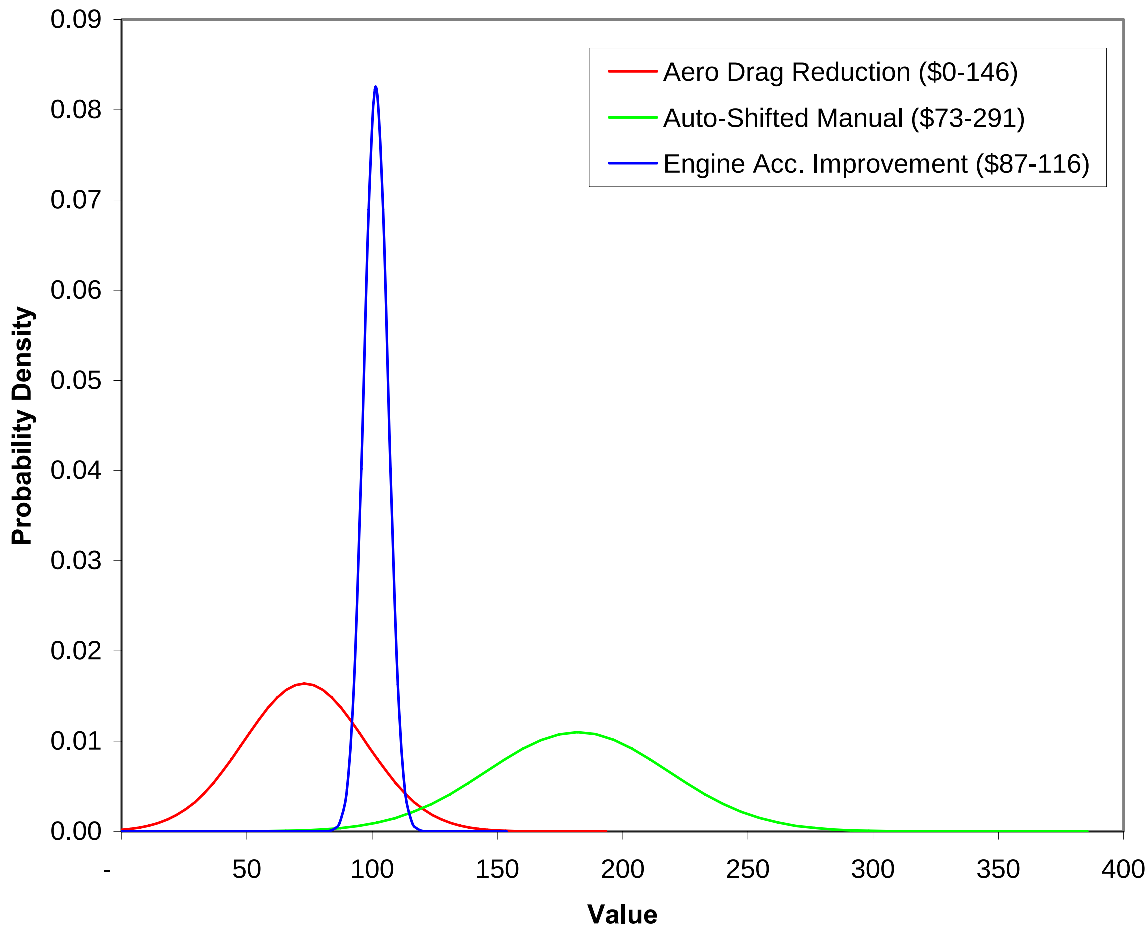
The rebound effect

Technology Costs

The costs incurred by manufacturers to modify their vehicles to meet new CAFE levels are assumed to be passed on to consumers in the form of higher new car prices. These technology costs are the primary determinant of the overall cost of improving fuel economy.

Thirty-one different technologies were examined as possible methods to comply with higher CAFE standards. These technologies were summarized in Table VI-4 earlier in this analysis. Table VI-4 also summarizes the estimated range of costs for these technologies as provided by the National Academy of Sciences (NAS) in their report on CAFE. The expected values from this table were used in the main analysis. For the uncertainties analysis, the full range of NAS cost estimates is used. The uncertainty model assumes a normal distribution for these costs, with each end of the range being three standard deviations from the mean (or expected) value. Figure X-1 graphically demonstrates the distributions of a sample of three of the technologies.

Figure X-1
Normal Distributions for 3 Different Technologies



Technology Effectiveness

The modifications adopted by manufacturers to enable their vehicles to meet new CAFE levels will improve fuel efficiency and reduce the cost of operating the more efficient vehicles. The effectiveness of each technology determines how large an impact it will have towards enabling manufacturers to meet the higher CAFE standards, and will thus determine how much additional improvement is needed and which additional technologies will be required to achieve full compliance. In selecting the likely path that manufacturers will choose to meet CAFE, the CAFE model tests the interaction of technology costs and effectiveness to achieve an optimal (cost-minimizing) technological solution. Technology effectiveness is thus a primary determinant of the overall cost and benefit of improving fuel economy.

Thirty-one different technologies were examined as possible methods to comply with higher CAFE standards. These technologies were summarized in Table VI-4 earlier in this analysis. Table VI-4 also summarizes the estimated range of effectiveness for these technologies as provided by the National Academy of Sciences in their report on CAFE. The expected values from this table were used in the main analysis. For the uncertainty analysis, the full range of effectiveness estimates is used. The uncertainties model assumes a normal distribution for these values, with each end of the range being three standard deviations from the mean (or expected) value.

<u>Fuel Prices</u>

Higher CAFE standards will result in reduced gasoline consumption, which will translate into lower vehicle operating costs for consumers. The value of this reduced fuel consumption is a direct function of fuel prices. Fuel prices are thus a primary determinant of the overall social benefit that will result from improving fuel economy.

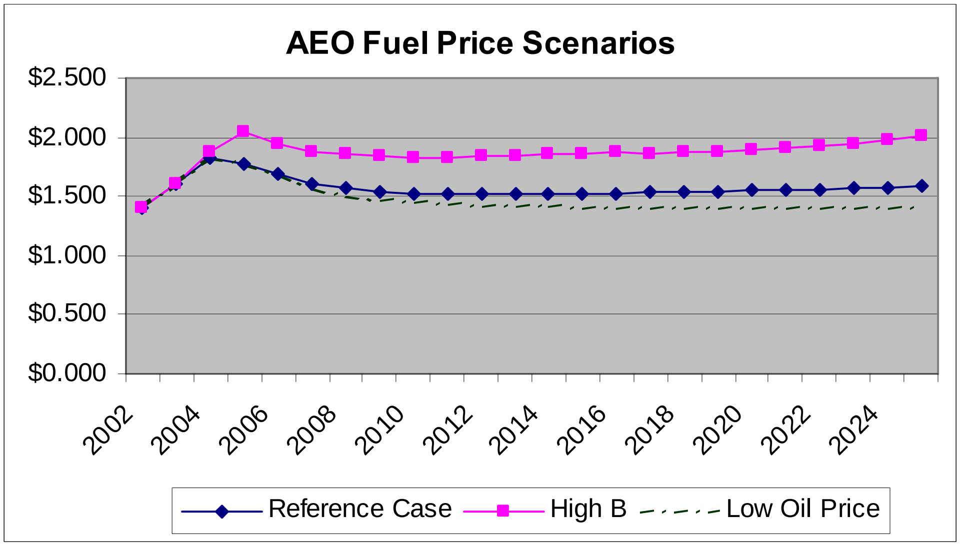
The analysis attempts to measure impacts that occur as much as 40 years in the future and estimating gasoline prices this far in advance is an uncertain process. In the main analysis, the Agency utilized predicted fuel prices from the Energy Information Administration's (EIA) publication Annual Energy Outlook 2005 (AEO). The main analysis is based on the AEO Reference Case scenario, which represents EIA's best estimate of future fuel prices. For the uncertainty analysis, the Agency examined two other AEO scenarios, the Low Oil Price scenario (LOP) and the High B oil price scenario. The LOP scenario was chosen to allow for the possibility that the EIA's Reference Case predictions could overestimate the price of gasoline in the future. However, recent escalation in the price of gasoline has resulted in prices that are significantly higher than those estimated by EIA for their reference case. It is unclear whether these higher levels are just a temporary spike in price levels or an indication of permanently higher prices. To reflect the possibility of significantly higher prices, the Agency selected the High B price case, which among the AEO 2005 scenarios comes closest to matching current gasoline price levels, and which gives the highest gasoline price forecasts among all AEO 2005 scenarios. For the final rule, the agency will be looking at the latest AEO projections. Based on the agency's methodology for selecting the Reformed CAFE standard for MY 2011, a higher price for fuel would result in larger benefits and the potential for a higher standard in the final rule.

Each of these scenarios was applied as a discreet input, i.e., draws were not made from among the 3 scenarios separately for each future year. Rather, for each draw, one of the 3 scenarios was chosen and applied across the full vehicle life for each model year. The probability of selection for each of the three scenarios was modeled using discrete weights of 50 percent for the Reference Case, and 25% for both the LOP and High B cases. Table XI-2 lists the AEO gasoline price forecasts under each scenario. These same prices are demonstrated graphically in Figure X-2. These fuel prices are in year 2003 economics.

Table X-2
AEO 2005 Gasoline Price Scenarios

	Reference Case	High B	Low Oil Price
2002	$1.404	$1.404	$1.404
2003	$1.603	$1.603	$1.603
2004	$1.817	$1.874	$1.817
2005	$1.774	$2.044	$1.774
2006	$1.686	$1.935	$1.686
2007	$1.600	$1.879	$1.563
2008	$1.574	$1.855	$1.503
2009	$1.539	$1.841	$1.469
2010	$1.524	$1.817	$1.454
2011	$1.525	$1.825	$1.440
2012	$1.512	$1.844	$1.423
2013	$1.512	$1.845	$1.413
2014	$1.513	$1.858	$1.412
2015	$1.516	$1.852	$1.410
2016	$1.524	$1.870	$1.407
2017	$1.532	$1.854	$1.403
2018	$1.536	$1.871	$1.398
2019	$1.540	$1.881	$1.400
2020	$1.549	$1.886	$1.403
2021	$1.554	$1.906	$1.395
2022	$1.562	$1.928	$1.409
2023	$1.574	$1.949	$1.406
2024	$1.573	$1.976	$1.404
2025	$1.585	$2.008	$1.405

Figure X-2



Oil Export Externalities

Reducing fuel consumption can benefit society in ways that are not directly reflected in the price of fuel consumed. Oil import externalities are effects that impact the demand for and supply of imported petroleum. They potentially include reduction in demand on world market price for oil, reductions in the threat of supply disruptions, and reductions in the cost of maintaining military security in oil producing regions and the strategic petroleum reserve. A full description of these costs is included in Chapter VIII under "Other Economic Benefits from Reducing Petroleum Use". These factors increase the net social benefits from reduced fuel consumption. Although they represent a relatively small portion of overall social benefits, there is a significant level of uncertainty as to their values. For this reason, they were examined in the uncertainty analysis.

Table X-3 lists the range of values that were examined for oil import externalities. The expected values were used in the main analysis. Both the value of reducing U.S. demand on the world market price for oil and the value of reduced threat of supply disruptions were derived from a study by Leiby et al (see Chapter VIII). For reasons noted in Chapter VIII, military security is not specifically valued in this analysis. A normal distribution was assumed for the range of values for oil import externalities with the low and high values assumed to be two standard deviations from the mean.

Table X-3
Uncertainty Ranges for Oil Import Externalities

	Low	**Expected**	**High**
For reducing U.S. demand on world market price	$0.027	$0.061	$0.091
For reducing the threat of supply disruptions	$0.013	$0.045	$0.061
For military security	$0.0	$0.0	$0.0
	$0.040	$0.106	$0.182

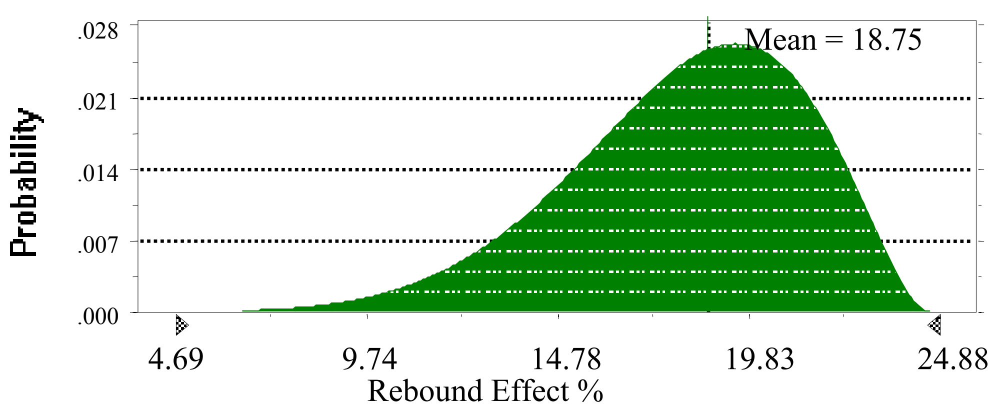
The Rebound Effect

By reducing the amount of gasoline used and thus the cost of operating a vehicle, higher CAFE standards are expected to result in a slight increase in annual miles driven per vehicle. This “rebound effect” thus impacts net societal benefits by offsetting a portion of the reduction in gasoline consumption that results from more fuel-efficient vehicles. Most recent estimates of the magnitude of the rebound effect for light duty vehicles fall in the range of 10-20 percent, i.e., increasing vehicle use will offset 10-20 percent of the fuel savings resulting from an improvement in fuel economy. A more complete discussion of the rebound effect is included in Chapter VIII. The Agency employed a rebound effect of 20% in the main analysis. For the uncertainty analysis, a range of 5 to 25 percent is used and employed in a skewed Beta distribution with a mean of approximately 20 percent. The skewed distribution reflects the agency's belief that the 20 percent value chosen for the main analysis is likely conservative and the probability that the correct value is less than 20 percent exceeds the probability that it is greater than 20 percent.

Figure X-3 demonstrates the distribution used for the rebound effect.

FIGURE X-3
Uncertainty Distribution for the Rebound Effect

Beta Distribution
Alpha = 9
Beta = 3
Scale = 25
Mode = 20.07
Range: about 5 to 25%



Modeling Results – Trial Draws

Because of the complexity of the CAFE model, the time required to perform the uncertainty analysis was significant. The uncertainty analysis conducted a total of 1756 trials over a 4-day period using eight separate computers (averaging about 26 minutes per run). The process was stopped when the accumulated draws were judged to adequately reflect the modeled distributions for the uncertainty factors (see for example Figures X-4 through X-12). This produced distributions that were imperfect, but which did reflect the general shapes expected for the uncertainty factor distributions. A significantly larger number of draws would have produced smoother fits, but the time and expense required to produce such fits would have been impractical given the time required to run each trial and the statutory deadline which determines the rulemaking schedule. However, the agency believes that the number of trials that were run adequately describes the level of uncertainty that exists within the analysis. Figures X- 4 Through X-12 illustrates the draw results for a sample of the 65 variables (31 technology effectiveness rates, 31 technology costs, the fuel price scenario, oil import externalities, and the rebound effect) that were examined.

Figure X-4

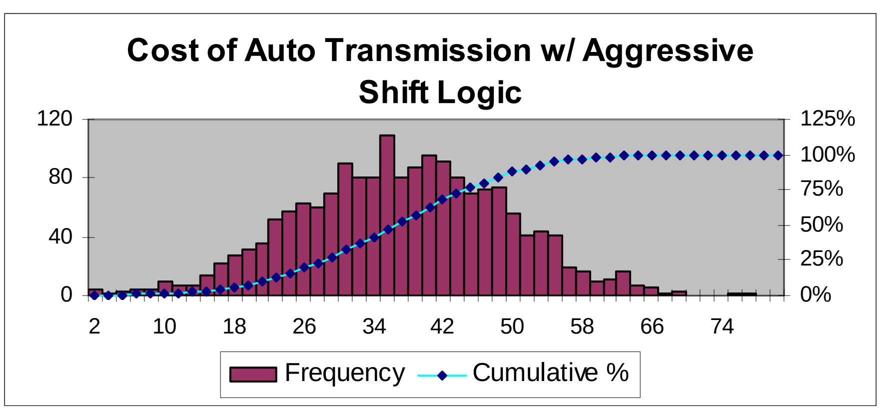


Figure X-5

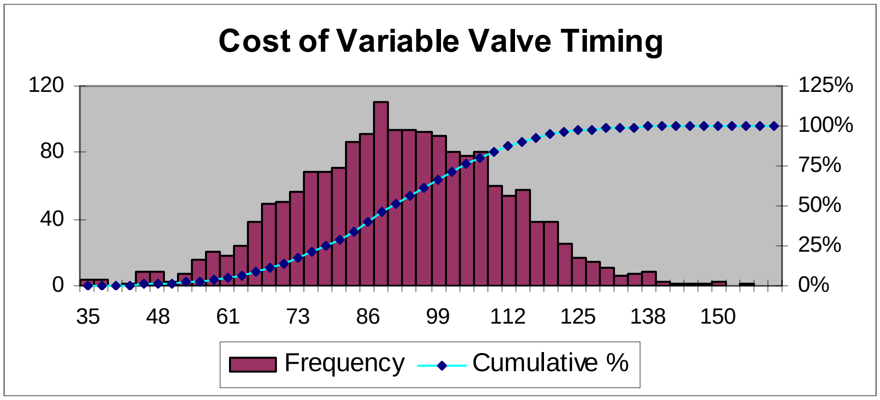


Figure X-6

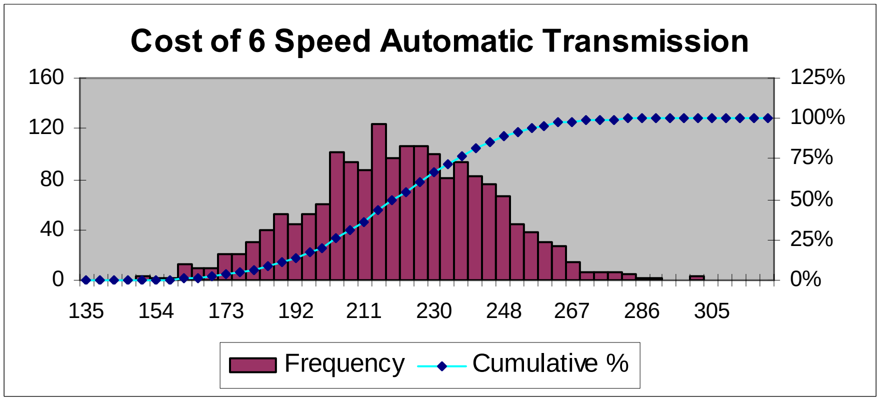


Figure X-7

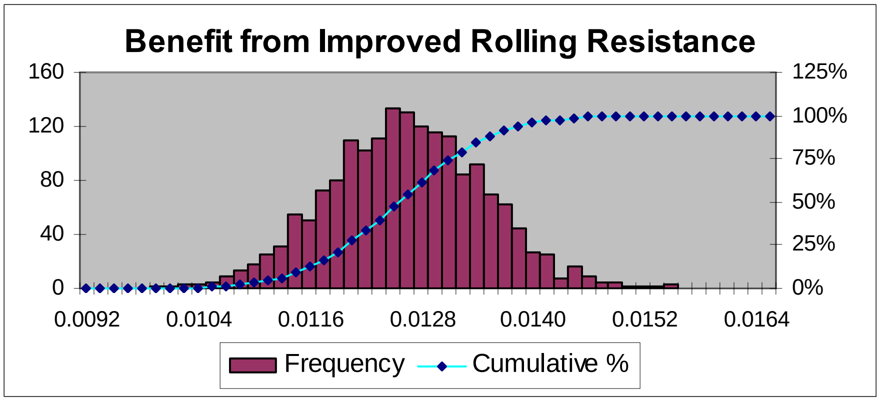


Figure 8

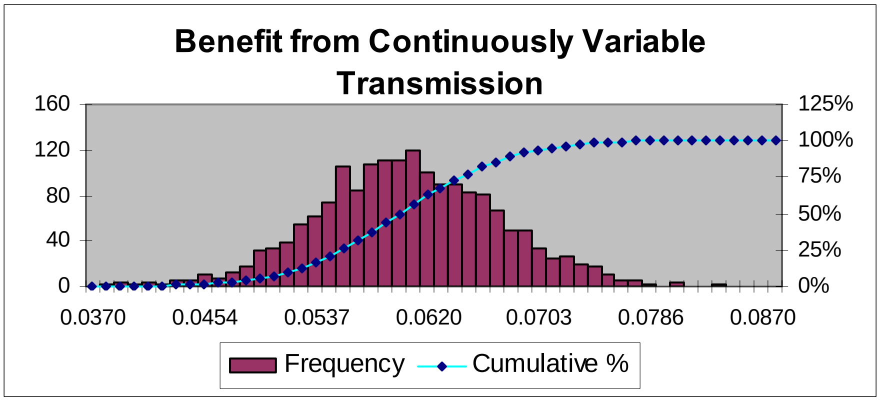


Figure X-9

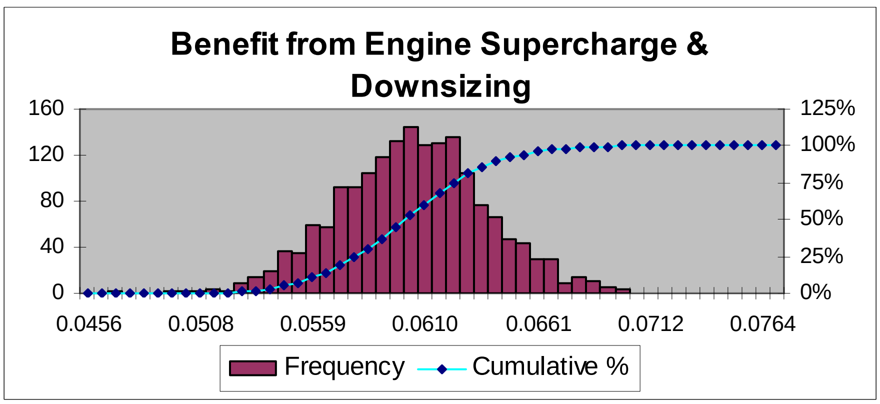


Figure X-10

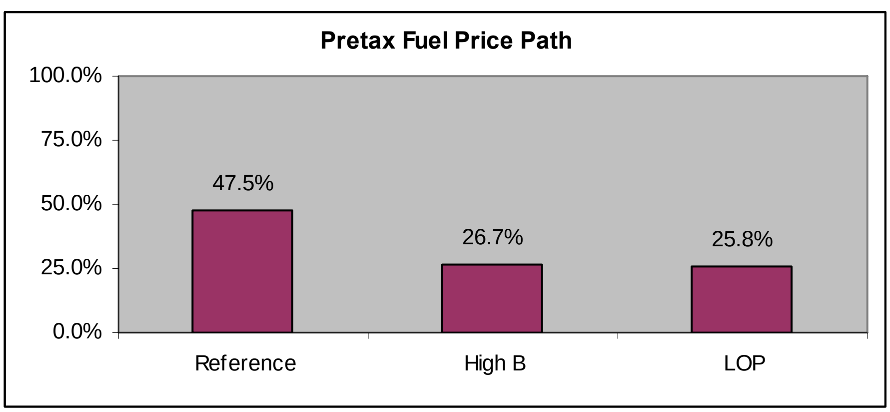


Figure X-11

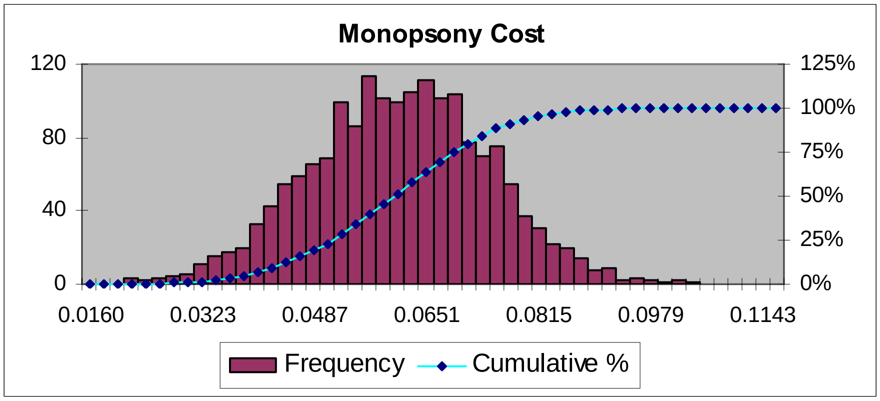
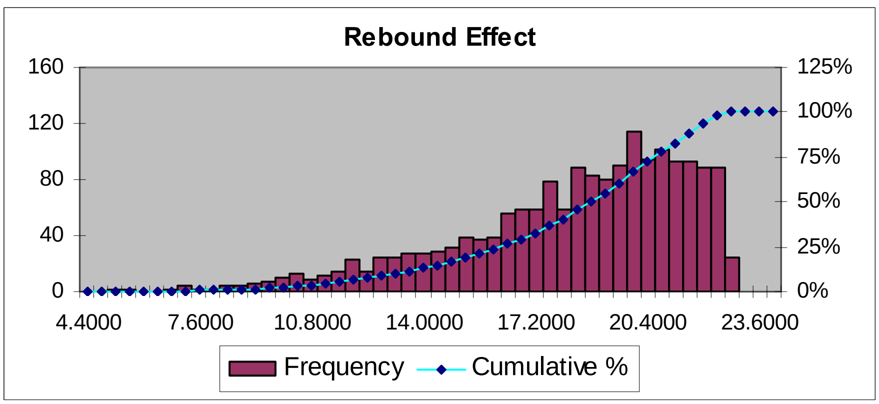


Figure X-12



Modeling Results – Output

Tables X-4 and X-5 summarize the modeling results for fuel saved, total costs, societal benefits, and net benefits. They also indicate the probability that net benefits exceed zero. These results are also illustrated in Figures X-13 through X-16 under Reformed CAFE at 7% for MY 2008. Although other combinations are not shown, the general shape of the resulting output distributions are similar for Unreformed CAFE and the 3 percent discount rate and for other years as well. The double-humped shape that occurs for both social benefits and net benefits reflects the different gasoline price scenarios. About three quarters of all draws were selected from either the AEO Reference Case or the Low Oil Price scenario while about one quarter were drawn from the High B case, which was noticeably higher than the other scenarios. The second hump reflects the impact of the High B gasoline price scenario. The following discussions summarize the range of results presented in these tables across both discount rates.

Fuel Savings: The analysis indicates that MY 2008 vehicles will experience between 691 million and 1,139 million gallons of fuel savings over their useful lifespan. MY 2009 vehicles will experience between 1,640 million and 2,686 million gallons of fuel savings. MY 2010 vehicles will experience between 2,447 million and 3,435 million gallons of fuel savings. MY 2011 vehicles will experience between 3,836 and 4,855 million gallons of fuel savings. Over the combined lifespan of the 4 model years, between 8.6 billion and 12.1 billion gallons of fuel will be saved.

Total Costs: The analysis indicates that owners of MY 2008 vehicles will pay between $385 million and $705 million in higher vehicle prices to purchase vehicles with improved fuel efficiency. MY 2009 owners will pay between $952 million and $1,631 million. MY 2010 owners will pay between $1,419 million and $2,202 million. MY 2011 owners will pay between $2,051 million and $3,195 million. Owners of all 4 model years vehicles combined will pay between $4.8 billion and $7.7 billion in higher vehicle prices.

Societal Benefits: The analysis indicates that changes to MY 2008 vehicles will produce overall societal benefits valued between $459 million and $1,418 million. MY 2009 vehicles will produce benefits valued between $1,123 million and $3,316 million. MY 2010 vehicles will produce benefits valued between $1,640 million and $4,360 million. MY 2011 vehicles will produce benefits valued between $2,590 million and $6,483 million. Over the combined lifespan of the 4 model years, societal benefits valued between $5.8 billion and $15.6 billion will be produced.

Net Benefits: The analysis shows that the Reform CAFE provides more net benefits than the Unreformed CAFE for every model year. Reform CAFE provides more benefits at roughly the same costs as Unreformed CAFE. The analysis indicates that the net impact of the proposed higher CAFE requirements for MY 2008 will be between a net cost of $110 million and a net benefit of $922 million. There is a at least a 93% certainty that changes made to MY 2008 vehicles to achieve the proposed CAFE standards will produce a net benefit. The net impact of the proposed higher CAFE requirements for MY 2009 will be between a net cost of $301 million and a net benefit of $2,007 million. There is at least a 93% certainty that changes made to MY 2009 vehicles to achieve the proposed CAFE standards will produce a net benefit. The net impact of the proposed higher CAFE requirements for MY 2010 will be between a net cost of $373 million and a net benefit of $2,596 million. There is at least a 93% certainty that changes made to MY 2010 vehicles to achieve the proposed CAFE standards will produce a net benefit. The net impact of the proposed higher CAFE requirements for MY 2011 will be between a net cost of $327 million and a net benefit of $3,814 million. There is at least a 96% certainty that changes made to MY 2011 vehicles to achieve the proposed CAFE standards will produce a net benefit. Over all 4 model years, the proposed higher CAFE standards will produce net impacts ranging from a net cost of $1.1 billion to a net benefit of $9.3 billion. There is at least a 93%

certainty that higher CAFE standards will produce a net societal benefit in each of the model years covered by this proposal.

Table X-4
Uncertainty Analysis Results
(3% Discount Rate)

	Unreformed			**Reformed**		
MY 2008	Mean	Low	High	Mean	Low	High
Fuel Saved (mill. gall.)	837	691	1,008	950	844	1,131
Total Cost ($mill.)	514	387	686	505	392	687
Societal Benefits ($mill.)	801	552	1,270	915	660	1,418
Net Benefits ($mill.)	287	7	753	410	64	922
% Certainty Net Ben. > 0	100%			100%		
MY 2009						
Fuel Saved (mill. gall.)	1,911	1,649	2,304	2,251	2,033	2,686
Total Cost ($mill.)	1,217	1,003	1,527	1,308	1,048	1,631
Societal Benefits ($mill.)	1,831	1,293	2,817	2,158	1,585	3,316
Net Benefits ($mill.)	613	-98	1,618	851	150	2,007
% Certainty Net Ben. > 0	99.8%			100%		
MY 2010						
Fuel Saved (mill. gall.)	2,755	2,498	3,207	2,937	2,667	3,435
Total Cost ($mill.)	1,747	1,436	2,139	1,767	1,419	2,190
Societal Benefits ($mill.)	2,652	1,915	4,093	2,833	2,071	4,360
Net Benefits ($mill.)	906	-67	2,345	1,066	149	2,596
% Certainty Net Ben. > 0	99.9%			100%		
MY 2011	**Not Applicable**					
Fuel Saved (mill. gall.)				4,200	3,887	4,855
Total Cost ($mill.)				2,603	2,051	3,164
Societal Benefits ($mill.)				4,078	3,012	6,483
Net Benefits ($mill.)				1,475	188	3,814
% Certainty Net Ben. > 0				100%		

Table X-5
Uncertainty Analysis Results
(7% Discount Rate)

	Unreformed			Reformed		
MY 2008	Mean	Low	High	Mean	Low	High
Fuel Saved (mill. gall.)	835	699	1,016	949	841	1,139
Total Cost ($mill.)	515	385	705	506	382	673
Societal Benefits ($mill.)	656	459	1,041	751	560	1,171
Net Benefits ($mill.)	141	-110	565	245	8	679
% Certainty Net Ben. > 0	93.7%			100%		
MY 2009						
Fuel Saved (mill. gall.)	1,905	1,640	2,239	2,247	2,005	2,605
Total Cost ($mill.)	1,216	952	1,597	1,306	1,047	1,629
Societal Benefits ($mill.)	1,500	1,123	2,214	1,775	1,335	2,606
Net Benefits ($mill.)	284	-301	1,141	468	-89	1,417
% Certainty Net Ben. > 0	93.7%			99.1%		
MY 2010						
Fuel Saved (mill. gall.)	2,749	2,447	3,146	2,933	2,604	3,379
Total Cost ($mill.)	1,747	1,421	2,187	1,767	1,428	2,202
Societal Benefits ($mill.)	2,177	1,640	3,158	2,329	1,764	3,425
Net Benefits ($mill.)	430	-373	1,644	562	-172	1,837
% Certainty Net Ben. > 0	93.6%			97.8%		
MY 2011	**Not Applicable**					
Fuel Saved (mill. gall.)				4,192	3,836	4,799
Total Cost ($mill.)				2,599	2,059	3,195
Societal Benefits ($mill.)				3,351	2,590	4,974
Net Benefits ($mill.)				752	-327	2,574
% Certainty Net Ben. > 0				96.8%		

Figure X-13

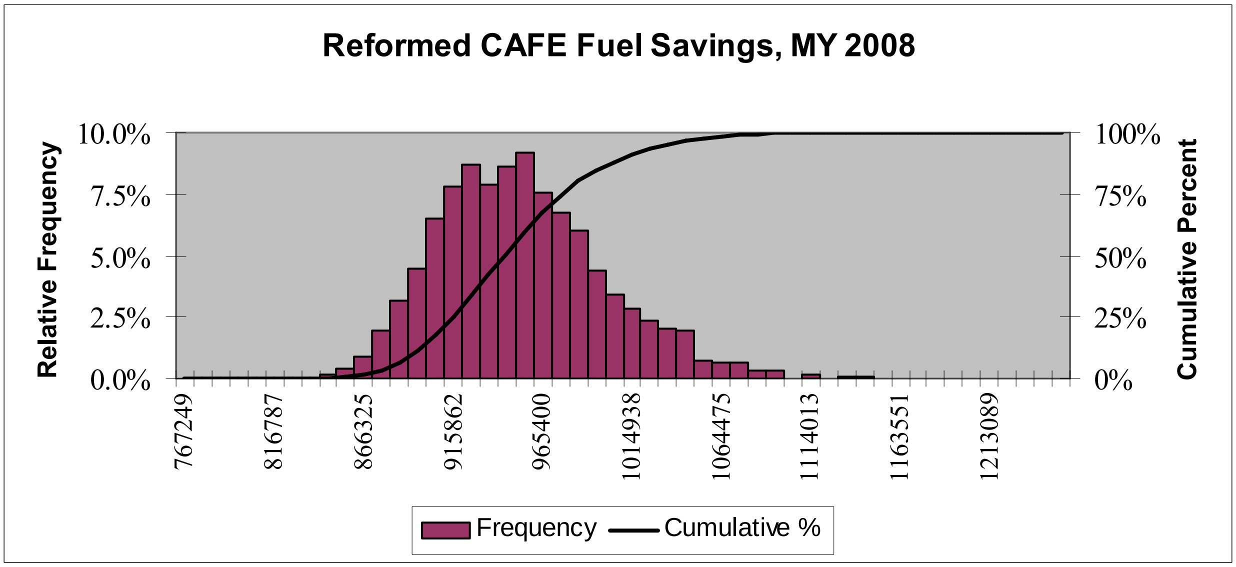


Figure X-14

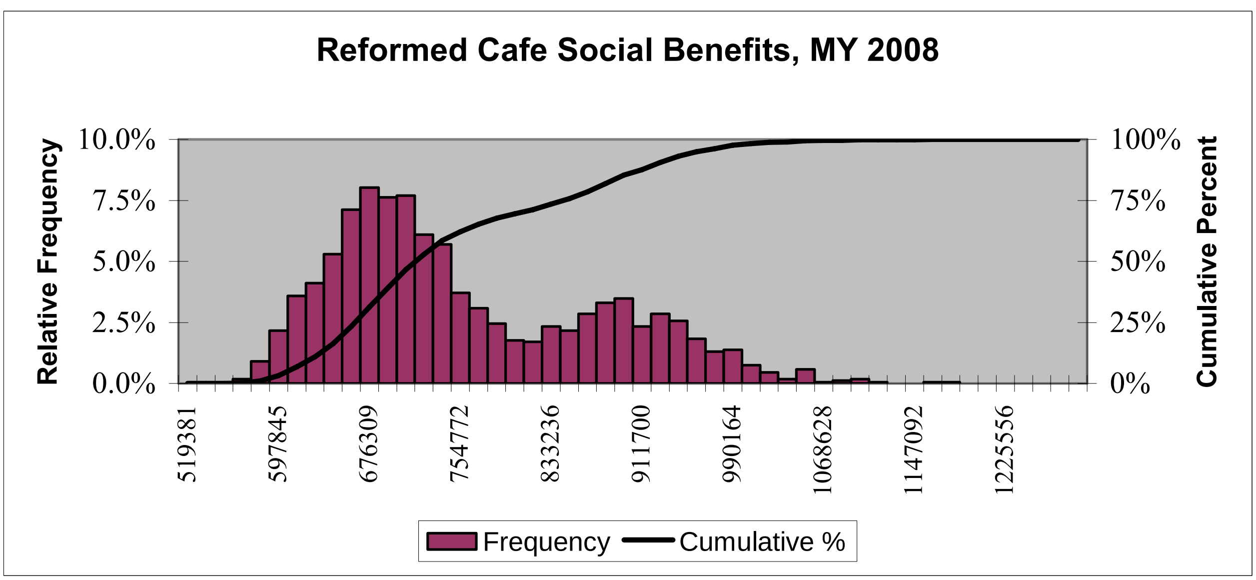


Figure X-15

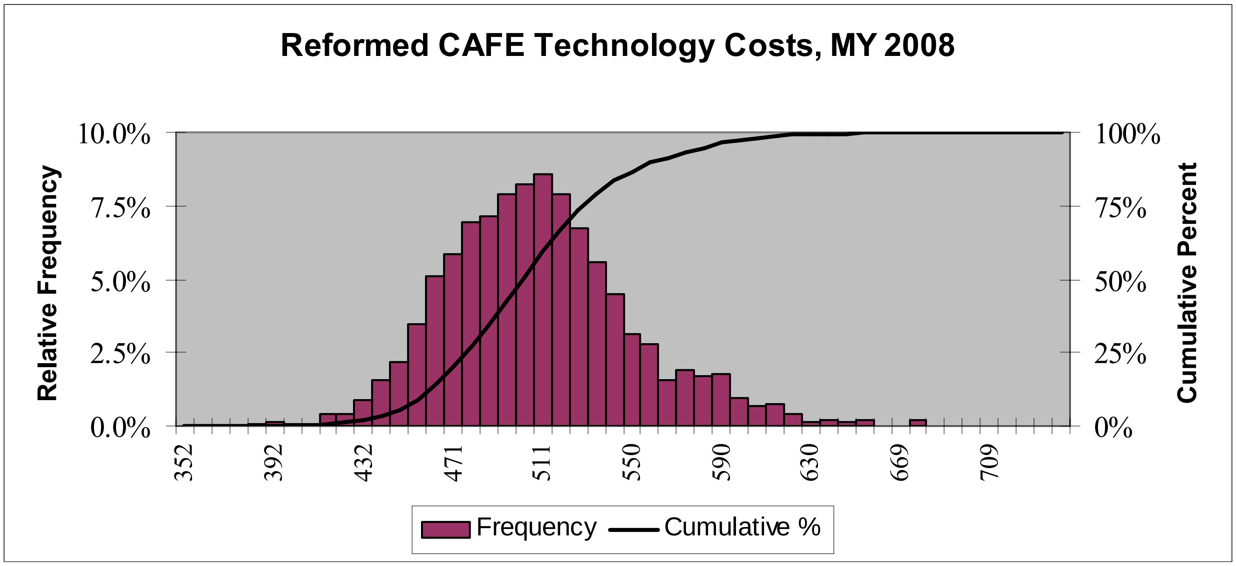
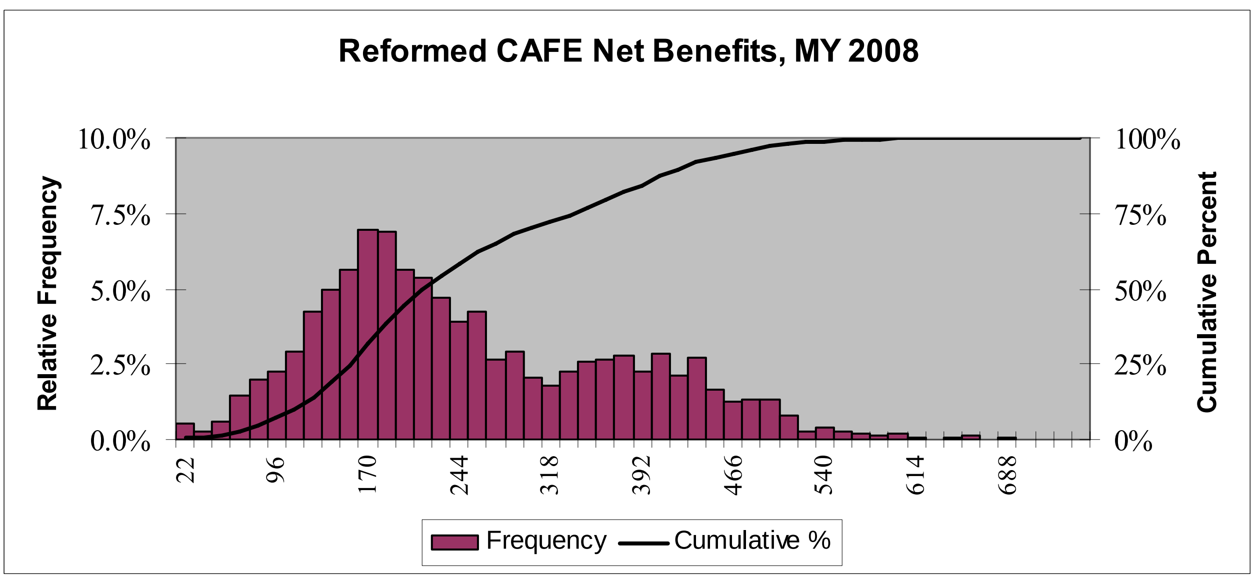


Figure X-16



XI. SMALL BUSINESS IMPACT

Regulatory Flexibility Act

The Regulatory Flexibility Act of 1980 (5 U.S.C. §601 et seq.) requires agencies to evaluate the potential effects of their proposed and final rules on small businesses, small organizations and small governmental jurisdictions. According to the Small Business Administration's small business size standards (see CFR 121.201), an automobile manufacturer (NAICS code 336111) must have less than 1,000 employees to qualify as a small business.

The agency knows of no small businesses that produce light trucks. All of the manufacturers of light trucks have thousands of employees.

Unfunded Mandate Reform Act Analysis

The Unfunded Mandates Reform Act of 1995 (Public Law 104-4) requires agencies to prepare a written assessment of the costs, benefits, and other effects of proposed or final rules that include a Federal mandate likely to result in the expenditure of State, local, or tribal governments, in the aggregate, or by the private sector, of more than $100 million annually (annually adjusted for inflation with a base year of 1995). Adjusting this amount by the implicit gross domestic product price deflator for the year 2003 (base year 2000 = 100) results in $115 million (105.998/92.106 = 1.15).

The assessment can be included in conjunction with other assessments, as it is here. These effects have been discussed in detail in previous sections of this Preliminary Regulatory Impact Analysis. This proposal is not likely to result in expenditures by State, local, or tribal governments of more than $115 million annually. However, it is estimated to result in expenditures by light truck manufacturers of more than $115 million annually.

Appendix A:

Expanded Applicability (8,500-10,000 lbs. GVWR)

In the ANPRM, the agency sought comment on whether to extend the applicability of the CAFE program to include vehicles with a GVWR between 8,500 lbs. and 10,000 lbs., especially those that are defined by the EPA as medium duty passenger vehicles (MDPVs) for MY 2011 or later. Under EPCA, the agency can regulate vehicles with a GVWR between 6,000 lbs. and 10,000 lbs. under CAFE if we determine that (1) standards are feasible for these vehicles, and (2) either that these vehicles are used for the same purpose as vehicles rated at not more than 6,000 GVWR, or that their regulation will result in significant energy conservation. The MDPV category includes vehicles with a GVWR greater than 8,500 lbs. but less than 10,000 lbs. and that were designed primarily to transport passengers, i.e., large vans and SUVs.

In preparing this proposal, the agency analyzed the feasibility of including MDPVs and the impact of their inclusion on the fuel savings of the CAFE standards. The agency believes that fuel economy technologies applicable to vehicles with a GVWR below 8,500 lbs. might be applicable to MDPVs, e.g., low-friction lubricants and cylinder deactivation. MDPVs are already required by EPA to undergo a portion of the testing necessary to determine fuel economy performance under the CAFE program. See, 40 CFR Part 600 Subpart F. If MDPVs were included in the CAFE standards, manufacturers would be able to rely on this testing to generate a portion of the data necessary to determine fuel economy performance. A similar test procedure could be used to generate the remaining necessary data. Accordingly, we do not believe that, if

MDPVs were included in the CAFE program, meeting the additional testing requirements would be burdensome.

The agency's analysis of the impact of including MDPVs on fuel savings indicated that their inclusion in MYs 2008-2010 would lead to a net loss of fuel savings. Under the Unreformed CAFE structure, maximum feasible standards are set with particular consideration given to the least capable manufacturer, which has been determined to be General Motors for this proposed rule. Almost all of the MDPVs are produced by General Motors and, due to their weight, have very low fuel economy. The inclusion of these vehicles would lead to greater fuel savings by General Motors, but less by the other manufacturers. This would occur because the addition of the low fuel economy MDPVs in MYs 2008-2010 would depress the level of General Motors' CAFE and, using the methodology we chose for selecting the proposed fuel economy levels, therefore would depress the level of the Unreformed CAFE standards. We calculate that the Unreformed CAFE standards for MYs 2008-2010 would be 0.3 mpg lower if MDPVs were included in those years. This would affect not only General Motors, but also some other manufacturers. Since the MY 2008-2010 Reformed CAFE standards would be set so as to equalize industry-wide costs with the MY 2008-2010 Unreformed CAFE standards to the extent possible, depressing the Unreformed CAFE standards for MYs 2008-2010 would also depress the Reformed CAFE standards for those years. The net effect of including MDPVs in the MY 2008-2010 Reformed CAFE standards would be a reduction in overall fuel savings of almost 1.1 billion gallons.

While the agency is not proposing to include MDPVs under Reformed CAFE in MY 2011, it seeks comment whether they should be included in final rule for that model year. Inclusion of MDPVs in the MY 2011 Reformed CAFE standard would result in a net increase in fuel savings. If the agency were to include MDPVs, we would adopt essentially the EPA definition of "medium duty passenger vehicles."

If we do not regulate MDPVs, manufacturers could very well decide, nevertheless, to install fuel-efficient technologies in their MDPVs as they become more widely used in their non-MDPV fleet, and thereby less expensive, in order to improve market demand for their vehicles.

Baseline and Alternatives

The baseline, against which costs and benefits are estimated for all the scenarios, are the manufacturer's plans for each model year 2008-2011 or the MY 2007 standard of 22.2 mpg without MDPVs, whichever is higher. Each manufacturer and each year was calculated separately and compared to the manufacturer's plans or the baseline of 22.2 mpg.
The scenarios examined were:

1: Adjusted baseline using 22.2 mpg minimum without MDPVs, or manufacturer's plans if higher than 22.2 mpg

2: Unreformed CAFE system without MDPVs for 2008-2010, Reformed CAFE system with MDPVs for 2011

3: Unreformed CAFE system with MDPVs for 2008-2010, Reformed CAFE system with MDPVs for 2011

4: The Reformed CAFE system without MDPVs with 2008-2010, with MDPVs for 2011

5: The Reformed CAFE system with MDPVs for 2008-2011

Examined CAFE Levels and Category Targets

Table A-1 shows the examined Unreformed CAFE levels for Scenarios 1, 2, and 3. Table A-2 shows the category targets for the Reformed Cafe Scenarios 4, and 5.

Table A-1
Examined Unreformed CAFE Standards for Scenarios 1, 2, and 3
(in mpg)

	2008	**2009**	**2010**	**2011**
Scenario 1 Baseline	21.64	21.92	22.00	22.01
Scenario 2 (Unreformed CAFE without MDPVs)	22.5	23.1	23.5	See Scenario 4 categories
Scenario 3 (Unreformed CAFE with MDPVs)	22.2	22.8	23.2	See Scenario 4 categories

Table A-2
Proposed Category Targets for Reformed CAFE Scenarios 4 and 5
(in mpg)

Category	**2008**	**2009**	**2010**	**2011**
Scenario 4 (Without MDPVs in 2008-10, With MDPVs for 2011)				
1 <= 43.0 square feet	26.8	27.4	27.8	28.5
2 >43.0 to < 47.0	25.6	26.4	26.4	27.1
3 47.0 to < 52.0	22.3	23.5	24.0	24.5
4 52.0 to < 56.5	22.2	22.7	22.9	23.3
5 56.6 to < 65.0	20.7	21.0	21.6	21.8
6 ≥ 65.0	20.4	21.0	20.8	21.3
Scenario 5 (With MDPVs)				
1 < 43.0 square feet	26.0	26.7	27.1	28.2
2 43.0 to < 47.0	25.7	26.2	26.3	27.3
3 47.0 to < 52.0	22.3	23.3	23.7	24.6
4 52.0 to < 56.5	22.0	22.4	22.6	23.5
5 56.6 to < 65.0	20.0	20.4	21.0	21.5
6 ≥ 65.0	20.3	21.0	20.8	21.6

Table A-3
Savings in Billions of Gallons of Fuel
Undiscounted over the Lifetime of the Model Year

	MY 2008	MY 2009	MY 2010	MY 2011
Scenario 2	0.8	1.9	2.7	4.6
Scenario 3	0.5	1.6	2.4	4.5
Scenario 4	0.9	2.2	2.9	4.5
Scenario 5	0.7	1.7	2.5	4.8

TABLE A-4
Incremental Total Cost
(in Millions of Year 2003 Dollars

	MY 2008	MY 2009	MY 2010	MY 2011
Scenario 2	528	1,244	1,798	2,783
Scenario 3	270	993	1,514	2,783
Scenario 4	484	1,317	1,772	2,783
Scenario 5	364	991	1,512	2,984

Table A-5
Incremental Total Societal Benefits
Over the Vehicle's Lifetime – Present Value
Discounted at 3%, in Millions of Year 2003 Dollars

	MY 2008	MY 2009	MY 2010	MY 2011
Scenario 2	723	1,695	2,400	4,105
Scenario 3	435	1,408	2,254	4,105
Scenario 4	801	1,961	2,575	4,105
Scenario 5	644	1,523	2,321	4,323

Table A-6
Incremental Total Societal Benefits
Over the Vehicle's Lifetime – Present Value
Discounted at 7%, in Millions of Year 2003 Dollars

	MY 2008	MY 2009	MY 2010	MY 2011
Scenario 2	605	1,366	2,007	3,394
Scenario 3	358	1,181	1,809	3,394
Scenario 4	665	1,622	2,144	3,394
Scenario 5	525	1,258	1,894	3,582

Table A-7
Net Total Benefits
Over the Vehicle's Lifetime – Present Value
Discounted at 3%, in Millions of Year 2003 Dollars

	MY 2008	MY 2009	MY 2010	MY 2011
Scenario 2	195	451	602	1,322
Scenario 3	165	481	740	1,322
Scenario 4	397	644	803	1,322
Scenario 5	280	532	809	1,339

Table A-7
Net Total Benefits
Over the Vehicle's Lifetime – Present Value
Discounted at 7%, in Millions of Year 2003 Dollars

	MY 2008	MY 2009	MY 2010	MY 2011
Scenario 2	77	122	209	611
Scenario 3	88	188	295	611
Scenario 4	181	305	372	611
Scenario 5	161	267	382	598