U.S. Department
Of Transportation

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FINAL ECONOMIC ASSESSMENT

CORPORATE AVERAGE FUEL ECONOMY STANDARDS FOR MY 2005-2007 LIGHT TRUCKS

Office of Regulatory Analysis and Evaluation
Plans and Policy
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EXECUTIVE SUMMARY

This assessment examines the costs and benefits of the final rule establishing corporate average fuel economy (CAFE) standards for light trucks for model years (MY) 2005-2007. It includes a discussion of the technologies that can improve fuel economy, the potential impact of the final rule on light truck retail prices and lifetime discounted fuel savings, and the gallons of fuel that could be potentially saved. Based on data provided by the manufacturers, analyses prepared by the National Academy of Sciences, and the agency's own analyses, the agency has examined General Motors, Ford, and DaimlerChrysler individually, and projected for each light truck manufacturer the manufacturers' capabilities and how they could meet the final rule. The agency assumes and expects there will be no reduction in performance and no reduction in weight compared to the manufacturer's plans.

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

Benefits: Benefits are also determined from the level of the manufacturer's plans up to the level of the final rule. The benefits are derived mainly from fuel savings over the lifetime of the vehicle. However, the benefits also include the results of a number of additional analyses that relate to the value of oil import externalities, criteria pollutant emissions, and a variety of beneficial transportation benefits associated with the "rebound effect". Table 1 provides the benefit estimates on a per vehicle basis and Table 2 provides them on a fleet-wide basis.

Net Benefits: Comparing the costs and benefits, the final rule fuel economy standards are cost beneficial on a societal basis.

Safety Impacts: The agency believes the manufacturers will meet the fuel economy levels without weight reductions. Thus, there need not be a safety impact due to reducing weights for light trucks.

Table 3 provides the level of the final rule, an adjusted baseline weighted average fuel economy based on the manufacturers' product plans, and a weighted average fuel economy for the fleet after assuming increases in technology to bring the manufacturers' average fuel economy up to the level of the standard. Some manufacturers already (in MY 2001) exceed the standard levels, thus the weighted average exceeds the level of the final rule. Finally, Table 3 shows the lifetime fuel savings in millions of gallons.

Table-1

Incremental Cost and Benefit Analysis
Per Average Vehicle - Over its Lifetime
(In Year 2000 Dollars)

	Costs	**Benefits**	**Net Benefits**
MY 2005	$22	$29	$7
MY 2006	$67	$83	$16
MY 2007	$106	$121	$15

Table-2

Incremental Total Cost Benefit Analysis
Over the Lifetime of the Fleet
(In Millions of Year 2000 Dollars)

	Costs	**Benefits**	**Net Benefits**
MY 2005	$170	$218	$48
MY 2006	$537	$645	$108
MY 2007	$862	$955	$93

Table-3
Savings in Millions of Gallons of Fuel

	Final Rule Fuel Economy Standard (mpg)	**Adjusted Baseline Fuel Economy Level Pre-Standard (mpg)**	**Estimated Fuel Economy Level Post Standard (mpg)**	**Lifetime Fuel Savings (in Millions of Gallons) Undiscounted**	**Lifetime Fuel Savings Present Discounted Value**
MY 2005	21.0	21.13	21.29	432	263
MY 2006	21.6	21.31	21.78	1,273	774
MY 2007	22.2	21.60	22.31	1,892	1,151

I. INTRODUCTION

The purpose of this document is to analyze the effects of the final rule on the fuel economy standards for light trucks from MY 2005 to MY 2007. It includes a discussion of the technologies that can improve fuel economy, the potential impacts on light truck retail prices, lifetime discounted fuel savings, and the potential gallons of fuel saved. The standards apply to light trucks (pickups, vans, and sport utility vehicles) with a gross vehicle weight rating (GVWR) of 8,500 pounds or less.

Model Year (MY) 1979 was the first model year for which light truck fuel economy standards were established. Since that time, the standards have slowly increased up to the current level of 20.7 mpg. This level has remained in effect from MY 1996 to MY 2004 The agency was precluded by Congress from spending funds regarding potential changes in fuel economy standards from 1995 to December 2001 through a yearly restriction in DOT's annual appropriations act. This factor precluded the agency from performing the analysis required to set a standard other than 20.7 mpg. The Department of Transportation and Related Agencies Appropriations Act for FY 2002 (Public Law 107-87) was enacted on December 18, 2001, and did not contain a provision restricting the Secretary's authority to prescribe fuel economy standards. Thus, the ban on spending has been lifted and the agency is statutorily required to determine the maximum feasible fuel economy level and set fuel economy standards for light trucks.

The agency published a final rule on April 4, 2002 (67 FR 16052), setting the CAFE standard applicable to light trucks for the 2004 MY at 20.7 mpg. The CAFE standard was set at the same level as prior years due to the limited manufacturer lead-time and the limited data available to the agency which could have justified a higher CAFE for MY 2004 light trucks.

On February 7, 2002, (67 FR 5767), the agency issued a Request for Comments, seeking data upon which it could assess the viability of a reinvigorated CAFE program. The Request for Comments also sought comment on the recommendations arising from the National Academy of Sciences study[1] published in January 2002. 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.

The NAS report includes a substantial amount of information, including findings on past CAFE standards, analyses of future technologies and their cost effectiveness, and recommendations for the future. These findings and recommendations are too numerous to summarize here. One of the report's findings (Finding #5) is that technologies exist for light trucks that would significantly reduce fuel consumption within 15 years. However, some of those technologies that can "significantly" improve fuel economy will not be available during the MY 2005 to MY 2007 time frame.

[1] "Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards", National Research Council, 2002.

On December 16, 2002, the agency published a Notice of Proposed Rulemaking (NPRM) in the Federal Register (67 FR 77015) proposing fuel economy levels for light trucks for model years (MY) 2005, 2006, and 2007. The proposed light truck fuel economy levels are shown in Table I-1.

Table I-1
Proposed Fuel Economy Levels

	Miles per gallon
MY 2005	21.0
MY 2006	21.6
MY 2007	22.2

The impact of the proposal was analyzed in the "Preliminary Economic Assessment, Corporate Average Fuel Economy Standards for MY 2005-07 Light Trucks", (PEA) December 2002, (Docket No. 11491-57).

The final rule light truck fuel economy levels that will be analyzed in this final Economic Assessment are shown in Table I-2.

Table I-2
Final Rule Fuel Economy Levels

	Miles per gallon
MY 2005	21.0
MY 2006	21.6
MY 2007	22.2

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. 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 and can reduce the flow of oil profits to certain nations now hostile to the U.S. Reducing the growth rate of oil use can 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.

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 2001, transportation's share of U.S. oil use had increased to 69% (12.5 out of 18.1 mmbd) (USDOE/EIA, 2002a). 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 (NEPDG, 2001, ch. 7).

We believe that the continued development of advanced technologies, such as fuel cell technology and the hydrogen-fueled vehicle, and an infrastructure to support it, may help to achieve significant reductions in foreign oil dependence and stability in the world oil market in the long run. The continued infusion of hybrid electric propulsion and advanced diesel engine vehicles is also likely to help reduce dependence on petroleum in the short term.

Trends and Outlook

The overall fuel efficiency of the new passenger car and light truck fleet remains approximately what it was in 1988. The increased market success of light trucks, combined with the maintenance of the CAFE standards at the levels set for 1996, has led the combined average fuel economy of new light-duty vehicles to actually decline to 24.0 mpg in 2002 (Hellman and Heavenrich, 2001). Considering all light-duty vehicles on the road, average fuel economy has inched upward from 19.6 in 1991 to 20.1 in 2000, as the oldest, least efficient vehicles were retired. At the same time, vehicle travel increased at an average annual rate of 2.5% (Davis, 2002, table 6.5). By 2020, the Energy Information Administration projects that light duty vehicle travel will increase by an additional 50 percent over today's level. But light truck travel 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. When the Automotive Fuel Economy Standards were enacted in 1975, light trucks accounted for only 20 percent of light-duty vehicle energy use. Light trucks account for 40 percent today, and their share is projected to increase to 55 percent by 2020.

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 10.1 mmbd. As a percent of U.S. petroleum use, imports have also more than doubled: from 27% in 1985 to 55% in 2001, the highest level of import dependency in our history. Over the past two years our trade deficit in oil has averaged $100 billion per year.

Projections by the Energy Information Administration foresee further growth in U.S. import dependence and growing world dependence on OPEC oil producers.[1] By 2020, transportation petroleum use is projected to expand from 13.7 to 19.9 mmbd, accounting for 90% of the increase in total U.S. petroleum requirements. Light trucks alone are expected to account for almost half of the growth in transportation oil use over the next 20 years (USDOE/EIA, 2001b). From 2000 to 2020, total transportation petroleum use is projected to increase by 6.2 mmbd; light trucks are expected to account for 2.9 mmbd of this increase.

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.

[1] According to DOE's Transportation Energy Data Book, page I-9, net imports of petroleum have been steadily increasing, while OPEC's share of net imports has remained around 50% for the past 5-6 years. For the same time period, the Transportation Energy Data Book also shows that the net Persian Gulf share has been increasing from 19% to over 25%.

Transportation is the predominant petroleum consumer in the U.S. economy. The transportation sector alone requires 50% more oil than the U.S. produces, 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 (USDOE/EIA, 2001a). Within the transportation sector, passenger cars and light trucks (the vehicles covered by fuel economy standards) account for almost 60% of petroleum consumption.

Increasing fuel economy without increasing the price of fuel will lead to some additional vehicle travel, but this has been found to be a relatively minor effect on fuel savings. It is estimated that increasing fuel economy by 10% will produce an 8% reduction in fuel use (Greene, Kahn and Gibson, 1999).

Past fuel economy increases have had a major impact on U.S. petroleum use. The National Research Council determined that if fuel economy had not improved since the 1970s, U.S. gasoline consumption and oil imports would be about 2.8 million barrels per day higher than they are today (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 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. Petroleum conservation by the U.S. over this same period played a major role in the collapse of oil prices in 1986, and the years of relatively low prices that ensued.

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III. DOCKET COMMENTS

There were a significant number of commenters to the docket (Docket #11419) that addressed a large variety of economic issues. In this chapter we will identify the issues and describe the agency's analysis and response to these issues.

1. <u>Impact of specific safety standards on vehicle weight, or fuel economy.</u>

General Motors (Docket #16447, page 1, 11, and Appendix Attachment 8, Page 68) and Ford (Docket #16457, page 4-6) provided estimates of the weight impacts of specific safety measures. Some of these safety measures are already required by standards, some are from proposals that have not been finalized (which may or may not be effective by MY 2007), and some are from voluntary safety measures. In the manufacturers' initial plans, they included discussions of the weight impact of several safety measures.

The agency examined the additional weight claimed by commenters to this docket, due to required or voluntary actions (but excluded those actions that probably won't be effective by MY 2007). The most significant fuel economy impact claim from General Motors was on the proposed FMVSS 139, to upgrade the tire standard. While the final rule on FMVSS 139 has not been published, the agency expects the revised tire standards will have almost no impact on new vehicle weight. Only Ford provided enough data for a complete analysis (see Chapter IV.)

2. Cost of Specific Technologies

General Motors (Docket #16447, pages 1, 6, and Appendix, page 23) noted that the agency made a clerical error that underestimated costs. The agency agrees and has made the correction. GM also argued that the agency assumed that all technologies will cost manufacturers the same amount for all models no matter how much progress they have made to date. GM argued that to assume that GM can continue to make improvements in these areas at the same rate and at the same cost as other manufacturers is not correct. In the final rule the agency has decided to rely on the NAS mid-point values for the fuel economy improvement and cost estimates for individual technologies. While we assume specific technologies for each manufacturer, we are not refining our analysis to assume different fuel economy improvements or costs for individual manufacturer situations.

General Motors (Appendix, page 23-26), Ford (Docket #16457, page 3), DaimlerChrysler (Docket #14922, page 2), the Alliance (Docket #16435 p. 7) and Toyota (Docket #16459, page 2) stated that the agency underestimated the costs of specific technologies.

Honda (Docket #16922, page 4) provided cost estimates for hybrid vehicles. Incremental price estimates from Electric Power Research Institute (EPRI) research are illustrative of the hybrid cost issue: \$2500-\$3600 higher for a compact car, \$4000 - \$5500 higher for a mid-size SUV, and \$4500 - \$6500 for a full size SUV (most of this additional cost was due to the NiMH battery pack).

Public Citizen (Docket #17228, page 23) provided comments that reference theoretical vehicles designed by the Union of Concerned Scientists (UCS), which were based on the Ford Explorer; the UCS Exemplar and the UCS Exemplar Plus. The Exemplar had a fuel economy of 28.4 mpg through use of current technologies and had a vehicle price $715 more than the Ford Explorer. The Exemplar Plus had a fuel economy of 34.1 mpg and had a vehicle cost $935 greater than the Ford Explorer.

20/20 Vision (Docket #16424, page 1) contends that raising fuel economy standards by only 1.5 miles per gallon over a three-year period is outpaced by gains attributed to technologies currently available. Drawing on information from the National Academy of Science report that available technology could be used to raise fuel standards by 20 percent or more, 20/20 Vision analyzed retrofit costs and determined "that a 20 percent gain in fuel economy would require $700 more per vehicle, and a 50 percent gain would cost $2,700 per vehicle." The technologies evaluated in the 20/20 Vision cost assessment are many of those considered by NHTSA in its CAFE NPRM and include "continuously variable transmissions, rolling resistance, tire efficiencies, load reduction, low friction lubricants, mass reduction, and streamlining."

The agency must consider economic practicability and lead time before it can suggest changes along the lines proposed by Public Citizen or 20/20 Vision. The large improvements in miles per gallon that they discussed do not appear feasible for MY 2007.

Many commenters took issue with NHTSA's assumptions regarding the incremental retail price equivalents (RPE) increases and fuel consumption reductions associated with technologies that had been identified by the NAS. As explained in the PEA[1], in developing such estimates, NHTSA staff considered the estimates in the NAS report, public and confidential information provided by manufacturers and other respondents to NHTSA's February 2002 notice, estimates in publicly available literature, and applied engineering and economic judgment in attempting to arrive at realistic estimates for these technologies.

However, some manufacturers and their associations argued that, in doing so, NHTSA had understated price increases. GM commented that the costs used by NHTSA in the Volpe analysis are in almost every case lower than the costs determined by the National Research Council in its recent study. On the other hand, some environmental organizations argued that NHTSA had both overestimated costs and underestimated potential fuel consumption reductions. Environmental Defense (ED) (Docket # 16454, page 1) claimed that "...many of the fuel economy benefits cited for technologies are at the low end of reasonable ranges in the literature." The Union of Concerned Scientists (UCS) (Docket #17231, page 2) indicated that "One major concern is that NHTSA appears to have inappropriately incorporated many of the arguments used by automakers in claiming that the National Academy of Sciences violated the laws of thermodynamics in their recent fuel economy assessment along with overall conservative estimates provided by the automakers." Similarly, the American Council for an Energy-Efficient Economy (ACEEE) (Docket # 17194, page 6) claimed, "in the absence of solid new information, NHTSA should have used cost and benefit numbers from the NAS report on fuel economy" and "...the NAS report in many cases underestimated the benefits of fuel economy strategies."

1 "Preliminary Economic Assessment, Corporate Average Fuel Economy Standards for MY 2005-2007 Light Trucks", December 2002, NHTSA, Docket #11419-57.

In developing the RPE increase and fuel consumption reduction estimates for the PEA, NHTSA gave significant weight to confidential information submitted by manufacturers. However, that information often covered very wide ranges with respect to both cost and performance. NHTSA tried to represent the level of uncertainty regarding costs and performance, and attempted to resolve this uncertainty in developing the PEA by exercising staff-level engineering and economic judgment. However, NHTSA recognizes that the NAS report drew from among those experts with the most fuel economy expertise in the country, considered information provided by the same manufacturers who commented on the current NPRM, and also sponsored studies of technology performance and costs by two contractors with established experience in the field. Given that these NAS cost estimates were agreed to by a distinguished committee and the additional information the agency is getting does not agree or converge on reasonably close cost estimates, the agency believes it is best to rely on the NAS estimates where they were available. Based on these comments and this reconsideration of the NAS report, NHTSA has determined that the best estimates of incremental retail price equivalent (RPE) increases and fuel consumption reductions are those stated in the NAS report, and has used the NAS report's mid-point estimates in preparing this Final Economic Assessment of the CAFE standards.

3. The standards will result in fewer products or products with limited utility being offered to consumers

GM (Docket #16447 page 2) stated that in view of the divergence between GM's product plan and NHTSA's proposed standards, [

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The Recreational Vehicle Industry Association (RVIA) (Docket #16926, page 3) raised concerns that reductions in the size and towing capacity of light trucks resulting from required increases in their fuel economy may have the effect of restricting the size, weight, and capacity of trailers they are capable of towing, thus restricting the products that can be offered for sale by manufacturers of travel trailers and conversion vehicles.

The National Truck Equipment Association (Docket #16449) warned that increasing CAFE standards in a manner that could curtail full size or adequately powered light trucks or vans could force commercial users to purchase larger vehicles, outside the scope of CAFE in order to meet their needs.

The agency does not believe that any manufacturer will choose to restrict product offerings because of the standard.

4. Lead time

There were a number of comments about the agency not providing the manufacturers enough lead time. GM (#16447 page 4), the Alliance (Docket #16435, page 2), Ford (Docket #16457, page 4), DaimlerChrysler (#14922, page 2), argued that incorporation of technologies is a multi-year task and the agency did not allow enough lead time for several technologies.

On the other hand, Public Citizen (Docket #17228, page 2) stated the agency "completely underestimates industry capability by relying on manufacturer representations…". The Union of Concerned Scientists (Docket #17231, page 6) contends that automobile manufacturers can incorporate fuel-efficient technology into vehicles faster than assumed in the NHTSA analysis. UCS recommends a further investigation into the acceleration of technology introduction. In addition, UCS asks NHTSA to consider a longer timeframe than 2005-2007 for the setting of standards. UCS advises NHTSA to use the uncertainty by automakers in their product plans as a tool to "lock in the use of technology for fuel economy gains rather than increases in weight and power."

The agency made projections about what technologies would be available to each manufacturer and when, and estimated what technologies could be packaged together in determining lead-times. The agency has projected what technologies could be added by manufacturers during specific model years 2005-2007. We have revised our assumptions about how quickly some technologies can be introduced. Some technologies are now assumed to take three years to reach 100 percent introduction. (See Tables VI-15 to VI-17 for our assumptions).

5. <u>The baseline (why we use 20.7 mpg, how we handle the alternative fuels issue, etc.)</u>

Ford (Docket #16457, page 1) and the Alliance (Docket #16435, page 10) notes that the product plan submitted previously in response to the ANPRM included many new small truck models and additional fuel economy technologies, and that the costs for these product changes are not reflected in NHTSA's estimate of the costs for complying with the proposed standard.

On the other hand, Public Citizen (Docket # 17228, page 5) argues that the agency relied too heavily on the manufacturers for the baseline mpg level and for estimated mpg levels for future model years. The Alliance to Save Energy (Docket #16928, page 1) says that the proposal should consider Ford's voluntary commitment to improve fuel economy of their SUV fleet by 25% by the year 2005.

The agency continues to believe that using the manufacturers' plans was the best way of defining a baseline, since the planned introduction of new vehicle models could be accounted for. Since manufacturers are required to achieve the current 20.7 mpg standard through MY 2004, we believe using the 20.7 mpg baseline is a valid measure. We determined the incremental costs for the proposed standards for MY 2005-07, over and above the current 20.7 mpg standard. In accordance with statutory requirements, the benefits that may accrue from the production of alternative fuel vehicles must be excluded from the agency's analysis.

6. Light Truck Use and Survival Rates

Ford and the Alliance stated that the agency should recalculate costs using only a 25-year useful life (vehicle age) using the survival rate from the latest Transportation Data book. The agency did use a 25-year life. Data reflecting an earlier assumption of a 30-year life was inadvertently provided in a spreadsheet that NHTSA placed in the docket (Docket #651), but it was not used in the calculations.

The Union of Concerned Scientists (Docket #17231, page 7) argues that NHTSA's estimate of vehicle miles traveled is low compared with other studies and, as a result, "underestimates the consumer benefits of fuel economy improvements and the associated cost effective technology options." UCS claims that NHTSA should use, as a baseline, either the mileage numbers provided in the Oak Ridge's Transportation Databook (15,000 miles) or mileage used in the NAS analysis (15,600 miles in the first year, declining at 4.5% per year thereafter).

GM (Appendix, page 48) argues that our assumptions regarding the fraction of the calendar year during which new model year vehicles are sold and on the road needs a small adjustment. This discussion involves the fact that most new vehicles are not in service the entire calendar year in which they are sold.

In response to these comments, we made two changes to our estimates of light truck populations, survival rates, and annual usage in developing the Final Economic Analysis. First, we replaced the previous estimates of average annual light truck mileage at each age with more recent estimates developed by EPA in its update of the MOBILE vehicle emission factor model. These estimates, which apply specifically to light trucks, were derived from detailed analysis of vehicle use data from the 1995 Nationwide Personal Transportation Study (NPTS) and the 1992 Truck Inventory and Use Survey (TIUS).[2] These data suggest that light truck use is significantly higher at each age than the estimates used in our previous analysis. Second, we replaced our previous estimates of light truck survival rates with updated estimates calculated from the most recent edition of the Transportation Energy Data Book, as suggested in the comments provided by the Alliance and by Ford.[3]

2 Update of Fleet Characterization Data for Use in MOBILE6 – Final Report EPA420-P-98-016, (http://www.epa.gov/otaq/models/mobile6/m6flt002.pdf), June 1998 Tables 4-4 and 4-5.

3 These updated survival rates were calculated from U.S. Department of Energy, Oak Ridge National Laboratory, *Transportation Energy Data Book Number 22*, Table 6.10, http://wwwta.ornl.gov/data/tedb22/Spreadsheets/Table6.xls

Our previous analysis did adjust for the fact that new vehicles are typically in service for less than twelve months during the year in which they are sold, although it did so using a slightly different procedure than that suggested in GM's comments. Instead of adjusting the estimated *sales* of vehicles of each model year downward during the calendar years when they are available for sale, as GM's comments apparently recommend, we adjusted our estimates of light truck *usage* (average annual miles driven per vehicle) downward for those ages corresponding to the years when each model year is on sale.[4] We believe that this procedure is consistent with that recommended by GM in its comments, and we have also applied it to the revised estimates of annual light truck use incorporated in our final analysis.

7. Value of externalities

In the Preliminary Economic Assessment, the agency estimated a total value of externalities of 8.3 cents per gallon, comprised of 4.8 cents per gallon in demand costs (monopsony effect) and 3.5 cents per gallon in supply disruption costs.

4 Specifically, our analysis adjusted the estimated usage figure for "age zero" light trucks (those sold during the calendar year preceding their model year) to assume that they are in service for an average of two months of the calendar year in which each model year is introduced. This assumption is intended to reflect the typical dates on which model years are introduced and monthly sales patterns for recent model years. Similarly, we adjusted the usage figure for "age 1" light trucks (those sold during the same calendar year as their model year) using the assumptions that one-quarter of those vehicles had been purchased during the previous calendar year and were thus in service for the entire calendar year, and that the remaining three-quarters were purchased throughout the first eight months of the following year (and were thus in service for, on average, two-thirds of that year). These assumptions are consistent with monthly sales patterns for recent model-year light trucks.

GM (Appendix, page 81) stated that the US consumes about 25% of the world's oil supply, enough to give it some "monopsony" pricing power. Whether this limited power could be effectively exercised is a complicated question. GM concludes, like Bohi and Toman of Resources for the Future[5], that using US monopsony pricing power has marginal benefits at best, and could well be harmful.

The other 3.8 cents per gallon of NHTSA's 8.3 cents per gallon energy security externality relates to the potential costs of oil supply disruptions. GM commented that this analysis fails to reference two major studies that question the existence of any significant externality associated with oil supply disruptions. Therefore, GM believes that NHTSA should not include either externality in its benefit analysis.

The Mercatus Center (Ronald J. Sutherland) (#16452 page 7) stated that the link between energy security and fuel economy is not well known, but likely close to zero. Energy insecurities relate to the price of oil, not the source of its origin.

The Alliance (Docket #16435, pages 10, 17, 18) stated that the sum total of all three external costs (monopsony, supply disruption, environmental emissions) is exceedingly small. If the U.S. reduced oil consumption, in theory, it would benefit from a reduction in oil price. In practice, however, it is doubtful that the U.S. would benefit from the expected response by OPEC and from reduction in non-OPEC oil supplies. Therefore, NHTSA should not include any

5 Bohi, D.R. and M.A. Toman, 1996. The Economics of Energy Security. Kluwer Academic Publishers, Boston, MA.

monopsony externality in its benefit analysis. Studies by Congressional Research Service6 and Bohi and Toman question the estence of any significant externality associated with oil supply disruptions. The Alliance argues that any monopsony and oil supply disruption externalities are exceedingly small, and that the appropriate value for an oil import externality is zero.

The Alliance to Save Energy (Docket #16928, page 3) stated that gasoline prices must take into account impacts of gasoline on the environment. A fleet wide fuel economy standard of 40 mpg would avert 345 million tons of CO2 emissions, up to 187 million pounds of toc emissions, and up to 404 million pounds of smog forming pollutants, while saving the consumers $16 billion annually.

The agency believes that our estimates of the value of economic externalities from oil imports and consumption, which are drawn from a careful and recent analysis (by Leiby and others at Oak Ridge National Laboratories), are conservative by comparison to other estimates of these costs. The estimates of zero externalities reported by Bohi and Toman obviously represent the lower extreme of available estimates, and those developed by Leiby and others are closer to zero than they are to most other estimates of the value of petroleum consumption externalities. Commenters argued that both the extent of any U.S. monopsony power in the world oil market and the potential cost of an oil supply disruption depend on total U.S. oil consumption rather than just imports. However, any additional value for domestic production is just a transfer

6 Marc Labonte and Gail Makinen, Energy Independence: Would it Free the United States from Oil Price Shocks? Report RS20727, Congressional Research Service, November 17, 2000, available at: http://www.cnie.org/nle/crsreports/energy/eng-74.pdf

payment from domestic oil suppliers to consumer, whereas imports are a value to the United States. Thus, we only apply market externality costs to U.S. imports of gasoline or crude oil.

8. <u>Rebound effect</u>

The Alliance, GM, Ford, and DaimlerChrysler urged the agency to use a value of 35% rather than 15%, with a sensitivity analysis of 20% to 50%. These commenters each based this recommendation on a recent survey article, Greening, Greene, and Difiglio[7] and on the agreement of participants in "Car Talk," a dialogue on fuel economy among the auto industry, environmental organizations, think tanks, and government organizations. DaimlerChrysler seemed also to recommend a value of about 35%, stating that "the commonly accepted price elasticity of VMT is a negative 3.5 percent, which means that a 10 percent reduction in per mile vehicle fuel consumption actually only reduces fuel consumption by 7 percent."

GM (Docket #16447, page 8) stated that the agency's 15% figure is not supported by most literature. It urged the agency to consider the comments it submitted in May 2002 and the research it cited. In its May 2002 comments, GM stated that the Greening, Greene, and Difiglio article estimated the rebound effect at between 20 and 50%. In its new comment, GM stated that this article reviewed 75 articles on the rebound effect, including 22 on automotive transport. The company stated that very few of the reviewed articles showed a rebound effect of less than 20%, except for the short term, and several of the reviewed articles showed a rebound effect of up to 50%. GM stated that a more thorough review of the literature would have led NHTSA to use a

7 Greening, Greene, and Difiglio, "Energy Efficiency and Consumption: The Rebound Effect – Energy Policy 28 (2000), 389-401.

rebound estimate of more than 20%. GM suggested using a 35% value, with a sensitivity analysis of 20% to 50%.

GM included as an attachment to its comment a study of costs and benefits prepared by Dr. Andrew N. Kleit (GM Appendix, page 111). Dr. Kleit stated that a recent study (Greene et al, 1999) found a rebound effect of 20%, and he employed that result in his study. Dr. Kleit also cited the Greening, Greene, and Difiglio survey article, and stated that a 20% rebound effect is a conservative estimate. Dr. Kleit stated that the Congressional Budget Office,[8] in a recent report on CAFE standards, also assumed a rebound effect of 20%.

ACEEE noted that, with regard to the rebound effect, NHTSA stated in the NPRM that increasing fuel economy by 10% would produce an estimated 8-9% reduction in fuel economy. According to ACEEE, this implies that the rebound effect is between 1% and 12%, in contrast to the rebound effect of 15% used to calculate benefits reported in the agency's Preliminary Economic Analysis. ACEEE stated that clarification was necessary, and offered that a 15% rebound might be too high.

The agency disagrees with the comments of the Alliance, GM, Ford and DaimlerChrysler that the rebound effect should be as high as 35 percent, for several reasons. First, the survey of the rebound effect conducted by Greening, Greene and Difiglio includes numerous studies of the rebound effect in consumer purchases of durable household goods and business investments in energy-saving production technologies or processes, which are not specifically relevant to the

8 Congressional Budget Office, A CBO Study: Reducing Gasoline Consumption: Three Policy Operations (November 2002).

magnitude of the fuel economy rebound effect in light-duty vehicle use. More careful review of this survey shows that a rebound effect of 20 percent is reasonable when limiting the review to the studies analyzing vehicle use.

Second, the recent comprehensive analysis of the effectiveness of CAFE standards conducted by the NAS also concluded that the best estimate of the current rebound effect was 10-20%, and the agency's analysis of NAS's fuel savings estimates indicate that a 20% figure was used in estimating them. The NAS estimate was based on a review of recent studies that focused specifically on the fuel economy rebound effect for personal vehicle use.

In response to ACEEE's comments, the agency notes that an 8-9% reduction in fuel use in response to a 10% improvement in fuel economy means that 1-2 percentage points of the fuel savings that would otherwise result from the 10% increase in fuel economy is offset by additional driving. This response implies a rebound effect ranging from 10% (calculated as 1% divided by 10%) to 20% (2% divided by 10%), the range specified in the Preliminary Economic Analysis and also used in the Draft Environmental Assessment.

After further reviewing the studies, in light of the comments, we have revised the estimate of the fuel economy rebound effect for light trucks used in this analysis from 15% to 20%. We recognize that the magnitude of the assumed rebound effect and the implications of any rebound effect are complex issues. NHTSA will continue to monitor relevant research for use in future CAFE rulemakings. In Chapter XI, we perform a breakeven analysis on the rebound effect to determine at what higher value of the rebound effect the costs equal benefits.

Various commenters emphasized that the rebound effect reduces fuel savings and increases externalities due to additional driving. However, there are also private benefits associated with increased driving. The mere existence of a rebound effect is an indication that drivers (and their passengers) value the benefits of extra driving MORE than fuel savings that they have foregone. The agency has added an analysis and estimate of the increased private benefits associated with the rebound effect.

9. Value of emissions savings per ton and method of calculating emissions reductions

There were several comments on the method we used to calculate emissions reductions related to changes in gasoline supply.

GM (Docket #16447 page 8 and Appendix Attachment 4, page 49) questioned NHTSA's calculations concerning the relationship between refinery emissions and fuel saved by CAFE. They suggest that any gasoline saved by CAFE may not reduce U.S. refinery emissions. They believe NHTSA's Benefit Model incorrectly used emission factors from the GREET model for refinery emissions. Even if NHTSA's assumption of reduced U.S. refinery emissions is used, GM believes NHTSA incorrectly included extraction emissions factors in their analysis. GM also took issue with NHTSA's assumption that 45% of the reduction in fuel would result in reduced domestic gasoline refining, and that 55% would be reflected in lower imports of refined gasoline. GM also noted that the pending Tier 2 regulations on gasoline sulfur content might constrain the ability of foreign refiners to meet U.S. gasoline demand.

Finally, GM commented that the domestic-import split in refined gasoline should be examined in terms of its marginal effects on refinery and other sources of emissions during the gasoline supply process.

Our previous estimate of how domestic refining and imports of gasoline were likely to be affected by reduced gasoline consumption was based on a detailed analysis of differences in gasoline consumption, imports, and domestic refining between the "Low Economic Case" and "Reference Case" forecasts presented in the Energy Information Administration's (EIA) ***Annual Energy Outlook 2002***. (This analysis was conducted by EIA at the request of the agency.) Based on the comments provided by GM, we have reexamined this issue and have determined that additional data are available to support a revised assumption about the distribution of CAFE fuel savings between savings in gasoline imports and reduced domestic refining. We have also developed a more detailed treatment of the effects of reductions in domestic refining and imports of gasoline on emissions generated during the gasoline supply process, which we believe better represents the marginal or incremental effects of reduced gasoline consumption on emissions occurring throughout this process.

Detailed data available from EIA allow direct measurement of historical and current variation in imported and domestic sources of gasoline supply in response to variations in U.S. gasoline consumption. Historical data on gasoline consumption and imports shows that from 1992 to 2002, growth in gasoline imports accounted for only about 10% of growth in total U.S. gasoline consumption.[9] More recently, EIA data for the four-week period ending February 14, 2003 show that 91.5% (7.939 MBPD) of the gasoline used by the U.S. during that period was refined domestically, while only 8.5% (0.736 MBPD) was imported.[10] The U.S. Environmental Protection Agency has also assumed a similar distribution of reductions in domestic and foreign refining in some analyses of potential reductions in refinery emissions in response to gasoline savings.

However, the historical response of gasoline imports to changes in U.S. gasoline consumption differs markedly from the response of domestic refining activity and gasoline imports to future increases in U.S. gasoline demand forecast using the Energy Information Administration's (EIA) National Energy Modeling System (NEMS), which includes detailed representations of various U.S. energy supply pathways. As an illustration, forecasts presented by EIA in its most recent Annual Energy Outlook (***AEO 2003***) imply that virtually all of the growth in U.S. gasoline consumption forecast to occur through the year 2020 would be supplied by increased U.S. imports of refined gasoline. Supplemental analyses conducted by both EIA and the agency using NEMS also concluded that nearly all (90-100%) of the future reduction in U.S. gasoline consumption from stricter fuel economy standards would be reflected in reduced imports of refined gasoline.

We have discussed the disparity between these forecast trends and the implications of current and historic gasoline supply data with representatives of the Department of Energy (DOE) and

9 Calculated from data reported in Energy Information Administration, Monthly Energy Review Database, "Petroleum," Table 3.4 (http://www.eia.doe.gov/emeu/mer/mets/table3_4.xls).

10 www.eia.gov, "This Week in Gasoline," four-week period ending February 14, 2003.

EIA, who acknowledge that predicting the specific gasoline supply sources likely to be affected by the modest reductions in U.S. gasoline use that would result from the agency's action is extremely difficult and its results uncertain. DOE also indicated that the sources of changes in refined gasoline supply vary greatly by region of the U.S. As a consequence, the specific geographic pattern of fuel savings resulting from the agency's action – which depends in turn on the distribution of light truck purchases and use – is likely to influence the mix of reduced gasoline imports and domestic refining that occurs in response to these fuel savings.

The agency believes that the consistent association between changes in gasoline demand and domestic refining activity revealed in current and historical data provides useful information about their likely future relationship, yet we also realize that the effects of future variation in gasoline demand on foreign and domestic sources of supply may differ from these historical patterns. Since the proposed action will affect future gasoline consumption levels, the agency thus believes it should also consider these forecast changes in foreign and domestic gasoline supply in its analysis.

Thus, the agency has elected to assume that 50% of the reduction in future light truck gasoline use resulting from its action will be reflected in reduced imports of refined gasoline, while the remaining 50% will be translated into reductions in domestic gasoline refining. This assumed distribution can be thought of as representing a probability-weighted "expected" impact of reduced gasoline consumption, which incorporates both the extreme range of possible outcomes suggested by historical and forecast data, as well as the approximately equal likelihood that either outcome will occur. The agency further assumes that the resulting decline in U.S. gasoline production will reduce domestic refiners' use of imported and domestic crude petroleum feedstocks in direct proportion to their current fractions of total U.S. refinery feedstock use.

We also used these more detailed assumptions about how different sources of gasoline supply would be affected by fuel savings from the agency's action to develop what we believe are more accurate estimates of the resulting reductions in emissions throughout the U.S. gasoline supply chain. To do so, we first used information derived from Argonne National Laboratory's Greenhouse Gases and Regulated Emissions in Transportation (GREET) model to disaggregate total emissions of each air pollutant throughout the gasoline supply process into those occurring during four separate phases of the gasoline production and distribution process: crude oil extraction, crude oil storage and transportation to refineries, gasoline refining, and transportation, storage, and distribution of refined gasoline. [11] (Emissions that occur during vehicle refueling at gasoline stations, included in our estimates of increased emissions from additional light truck use due to the rebound effect, are presented elsewhere in this analysis.)

Our revised analysis incorporates the following assumptions in estimating the reductions in these emissions from lower gasoline use by light trucks: (1) reductions in imports of gasoline reduce emissions associated with gasoline transportation, storage, and distribution; (2) reductions in domestic refining of gasoline from imported crude oil reduce emissions associated with crude oil transportation and storage, crude oil refining into gasoline, and gasoline transportation, storage, and distribution; and (3) reductions in domestic refining of gasoline from domestically-produced

[11] Argonne National Laboratories, *The Greenhouse Gas and Regulated Emissions from Transportation (GREET) Model*, Version 1.6, February 2000, http://www.transportation.anl.gov/ttrdc/greet/index.html.

crude oil reduce emissions associated with crude oil extraction, crude oil transportation and storage, gasoline refining, and gasoline transportation, storage, and distribution.[12]

We combined these assumptions and the emission factors for each phase of the gasoline supply process with our assumption about the effects of fuel savings resulting from the agency's CAFE action on imports and domestic refining of gasoline to calculate revised estimates of reductions in emissions throughout the gasoline supply process. We believe that the resulting figures represent more reliable estimates of the incremental changes in emissions throughout this process than those reported in our previous analysis.

In response to GM's comment about emissions caps, the agency contacted EPA, which state that refineries are not regulated under any national cap and trade system. While refineries in States with Clear Air Act State Implementation Plans may be under some regulatory framework at the local or regional level, we found no regulatory programs that lead us to question the existence of real reductions in refinery emissions from baseline levels. GM's comment that the domestic-import split be examined in terms of marginal effects on emissions is addressed

Environmental Defense (page 6) requested that the agency place a value on the benefit of avoided greenhouse gas emissions, while also noting that "the magnitude of the global warming externality is admittedly difficult to estimate." The value of avoiding greenhouse gas emissions is unquantifiable at this time. However, our analysis in the Environmental Assessment indicates

12 In effect, these assumptions imply that the distances that crude oil typically travels to reach refineries are appromately the same regardless of whether it is transported from domestic oilfields or import terminals, and that the distance that domestically-refined gasoline travels from refineries to retail gasoline stations is appromately the same as foreign-refined gasoline must be transported from import terminals to these same gasoline stations.

that this final rule will result in an estimated 9.4 million metric tons of avoided greenhouse gas emissions over the 25-year lifetime of the vehicles (measured in terms of carbon equivalents).

10. Present Value of Benefits (including 7% discount factor)

The Mercatus Center (Ronald J. Sutherland) (Docket #16452 page 4 and later). Mr. Sutherland argues that the discount rate should be at least 14 percent, but probably closer to 21 to 28 percent, since fuel economy should be treated like an irreversible investment. His rationale is that 7% is the discount for government projects, not the rate that applies to consumers. On page 12, he argues that the proposed CAFE standards would have a redistributive effect that adversely affects low-income households relative to high-income households. Low-income households apply a larger discount rate to future reduced costs than high-income households.

The AEI-Brookings Joint Center for Regulatory Studies (Docket # 18145, page 9) argues that the analysis presented in the NPRM may have underestimated the rate at which vehicle buyers discount future fuel savings resulting from improved fuel economy. Financing rates on new and used cars were considerably higher than 7% (7.6-10%) during the 1984-95 period.

Discounting is required to adjust future impacts to a basis that is comparable with current impacts and to reflect society's preference for current consumption or investment opportunities. The appropriate basis for determining discount rates is the marginal opportunity cost of lost or displaced funds. When these funds involve capital investment, the marginal real rate of return on capital may be appropriate. The Office of Management and Budget has prescribed a 7% discount rate to represent the average before-tax rate of return to private capital in the U.S.

economy. It approximates the opportunity cost of capital and is, according to OMB, "... the appropriate discount rate to use whenever the main effect of a regulation is to displace or alter the use of capital in the private sector." The investments required to achieve fuel economy improvements will require some temporary displacement of capital. NHTSA consistently uses this discount rate in evaluating the impacts of its regulations.

For illustrative purposes, the agency has performed a breakeven analysis (see Chapter XI) to determine what discount rate would be required to equate the total costs to the discounted present value of benefits.

11. <u>Small Business Impacts</u>

The Recreational Vehicle Industry Association (Docket # 16926, page 4) stated that the impacts of required increases in light truck fuel economy on sales and production of trailers, other recreational vehicles that require towing, and conversion vehicles based on light trucks would be disproportionately or exclusively borne by small businesses.

NHTSA only included one engine downsize in the NPRM and has not counted that downsizing in the final rule analysis. Therefore, NHTSA does not believe this standard will have adverse consequences on the recreational vehicle industry.

12. <u>Crash Costs</u>

General Motors (Docket #16447, page 10) argued that increased travel from the rebound effect will likely result in an increase in traffic crashes, injuries, and fatalities. Attachment 7 of GM's docket submission shows that with a rebound effect of 0.15 (NHTSA's estimate), the proposed standards would result in 124 additional fatalities over the lifetime of the 2005-2007 models (assuming no significant change in the rate of fatalities per million miles traveled). GM's estimates are based on a fatality rate in the U.S. of approximately 1.5 deaths per 100 million miles (National Highway Traffic Safety Administration, "Traffic Safety Facts 2001").

In GM's submission (Appendix page 111), Dr. Kleit states it is necessary to calculate the increase in externalities caused by higher CAFE standards. CAFE standards lead to more miles driven, which lead to increased accidents and congestion. Edlin[13] estimates that accidents cost about 8 cents per additional mile driven. Winston and Shirley[14] present a higher estimate of about 20 cents per mile.[15]

The AEI-Brookings Joint Center for Regulatory Studies (page 12-13) also stated that the economic analysis should include the external costs of increased accidents caused by additional driving due to the rebound effect. Estimates of marginal external accident costs range from 5 to 20 cents per vehicle-mile.

13 Edlin, "Per Mile Premiums for Auto Insurance," Working Paper W6934, National Bureau of Economic Research (1999) Page 4.

14 Winston and Shirley, Alternate Route: Toward Efficient Urban Transportation (The Brookings Institution, Washington D.C.) (1998), page 64.

15 Dr. Kleit notes that both the Edlin and the Winston and Shirley estimates for the impact of accidents are taken from the fact that drivers do not pay insurance on a per mile basis. If, on the other hand, one modeled the decision to drive as including the probability of an accident and the resulting higher insurance costs, these figures might be lower.

The agency has added the additional crash costs into the analysis. The FHWA estimate for pickups and vans is about 2 cents/mile. A recent review by Parry and Small of Resources for the Future recommends about 3.5 cents/mile. We believe the values used by Brookings and recommended by GM are out of the mainstream of estimates, and have employed those developed by FHWA (2 cents/mile) in our revised analysis.

13. <u>Congestion</u>

GM (Appendix, Page 83) argues that NHTSA fails to address externalities associated with congestion and the cost of congestion that ensues as a result of increased driving.
Randall Lutter in an AEI Brookings paper, "CAFE – The Numbers Behind the Story" (Policy Matters 02-13, March 2002), estimates the congestion externality at $0.024 per mile, and notes that other researchers place this cost between $0.01 and $0.25 per mile. (See also "Reducing Gasoline Consumption", Chapter 5, by the Congressional Budget Office, 2002, which cites work by Ian Parry at Resources for the Future.) Mr. Lutter states that at 150,000 miles per light truck and 93,000 "net miles" at 7% interest, we need to assume the size of the rebound effect to calculate this externality on a per gallon basis. According to Mr. Lutter, under the NPRM, a rebound effect of 25% can be shown to save 268 net gallons per truck and causes a $40.43 congestion externality, or $0.15 per gallon; a rebound effect of 35% saves 232 net gallons and causes a $56.61 congestion externality, or $0.24/gallon externality; and if NHTSA's unrealistically low estimate of a 15% rebound effect is used 304 net gallons are saved with a resulting $24.26 externality, or $0.08/gallon externality.

Dr. Kleit's analysis (GM, Appendix, page 111) includes Mr. Lutter's findings that the average congestion cost per mile of vehicle use is about 2.4 cents per mile. Dr. Kleit believes this is likely a conservative estimate of the congestion cost of extra driving, as the marginal cost of congestion is expected to be higher than the average cost.[16] Dr. Kleit uses an externality estimate of 10.4 cents per mile (the Edlin estimate for accidents plus the Lutter estimate for congestion).

The AEI-Brookings Joint Center for Regulatory Studies (Docket #18145, pages 13-16) states the economic analysis should include the external costs of increased congestion caused by additional driving due to the rebound effect. Estimates of marginal external congestion costs caused by additional peak-period driving overstate the increase in congestion costs from additional driving that is distributed over the entire day and across urban areas, as would be expected for additional driving caused by the rebound effect. AEI-Brookings states that the economic analysis should use estimates of congestion costs ranging from 6 to 10 cents per vehicle-mile, and perhaps considerably higher.

The Alliance (Docket # 16435) cited studies by Randall Lutter (AEI Brookings) and the Congressional Budget Office, and argued that, if realistic rebound effects are used, the congestion externality more than offsets NHTSA's other two externalities.

16 This is the average cost calculated as the cost of congestion-related delays and fuel costs, $78 billion, divided by aggregate VMT by light duty vehicles. See Lutter, "CAFE: The Numbers Behind the Story" March 2002 http://www.aei.brookings.org/policy/page.php?id=84

The agency has added congestion costs to the analysis. We use the FHWA estimate for pickups and vans from the 1997 Highway Cost Allocation Study of 4 cents/mile. An extensive recent review by Parry and Small of the Resources For the Future recommends a slightly lower value.

14. Impact of higher prices on sales

Public Citizen (Docket #17228, page 9) provided the results of several surveys showing that consumers are willing to pay more for vehicles that have higher fuel economy or less emissions, etc. For example, an August 2002 national survey of drivers of pickup trucks, conducted by the Mellman Group found that 76 percent of pickup drivers favor increasing the fuel economy of pickups. 87 percent of those surveyed said that they would be willing to pay an additional $500 for a higher-mileage pickup when told that they could expect to save $2,000 worth of gasoline during the life span of their vehicle.

In contrast, Honda (Docket #16922, page 8) stated that most customers will not insist on trading fuel economy for other more highly desired features. Most customers would be willing to pay a little extra to buy a car with higher fuel economy as long as it also has all the other desired features. The JD Power Report, states that 2/3rds of those considering a hybrid vehicle would not buy one if the extra cost exceeded the fuel savings just during their ownership period. Honda states that this consideration of ownership period extends to vehicle purchasers in general. Purchasers will not consider the fuel savings beyond that of their ownership period (50,000 miles driven), and fuel economy has virtually no impact on used vehicle prices.

20/20 Vision (Docket #16424, page 2) offers the view that the public would support higher CAFE standards than the ones proposed by NHTSA. Citing a national survey, 20/20 Vision claims that 87 percent of those surveyed would "pay an additional $500 for higher mileage pickup trucks when they were told that they would save $2,000 in gasoline bills."

The agency has added into its analysis a discussion of the impact of higher prices on sales. Based on the economic literature, a price elasticity of 1.0 is assumed. Higher light truck prices could shift some new vehicles from light trucks to automobiles (which would probably increase fleet fuel economy), but might delay retirement and replacement of used vehicles (which could increase or reduce fleet fuel economy, depending on the exact model years affected, since fuel economy has not changed much over a relatively long time period.)

15. Impact on Employment

GM argued that the agency should consider the EIA's National Energy Modeling System (NEMS) estimates regarding the impact on employment. The NEMS estimates were discussed in the NPRM (67FR 77023 and 77024) and were found to deal in general aggregate estimates that weren't specific enough for this assessment. For example, the NEMS model aggregates the results to a 45-sector representation in which transportation equipment (SIC37) is carried as a single number that includes aircraft production, shipbuilding, etc. Employment is only estimated on a 45-sector basis, so employment changes specific to Motor Vehicles and Parts are never calculated. We believe the level of this model is too aggregate for us to use.

20/20 Vision stated that its study "Fuel Standards and Jobs" shows that raising CAFE standards by 20 percent in 2010 would net 70,000 jobs by 2010 and 30,000 jobs by 2020. The study used a large-scale econometric 80-sector inter-industry model of the U.S. economy using the Management Information Services, Inc. (MISI) model. It assumes no major market penetration of hybrid, fuel cell, or alternative fuel vehicles. Based on our analysis of the MISI assumptions, the actual affect of this rulemaking would be much less. First, since the MISI model assumed a 20 percent increase in CAFE for passenger cars and light trucks, and light trucks are about 50 percent of the market, their estimates should be multiplied by 0.5 for this light truck rulemaking. Second, since the proposed fuel economy increase by NHTSA is about 7 percent (22.2/20.7 mpg) rather than 20 percent, if the model were linear, the estimate might be multiplied by 0.35 (7/20). Third, the cost impact assumed ($700 per vehicle, which is related to the 20 percent increase in fuel economy) is disproportionately high compared to our estimate for this rule. Fourth, the MISI model translates increased expenditures for reconfigured motor vehicles into per unit outputs for that industry and support industries. This assumption does not seem appropriate to the agency. Many of the technology improvements would not increase the number of jobs. For example, going from a 4-speed to a 5-speed or 6-speed automatic transmission would result in very few additional jobs, and changing tire designs would result in very few additional jobs. It appears that the MISI model assumes these are increases rather than substitutions of technologies.

Thus, if we could apply 20/20 Vision's study to our analysis, the estimated impact on jobs would be much lower. In addition, 20/20 Vision's analysis of a 30 percent increase in CAFE estimates an increase in employment in the Motor Vehicle and Equipment Industry of 155,000 jobs. This seems implausible to the agency, since there are about 900,000 jobs in that industry. Finally, the MISI model does not seem to take into account that higher prices potentially reduce sales and reduce jobs.

The Public Citizen comment (Docket #17228, page 24) quoted from the Union of Concerned Scientists (UCS) report[17] that an increase in the fuel economy standard to 40 mpg, using fuel cells and hybrid vehicles, would create 40,000 jobs in the automotive sector by 2010. The agency's final rule has a much smaller increase in fuel economy than assumed in this analysis. We are not assuming an increase in hybrid vehicle sales or fuel cells. The basic assumptions in the model used by UCS (Impact Analysis for Planning model), that increases in automobile prices will lead to increased income for automakers which will relate to job increases, don't seem to apply to our analysis. As discussed above, many of the technology improvements will not lead to an increase in the number of jobs.

The agency believes some jobs will be created to produce new technologies. Job losses depend on price increases, which affect demand through the response of new light truck purchases to higher prices. We have estimated sales losses in the analysis, but not increases or losses in jobs, which are not easy to determine with the many different factors that affect jobs.

16. Value of time and time saved from refueling vehicles.

There were no comments on the value of time saved from having higher fuel economy and a longer range between refueling, which will result in less frequent refueling over the lifetime of

17 "Drilling in Detroit", Union of Concerned Scientists, June 2001, pages 36-45.

the vehicle. However, subsequent to issuing the NPRM, the agency recognized that it did not account for these benefits. Accordingly, the agency has included these benefits from better fuel economy into the analysis.

17. <u>Safety impact of changes in weight or mix shifts</u>

GM (Docket #16447, page 2) states that NHTSA concluded that the proposed standards would have no impact on fleet safety because they do not mandate weight reduction. Consistent with past impacts of the CAFE program, however, GM believes that weight reductions may still result from the higher standards and thus threaten greater fatalities than would occur without increases in the standards to the level proposed.

The Competitive Enterprise Institute and Consumer Alert (Docket #16923, page 1) said that NHTSA failed to consider the lethal impact that higher light truck standards would have on automotive safety. It is likely the standards will lead to further downsizing, or restrict the upsizing trend of recent years in light trucks. In either case, the result would be more traffic deaths, above and beyond those already occurring. CEI states that NHTSA fails to acknowledge, let alone analyze, these effects.

AEI-Brookings Joint Center for Regulatory Studies (Docket # 18145, page 9 -10) stated that NHTSA's analysis does not include weight reduction through substitution of lighter materials as a strategy manufacturers might use to improve fuel economy. AEI-Brookings stated that weight reductions would reduce vehicle crashworthiness.

On the other hand, Environmental Defense (Docket #16454, page 7) said NHTSA's failure to further raise light truck fuel economy might adversely impact safety. There is a lost opportunity to reduce mass disparity in the fleet that might come from weight reduction of the heaviest light trucks. They claim the most serious problem with NAS and NPRM interpretations of weight-safety impacts is that the studies on which they rely treat weight as the only vehicle attribute that has an effect on safety. Studies by Ross and Wenzel and DRI show near elimination of an apparent association between weight and fleetwide fatality risk.

The Center for Auto Safety (Docket #17476, page 1) argued that by assuming that manufacturers will not reduce vehicle weight in order to comply with the proposed new standard, NHTSA misses the fuel efficiency and safety gains of strong light-weight materials that absorb energy in a crash, that can be achieved by reducing the weight but not the size of light trucks. Lighter SUVs would create a more homogeneous and safer vehicle fleet.

The Insurance Institute for Highway Safety (Docket #7906, page 3) says the standard "should be achievable without significant down weighting or mix shifting of vehicle sales", but warns that we cannot be completely sure what will happen. Mix shifting would result in a higher disparity between vehicle weights and higher sales of SUVs to younger (inexperienced) drivers. Both consequences have negative safety impacts.

The Sierra Club (Docket #15816, page 2) believes that occupant safety is a function of vehicle design rather than size or weight, so that vehicle weight can be reduced without adverse effects on occupant safety.

Public Citizen (Docket #17228, page 12) stated that down weighting should be considered because it can be done with minimal negative safety effects. Public Citizen stated that the *Kahane* study was flawed by relying on hypothetical projections instead of real world data. The 1992 GAO study and the NAS report state that down weighting vehicles that weigh more than 4,000 pounds will have minimal negative safety effects. This should be considered in setting CAFE standards. In fact, down weighting may have positive safety effects when combined risk is considered.

Honda (Docket #16922 page 6) stated that the assumption that reducing weight of vehicles would have a negative impact on overall societal safety is incorrect. The majority finding in the NAS report on safety only applies to older vehicles. The 1997 *Kahane* study only considered vehicles older than 1993 and did not account for improved safety of newer vehicles that continued to meet the CAFE Standards. Vehicle design and size, not just mass, must be considered when looking at the relationship between fuel economy and safety.

The Union of Concerned Scientists (Docket #17231, page 6) argues that NHTSA's assumption that automobile manufacturers' "projected power to weight ratios should be fixed to their projections" causes an understatement of the potential fuel economy that could be achieved. This argument is underscored by UCS's belief that weight savings technology should be an option for improving fuel economy. Citing studies from the NAS and NHTSA, UCS states that a reduction in weight would also "save lives".

The agency has projected a series of technologies that a manufacturer could employ outside of weight reductions or changes in model mix to achieve the CAFE levels in the final rule. While the manufacturers are free to choose the method they use to achieve the fuel economy levels, we believe that the fuel economy levels established in this final rule will not result in reducing weight. As shown in Table VI-4, there are many other technologies that cost less than weight reduction on the basis of cost per percent improvement in fuel economy.

18. Risk

GM (Docket #16447 page 1) states that NHTSA made no allowance for any deterioration, or "risk", in GM's forecasts, despite the fact that in past rulemakings the agency has significantly overestimated GM's CAFE capability as well as that of other manufacturers.

The Alliance (Docket #16435, pages 5-6) stated that NHTSA must fully account for implementation risks including availability of technology options, cost of technology, level of technology applied, success of each new technology in meeting its targets, range of product offerings, overall economic climate, customer requirements for utility, size, performance, usage patterns, options, powertrains, and the level of new regulations in vehicle safety and emissions.

The agency did not take the highest percent improvement for each technology, but the middle estimate from the NAS report. Risk has both an upside and a downside. There are potential external events (external to technologies alone) that could make it easier to improve fuel economy. For example, tax incentives for hybrid vehicles, higher gas prices, or an increasing trend toward the more fuel-efficient crossover utility vehicles could occur.

19. Other Cost/Benefit Analyses

General Motors (Docket #16447, page 9 and Attachment 4) stated that the Energy Department's EIA model reported directionally opposite results compared to NHTSA's own cost-benefit analysis. The EIA model found higher CAFE standards would decrease GDP, cause job losses, and be accompanied by a reduction in vehicle weight. Similarly, recent studies by the Congressional Budget Office and Professor Kleit concluded CAFE standards are not cost-effective (see Attachment 9 of GM's docket comment for Professor Kleit's latest work).

Given these different analyses and models, the agency is including many of their concepts and philosophies (although with different estimates of their impacts) into our Final Economic Assessment. Many of these analyses were not in the Preliminary Economic Assessment. These have already been discussed earlier in the comments relating to crash costs, congestion, sales, etc. The agency considered the EIA analysis earlier; and the model starts with an increase in truck prices of $275 per vehicle, which is much higher than the average cost we estimate in our analysis. Thus, their impacts will be larger. However, the EIA study is not a cost-benefit analysis of the sort the agency has produced, and thus the results of the two studies cannot be fully compared. The agency also discussed the earlier, but very similar, analysis by Professor Kleit, (See Docket #4275), questioning several of the main assumptions of the analysis. In the agency's opinion, the main problem with Professor Kleit's model is that it assumes all fuel economy technologies that produce fuel savings exceeding manufacturers' costs for installing them have already been fully employed before the standard is raised.

20. Market Efficiency and Consumer Rationality

General Motors (Docket #16447 page 12), stated that the recent study of CAFE by the Congressional Budget Office concludes that making public policy decisions based on projections that ignore tradeoffs between fuel economy and other vehicle attributes such as "power, safety, and design" is likely to impose substantial opportunity costs on consumers and producers and to impose substantial net costs on society, both absolutely and relative to other measures to conserve fuel and to address energy security issues.

GM (Appendix Attachment 9 page 70) argues that customers, not manufacturers, determine the levels of fuel economy and other attributes that are produced and sold. GM argues that there are no significant externalities and makes the following points:

- NHTSA's own estimate of the external benefits of increasing the CAFE standard never exceeds 4% of the total societal benefits in any model year.
- Peer-reviewed studies show there is no market failure associated with increased fuel consumption.
- Peer-reviewed studies also show there is a government regulatory failure associated with CAFE standards, which leads to increased highway congestion and reduced safety.
- The CAFE standard should be lowered, not increased, if negative externalities are to be reduced.
- Consumers and producers are informed and rational. Buyers of new motor vehicles are extremely well informed about fuel economy and fuel costs.

- Numerous consumer and governmental publications report and compare the fuel economy and fuel costs of alternative cars and light trucks.
- Prices for gasoline are clearly posted at service stations. Gasoline is frequently purchased so that consumers are well aware of the prices and of price changes.
- Every vehicle carries a fuel economy label for comparative purposes.

GM (Appendix page 102) presents the following paper:
"The Costs and Benefits of NHTSA's Proposed Increase in Truck CAFE Standards", by Andrew N. Kleit, Ph.D., February 2003. Dr. Kleit argues that NHTSA implicitly makes two assumptions in its analysis. "First, that consumers in the market for fuel economy do not have "full information" and therefore this market cannot be expected to serve consumers' best interest. Second, that inefficiency in the market for fuel economy causes a bias against purchases of fuel economy. Neither assumption is warranted."

Dr. Kleit argues that information exists because of the fuel economy label on the window. But assuming that consumers have inefficient amounts of information is not a sufficient rationale for an increase in CAFE standards. There is no reason to believe purchasers would be biased against fuel economy.

Dr. Kleit develops a model, using GM supplied elasticities and cross-elasticities. He assumes that a firm will invest in fuel efficiency in a world without CAFE standards as long as the firm finds it profitable to do so, that is, consumers are willing to pay for fuel economy increases. He assumes that there was equilibrium in MY 1999, where firms invested up to the point that consumers were willing to pay for fuel economy. There are many assumptions, but the result of the model assuming an increase in CAFE to 22.2 mpg (requiring a 1.5 mpg increase for GM and a 0.5 mpg increase for Ford and Chrysler) are a loss in profits for GM of $49 to $131 million, a gain in profits for Ford and Chrysler totaling $21 to $41 million, a loss in consumer surplus of $133 to $212 million, an increase in miles driven from 5.8 to 6.0 billion miles, externality costs from increased driving, congestion, and accidents of $603 to $625 million, and total costs of $766 to $928 billion. Total costs per gallon saved were estimated to range from $0.67 to $0.84. Dr. Kleit concludes that the truck CAFE standard of 22.2 mpg is a remarkably inefficient manner of saving gasoline, with costs 8.5 to 10 times greater than benefits.

The Mercatus Center (Ronald J. Sutherland) (Docket #16452 page 2,10) stated the analysis should include the foregone benefit to consumers from being unable to choose attributes they prefer in a vehicle, from restricting engine choice in the GM 6.0L to 5.3L. Also, the analysis should include a foregone benefit from those people who can't purchase trucks because of increased price. This is a loss in consumer surplus. Some consumers will keep their older trucks longer, which reduces the amount of fuel saved. Consumers have direct knowledge of gasoline prices, monthly fuel expenditures, and official MPG estimates. The allegation of information failure has no basis.

The AEI-Brookings Joint Center for Regulatory Studies (Docket # 18145, pages 6-8) states that NHTSA's analysis assumes that consumers have inadequate information about vehicle fuel economy, and are thus unable to value correctly the future fuel savings resulting from improved fuel economy. As a consequence, vehicle manufacturers supply inadequate levels of fuel economy. NHTSA's cost estimates for fuel economy technologies do not reflect the value of declines in vehicle performance that would result from applying them.

The Alliance (Docket #16435, page 12) stated that the EIA analyses are directionally correct and should have been fully considered by NHTSA in this rulemaking. The EIA model showed higher CAFE standards would decrease GDP, cause job losses, and is accompanied by a reduction in vehicle weight. Inherent to NHTSA is a systemic upward bias that fails to take into account how consumers can be expected to spend the money from fuel efficiency advances. When NHTSA's projections are adjusted for this bias, the cost-effective increase for the light truck standard ranges from zero to negative. NHTSA's calculations should reflect the opportunity costs, e.g., vehicle attributes such as power, safety, and design, of foregone consumer choice. (p. 21)

The Alliance states that there is a portion of customers who buy light trucks based on fuel economy, but it is much smaller than the portion who buy small to midsize passenger cars. Fuel economy ranks eighth as a buying motivator in consumers' purchase decision according to J.D. powers and increases in importance only after the purchase is made. (p. 10)

The Alliance states that the recent Congressional Budget office study of CAFE concludes that auto buyers are rational and informed and that vehicle producers effectively respond to their preferences for fuel economy. (p. 2)

The Center for Regulatory Effectiveness (Docket #328, page 3) stated that NHTSA should consider reforms based on criteria cited in Bond-Levin and the NAS report before setting new standards.

Public Citizen (Docket #17228, page 10-12) stated there is no validity to the "consumer choice" argument made by manufacturers. Vehicle offerings are driven not by consumer choice but by manufacturers' advertising. In 2000, manufacturers spent $1.51 billion on SUV advertising (Page 10, Section A 1st Paragraph). If consumer preference were driving the market there would not be the need to spend such a high amount on advertising. Eighty-five percent of the fuel economy improvements by the manufacturers to meet the 1985 statutory standard for passenger cars were made through technology, not weight reduction, without restriction on consumer choice.

The Mercatus Center/GM University (Docket #16452, page 10) stated that the Stage 3 technologies include reducing engine size from 6.0 liters to 5.3 liters. Since consumers value larger engines, there is a consumer welfare loss that is not accounted for in the analysis.

Many commenters asserted that the agency has made a determination that there is a market failure in the provision of vehicle fuel efficiency. In the NPRM, the agency made no such determination. NHTSA noted a paradox that cost-saving technologies appeared to be penetrating the market to only a limited extent and therefore sought public comment on possible sources of market failure. First, on the supply side of the vehicle market, it is well known that the light truck market is concentrated in three large producers that account for roughly 75 percent of the market share, though there are a number of producers who account for the remaining 25 percent of the market. As several commenters noted, there is substantial evidence of competition among producers in the light truck market and indications that the three large producers are under increasing competition from the smaller producers. Under these circumstances, NHTSA maintains its previous statement that there is only a "remote" possibility that a supply side failure in the marketplace accounts for the limited market penetration of cost saving, fuel-saving technologies. Second, commenters discussed whether there could be a failure on the demand side of the market for fuel economy, rooted perhaps in the way consumers perceive the private benefits of enhanced fuel economy and incorporate that information in their purchasing decisions. Several commenters noted that consumers are provided clear and substantial information about the fuel efficiency rating of different vehicles, including information about the operating expenses associated with these fuel efficiency ratings. However, the argument for demand side failure may have less to do with the absence of consumer information about fuel efficiency than with the overall complexity of the vehicle-purchasing decision, the number of other factors of greater salience to consumers, the temporal aspects of ownership and resale, and the difficulty of weighing fuel efficiency differences against other (especially non-monetary) attributes of vehicles. Rational consumers, cognizant of decision making costs, may use simplified decision rules when purchasing vehicles that give limited diminished or no weight to fuel economy difference – at least when projected fuel prices are relatively low. The agency does not know whether this demand-side argument is true and did not receive much comment that supports or refutes is. The agency believes the plausibility of this argument is less remote than the supply-side argument but still quite speculative. Regardless of how consumers perceive fuel economy benefits when they make purchasing decisions, it is clear that consumers will experience the benefits of cost-saving technologies when they operate their vehicles, assuming the engineering-economics information underlying the NAS report is accurate.

IV. IMPACT OF OTHER FEDERAL MOTOR VEHICLE STANDARDS ON LTV 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) 2005-2007 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 General Motors, Ford, and DaimlerChrysler light trucks subject to the standard for MY 2001 was 4,627 pounds. The average weight for these three manufacturers for MY 2007 is 4,679 pounds. Thus, overall, the three largest manufacturers of light trucks expect weight to increase slightly over the time period. 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 the MY 2005 and MY 2007. These have been analyzed for their potential impact on light truck fuel economy weights for MY 2005-2007:

1. FMVSS 138, tire pressure monitoring system (Final Rule)
2. FMVSS 139, tire upgrade (Proposed)
3. FMVSS 201, occupant protection in interior impact (Final Rule)
4. FMVSS 202, head restraints (Proposed)
5. FMVSS 208, occupant crash protection (Final Rule)
6. FMVSS 225, child restraint anchorage systems (Final Rule)
7. FMVSS 301, fuel system integrity (Proposed)

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, effective in November 2003. We estimate the weight that would be added consists of electrical parts that would not weigh more than half a pound (0.23 kilograms or less). A confidential docket comment from Ford estimated this weight at [ ].

FMVSS 139, tire upgrade

The TREAD Act of 2000 mandated a rulemaking proceeding to revise and update the safety performance requirements for tires. A Preliminary Economic Assessment of the proposed tire upgrade indicated there would be added cost for the improved tires but no increased weight. A confidential docket comment from Ford estimated a weight increase of [ ] lbs. for tires and [ ] lbs. for rims. A docket comment from General Motors estimated an increase in rolling resistance, cost and mass for many truck tires with an impact of [ ].

Although NHTSA has not yet issued a final rule, the agency believes that the concerns raised by Ford and General Motors are not well founded. While General Motors did not indicate with specificity exactly why it believed that FMVSS 139 would increase rolling resistance, NHTSA believes that the standard is more likely to decrease rolling resistance. One component of NHTSA's proposal for FMVSS 139 is new requirements for high-speed endurance. Meeting these new endurance requirements is likely to result in tires that have less, rather than more, rolling resistance. One of the principal factors affecting tire endurance at high speeds is heat buildup in the tire. Tires with less rolling resistance generate less heat and have more endurance. Therefore, the new requirements are likely to encourage tires with less rolling resistance. Ford's concern, which indicated a weight penalty from heavier tires and rims, evidently stems from a concern that complying with new high speed test requirements in FMVSS 139 and application of the load reserve requirements of FMVSS 110 to light trucks will force manufacturers to use heavier tires and rims on these trucks. FMVSS 110 specifies requirements for tire and rim selection for new vehicles. One purpose of these requirements is to prevent tire overloading by specifying that rims and tires provide a minimum load reserve.

According to Ford, the agency's proposal to modify FMVSS 139 and 110 to require light truck manufacturers to meet these load reserve requirements could, for those light trucks that did not already meet the new load reserve requirements, have the effect of making it necessary for manufacturers to use larger wheels and tires on their vehicles. If NHTSA were to adopt this proposal without any changes, Ford would be correct in asserting that a weight penalty exists. However, NHTSA is currently evaluating its proposal in light of the public comments and has not yet issued a final rule. We anticipate that the requirements contained in the final rule will not require that light trucks be equipped with larger wheels and tires. Accordingly, it is our position that the new load reserve requirements will not require any weight increases for light trucks.

FMVSS 201, occupant protection in interior impact.

This standard specifies requirements to afford protection for occupants from impacts with interior parts of the vehicle. On April 5, 2000, the agency issued a proposal to require that the door frames on pillarless multi-door vehicles and seat belt mounting structures on soft top utility vehicles meet the upper interior head protection requirements of FMVSS 201. It applies to passenger cars and to multipurpose vehicles, trucks, and buses with a GVWR of 10,000 pounds (4,536 kilograms) or less. Additional padding could be added or pillars could be redesigned to pass the upgraded standard. Because these proposed requirements apply only to a very small percentage of light trucks, the agency believes the requirements will not have an effect on the CAFE of any manufacturer.

FMVSS 202, head restraints.

This proposed regulation would improve front seat head restraints in passenger cars, pickups, vans, and utility vehicles and require head restraints in the rear outboard positions. Because many pickup trucks and some vans do not have rear seats, the average weight increase for this standard is lower than for automobiles. We estimated the average weight gain across light trucks would be 4.3 pounds (1.94 kilograms). A docket comment from Ford provided a confidential estimate of [

]. The agency proposed three years lead time for the head restraints final rule. Since it has not been issued yet, the earliest effective date could be September 1, 2006 or model year 2007.

Ford was the only commenter to suggest that FMVSS 202 might have any impact on CAFE, based on the proposal to require rear head restraints. Even if this standard is effective for MY 2007, and we assume the projected weight penalty estimated by Ford, the weight increase is not significant enough to affect Ford's ability to meet the CAFE standard for MY 2007.

FMVSS 208, occupant crash protection.

This rule amends our occupant crash protection standard. Additional weight would come from sensors, switches, indicators, and associated electrical equipment. We estimate the average weight gain would be 3.4 pounds (1.54 kilograms). Ford estimated [ ] lbs. in its May 2002 submission. We believe that the bulk of this weight penalty is related to the frontal offset crash requirements currently under study. The agency has not yet issued a frontal offset proposal, no considered the model years to which any new requirements would apply.

FMVSS 225, child restraint anchorage systems.

The Final Economic Assessment (February 1999) for FMVSS 213 and 225 estimates the additional weight for improved anchorages would be less than 1 pound (0.45 kilogram). A docket comment from Ford provided a confidential estimate of [ ], if the standard is harmonized with Canadian regulations, or [ ] without Canadian harmonization. Ford's claimed weight penalties appear to assume all light trucks will require significant additional structure. We do not believe this FMVSS will adversely affect CAFE performance. Ford's claimed weight penalty appears to assume that all light trucks will require significant additional structure. However, we believe that any need for additional structure will be much more limited than Ford claims. Our estimate is that some additional weight will be required and do not believe Ford provided compelling evidence to alter our assessment that the impact of FMVSS 225 requirements will impose an inconsequential weight penalty with no adverse CAFE effect.

FMVSS 301, fuel system integrity.

This proposal would amend 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 next two tables summarize estimates made by NHTSA and the truck manufacturers regarding the weight added to institute these standards between MY 2001 and MY 2007. Table IV-1 presents the actions that are required of the manufacturers by changes in the safety standards. Table IV-2 presents voluntary actions planned by the manufacturers, which do not have to be considered in setting the fuel economy standards. As is true in other sections of this report, figures in square brackets ([ ]) are confidential.

Table IV-1
Weight additions due to required FMVSS regulations

Source of Estimates	FMVSS 138 TPMS	FMVSS 139 tire upgrade	FMVSS 201 int., protection[3]	FMVSS 202 head restraint	FMVSS 208 crash protect'n	FMVSS 225 restraint anchr.	FMVSS 301 fuel system
NHTSA	**0.5 pounds**	**None**	**None**	**4.3 pounds**	**1.59 pounds**	**< 1.0 pound**	**0.25 pounds**
Daimler-Chrysler				Mentioned[1] but no specific weight given.	[ ] pounds, CAFE impact [ ] mpg.	Mentioned[1] but no specific weight given.	Mentioned[1] but no specific weight given.
General Motors		[ ]			[ ] pounds	[ ] pound	
Ford	[ ]	[ ]		[ ]	Mentioned[2] but no specific weight given.	[ ] or [ ] without Canadian harmonization	
Honda	"Not possible to predict."						
Toyota	"In MY 2005 we expect about a [ ] FE penalty due to increased weight associated with safety features."						
Nissan	No figures given.						

1DaimlerChrysler estimated [ ] pounds, with a CAFE impact of [ ] mpg. This figure includes weight increases from many regulations lumped together: 225, 202, 301 (which will be in place around Model Year 2005-07), Offset Frontal Protection, Improved Door Latch Integrity, and Dynamic Roof Crush (which may not be in place). The [ ] pounds shown for FMVSS 208 must include some type of structural upgrade, which might occur with an offset frontal protection rule, but in our opinion would not be part of the advanced air bag rule.

2Ford made a weight estimate of [ ] pounds, which included strengthening to improve FMVSS 208 protection, NCAP, and offset frontal protection.

3 In the PEA we included 7.5 pounds for FMVSS 201, under the assumption that MY 2001 were the baseline vehicles. Since we are now only looking at standards effective in MY 2005-07, and dealing with manufacturer's plans for those years, and since FMVSS 201 is already effective before MY 2005, it has been taken out of this analysis.

Table IV-2
Weight additions due to voluntary safety improvements

Vehicle Manufacturer	Antilock Brakes	Side/Head Impact Air Bags	Reduce Rollover	Lap/shoulder belt in center rear seat	Improve ratings in NCAP and offset crash tests.
DaimlerChrysler					[ ] pounds[4]
General Motors	[ ]	[ ] pounds		[ ] pounds	[ ] pounds[3]
Ford[2]	[ ] pounds	[ ] pounds	[ ] pounds[5]		[ ] pounds[2]
Honda					
Toyota	"In MY 2005 we expect about a [ ] Fuel Economy penalty due to increased weight associated with safety features."				
Nissan	No figures given				

2 See footnote 2 from Table III-1.

3 In their response to "question 8" of the information request, GM states the overall addition will be [ ] pounds for a full-sized truck or [ ] pounds for a full-sized van, with an effect of [ ] mpg or [ ] mpg.

4 Includes Frontal NCAP, Side NCAP, Rollover Ratings, Offset Frontal Protection, Head Restraint Ratings, and Bumper Performance.

5 In Ford's comment to the docket, this figure was broken out into [
]

NHTSA's estimates come from Preliminary and Final Regulatory Evaluations for the respective standards. Estimates from the vehicle manufacturers come from NHTSA's requests for information, or docket comments, and are confidential. The Japanese manufacturers gave either no information or very generalized information. Information from other manufacturers was sometimes specific but often combined several categories.

Honda stated that they would be able to minimize additional weight due to Federal safety requirements if they were given sufficient lead time. Toyota's entire response is given in the tables above. Nissan discussed known issues in fuel economy trade-offs without offering any specific or new information. DaimlerChrysler estimates that FMVSS 208 changes will add [ ] pounds on the average, for a CAFE impact of [ ] mpg. This effect will hold steady between 2005 and 2010. General Motors gave specific information on weights for various parts, all of which were safety related, but most of which were not required for the standards. Ford estimates that changes to FMVSS 208 (occupant crash protection) will add [ ] pounds, for a CAFE impact of [ ] mpg. Much of this may be due to strengthening to improve NCAP and frontal-offset crash ratings and is shown in the right hand column of Table IV-2.

In summary, NHTSA estimates that weight additions required by FMVSS regulations that will be effective between the MY 2005 fleet and MY 2007 fleet to average about 9.5 pounds[1].

NHTSA examined the changes in safety-related weight, regardless of whether mandatory or voluntary, from the plans submitted in response to the RFC and the NPRM to see if there were changes affecting their fuel economy levels. Only Ford took issue with our estimates of weight penalties and provided enough data for a complete analysis. Taken together, Ford's submissions in response to the RFC and the NPRM estimated weight impacts for complying with FMVSSs ranging from approximately 100 to 200 pounds per vehicle. Ford indicated that these weight impacts could reduce its fuel economy by approximately 0.20 mpg to 0.30 mpg. Our reading of Ford's comments indicates that the bulk of this weight increase is attributable to that company's belief that the agency will require light trucks to meet a frontal offset crash test requirement for

[1] This figure is determined by adding together the NHTSA estimated weights for the standards from Table III-1, with the exception of using [ ] from the manufacturers confidential estimates.

FMVSS 208. Ford also attributes a significant weight increase to child restraint anchorage requirements and our current proposal to upgrade tire performance.

The agency agrees that we must consider all of our regulatory programs, as well as those of other agencies, when establishing CAFE standards. We also agree that we should consider anticipated requirements as well as those that have been finalized. Having done so, however, we do not believe that new safety requirements likely to be applied to MYs 2005 - 2007 necessitate any reduction in the proposed standards. It appears that there is a small increase in safety related weight for FMVSS 225 for MYs 2005 and 2006 and a somewhat larger increase in safety related weight if a final rule incorporating the proposed requirements for FMVSS 202 is promulgated and applies to MY 2007 light trucks. The CAFE penalties for these weight increases are too small to alter the agency's estimates of Ford's capabilities in these years. Further, the rulemaking process will allow for ample opportunities for manufacturers to comment and the agency to consider whether any future rulemakings will in fact be inconsistent with this final rule.

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[ ]) 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, rated at less than 6000 pounds GVWR, the Tier 2 standards phase-in beginning in 2004, and are to be fully phased-in by 2007.

During the phase-in period from 2004-2007, all passenger cars and light trucks not certified to the primary Tier 2 standards must meet an interim standard equivalent to the current National Low Emission Vehicle (NLEV) standards for light duty vehicles. 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. Onboard Vapor Recovery

On April 6, 1994, EPA published a final rule (59 FR 16262) controlling vehicle-refueling emissions through the use of onboard refueling vapor recovery (ORVR) vehicle-based systems. These requirements applied to light-duty vehicles beginning in the 1998 model year, and phased-in over three model years. The ORVR requirements also apply to light-duty trucks with a GVWR of 6,000 pounds or less beginning in model year 2001 and phasing-in over three model years. For light-duty trucks with a GVWR of 6,001-8,500 lbs, the ORVR requirements first apply in the 2004 model year and phase-in over three model years.

The ORVR requirements impose a small weight penalty on vehicles as they necessitate the installation of vapor recovery canisters and associated tubing and hardware. In its comments, Honda indicated that it did not agree with the assertion in the NPRM that the ORVR system, which results in fuel vapors being made available for combustion, provides a fuel economy benefit offsetting the weight of the system.

Assuming the correctness of Honda's argument that there are negligible fuel economy benefits from ORVR systems, we note that weight increases attributable to replacing older vapor recovery technology with ORVR compliant systems are not likely to be significant enough to have an impact on fuel economy.

3. Supplemental Federal Test Procedure

On October 26, 1996, EPA issued a final rule (61 FR 54852) revising the tailpipe emission portions of the Federal Test Procedure (FTP) for light-duty vehicles (LDVs) and light-duty trucks (LDTs). The revision created a Supplement Federal Test Procedure (SFTP) designed to address shortcomings with the existing FTP in the representation of aggressive (high speed and/or high acceleration) driving behavior, rapid speed fluctuations, driving behavior following startup, and use of air conditioning. The SFTP also contains requirements designed to more accurately reflect real road forces on the test dynamometer. EPA chose to apply the SFTP requirements to trucks through a phase-in. Light-duty trucks with a gross vehicle weight rating (GVWR) up to 6,000 lbs were subject to a three-year phase-in ending in the 2002 model year. Heavy light-duty trucks, those with a GVWR greater than 6,000 lbs but not greater than 8,500 lbs, are subject to a phase-in schedule in which 40 percent of each manufacturer's production must meet the SFTP requirements in the 2002 model year, 80 percent in 2003, and 100 percent in the 2004 model year.

The 2004 model year represents the final phase-in year for light trucks subject to CAFE standards. Neither Ford nor GM indicated in their comments to the MY 2004 NPRM that the SFTP would have any impact on their ability to meet the proposed 2004 standard.

In their comments, DaimlerChrysler claimed that changes in the EPA test procedure would have a negative effect on the fuel economy values for light trucks.

NHTSA has, from time-to-time, included the effects of EPA's changes to the test procedures when setting CAFE standards for light trucks. However, in this case, EPA has determined that the net effect on fuel economy for the recent test procedure changes is near zero. Consequently there is no need to adjust the CAFE standards for these test procedure changes.

EPA's decision was based on the joint recommendation of the Alliance and AIAM that the net effect of all the test procedure changes was near zero and that "no adjustment" was appropriate. EPA considered the effects of four test changes: single-roll electric dynamometer with full-speed load simulation, elimination of the 10% air conditioning load factor, elimination of the 5,500 maximum test weight for cars, and improved test equipment. While some changes decreased measured fuel economy, others raised it, with the net result of a near zero effect. This decision was based on the total fleet, which is a mix of front wheel drive and rear wheel drive cars and trucks.

Considering trucks alone is not likely to change that decision. Trucks, as a sub-class, have a larger mix of rear wheel drive vehicles than the combined fleet. This would lead to slightly increased effect of the single roll dynamometer and thereby slightly lower measured fuel economy. However, the truck sub-class also has higher road load horsepower than the combined fleet. This would lead to slightly higher effects due to the elimination of the 10% air conditioning load and thereby slightly higher measured fuel economy. The net effect of the combined test procedure changes on the truck sub-class is still expected to be near zero.

4. California Air Resources Board LEV II

The State of California Low Emission Vehicle II regulations (LEV II) will apply to passenger cars and light trucks in the 2004 model year. The LEV II amendments restructure the light-duty truck category so that trucks with gross vehicle weight rating of 8,500 pounds or lower are subject to the same low-emission vehicle standards as passenger cars. LEV II requirements also include more stringent emission standards for passenger car and light-duty truck LEVs and ultra low emission vehicles (ULEVs), and establish a four-year phase-in requirement that begins in 2004.

The agency notes that compliance with increased emission requirements is most often achieved through more sophisticated combustion management. The improvements and refinement in engine controls to achieve this end generally improve fuel efficiency and have a positive impact on fuel economy.

In summary, the agency believes there will be no impact from emissions standards on light truck fuel economy between the baseline MY 2001 and MY 2007 fleets.

V. FUEL EFFICIENCY 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. In response to a Congressional directive in the FY 2001 DOT Appropriations Act, the National Academy of Sciences (NAS) recently completed a review of fuel economy standards. This review included an examination of technologies that could be used to increase the fuel economy of new light duty vehicles. The NAS did not discuss all possible technologies, but rather a list of about two-dozen specific technologies and groups of technologies. The NAS report has received extensive external review, and is considered to be a reasonably diverse and complete documentation on a range of technologies.

NHTSA's February 7, 2002, notice in the Federal Register and the December 16, 2002 NPRM requested comments on, among other things, the technologies included in this NAS report. Many respondents to both notices have provided estimates of the cost and efficiency characteristics of the same specific technologies. Some manufacturers indicated that the NAS approach to estimating the combined effects of multiple technologies was flawed because the report used a multiplicative approach to combining estimated fuel consumption reductions rather than performing system-level analysis. These manufacturers stated that the multiplicative approach could lead to fuel consumption reduction estimates that exceed theoretical limits, because energy losses of each specific type—in particular pumping losses—cannot be reduced by more than 100 percent. On the other hand, the Union of Concerned Scientists (UCS) indicated that the multiplicative approach used for the NAS study tended to underestimate fuel consumption reductions from specific technologies, compared to those using a system analysis approach developed by UCS.

The remainder of this section summarizes the nature of each technology considered, key findings of the NAS report, and major related comments submitted in response to the NHTSA Federal Register notice. A summary of the estimates can be found in Table VI-3. In the Preliminary Economic Assessment the agency made judgments on each technology of what would be the expected outcome. For the final rule, we have decided to rely on the NAS judgments.

Engine Technologies

Reduction of Engine Friction Losses

The amount of energy an engine loses to friction can be reduced in a variety of ways. Examples include low-tension piston rings, roller cam followers, 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 retail price equivalent (RPE) cost of $35 to $140. However, even without any changes to fuel economy standards, most MY 2005-2007 light trucks are likely to employ one or more such techniques, and manufacturers indicated smaller potential fuel consumption reductions. On the other hand, further incremental reductions of engine friction and other mechanical and hydrodynamic losses will likely remain available.

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 RPE cost of $8 to $11. However, even without any changes to fuel economy standards, most MY 2005-2007 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.

Multi-valve Overhead Camshaft Engine

Without changes to fuel economy standards, it appears likely that many MY 2005-2007 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 valvetrain'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 RPE cost of $105 to $140. 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 RPE cost of $35 to $140. 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.

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 RPE cost of $70 to 210. Some manufacturers estimated considerably higher significant potential fuel consumption reductions. However, manufacturers also estimated that VVLT would add costs somewhat higher than the range projected by the NAS.

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. Without changes to fuel economy standards, it appears that some light trucks would begin using cylinder deactivation by MY 2005 (also referred to as variable displacement or displacement-on-demand). The NAS report projected that cylinder deactivation could reduce fuel consumption by 3.0 to 6.0 percent at a RPE cost of $112 to $252. However, some manufacturers estimated considerably lower potential incremental fuel consumption improvements, in part because of theoretical limits on the amount of fuel consumption reduction that can be attributed to pumping loss reduction. Most manufacturers estimated that the application of cylinder deactivation would be much more expensive than the range projected by the NAS.

Direct Injection Spark Ignition

With direct fuel injection, spark ignition engines can utilize well-controlled lean mixtures, resulting in higher thermodynamic efficiency. 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 to 6 percent. The NAS report had no cost estimate for the technology. Two manufacturers commented on it, estimating similar fuel consumption gains.

Direct Injection Diesel Engines

Direct injection (DI) diesel engines with turbochargers are widely used in Europe in light duty vehicles. These applications yield a fuel consumption improvement of 30 to 40 percent over two-valve spark ignition engines. As with direct injection spark ignition engines, NOx and particulate standards may be difficult to meet. DI diesels are currently offered in the U.S. on Volkswagen passenger cars and on Ford and DaimlerChrysler light trucks of over 8,500 lb GVWR. NAS suggests a RPE cost of $2,000 to $3,000 for this technology. One manufacturer provided a similar cost.

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 RPE cost of $84 to $112.

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 RPE cost of $350 to $560. Some manufacturers estimated considerably lower available fuel consumption reductions, in part because of theoretical limits on the amount of fuel consumption reduction that can be attributed to pumping loss reduction. Most manufacturers estimated that supercharging and downsizing would entail considerably greater incremental cost penalties.

Intake Valve Throttling

VVLT engines reducing 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 RPE cost of $210 to $420 when compared to VVLT. Some manufacturers estimated much lower potential fuel consumption reductions when IVT is compared to VVLT. However, the same manufacturers also estimated that IVT would entail somewhat lower incremental costs

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 RPE cost of $280 to $560. Although some manufacturers provided similar cost estimates for camless valve actuation, the same manufacturers estimated much smaller potential fuel consumption reductions when camless valve actuation is considered as an incremental improvement over IVT.

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 engine's susceptibility to knock, particularly under high load conditions. Engines with variable compression ratio (VCR) could provide for higher compression ratios, and therefore greater efficiency, under partial load conditions. The NAS report projected that VCR could reduce fuel consumption by 2.0 to 6.0 percent over 4-valve VVT at a RPE cost of $210 to $490. Manufacturer estimates for VCR were approximately similar to those provided by NAS.

Transmission Technologies

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. Without changes in fuel economy standards, it appears that some trucks would use 5- or 6-speed transmissions. The NAS report projected that a 5-speed automatic transmission could reduce fuel consumption by 2.0 to 3.0 percent at a RPE cost of $70 to $154 (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 RPE cost of $140 to $280.

Some manufacturers estimated slightly higher available fuel consumption reductions, and others estimated lower potential values based on increases in rotating mass as well as theoretical limits on the amount of reduction that can be attributed to pumping losses. Manufacturer cost estimates covered a considerably broader range than suggested by the NAS, particularly for 5-speed transmissions.

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 RPE cost of $0 to $70. The only manufacturer to provide detailed comments on aggressive shift logic indicated that this technology is [ ]. The same manufacturer provided cost estimates [

].

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. This enables even finer optimization of the transmission ratio under different operating conditions and, therefore, some reduction of pumping and engine friction losses. Compared to 5-speed transmissions, the NAS report projected that CVTs could reduce fuel consumption by 4.0 to 8.0 percent at a RPE cost of $140 to $350. 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 RPE cost of $350 to $840.

Most manufacturers projected similar potential fuel consumption reductions for "conventional" CVTs. However, two manufacturers provided considerably lower estimates, citing the relative internal inefficiency of CVTs and theoretical limits on the amount of reduction that can be attributed to pumping losses. One manufacturer estimated much higher potential fuel consumption reductions for "advanced" CVTs, one agreed with the NAS report estimates, and one suggested that although "advanced" CVTs might increase CVT penetration rate, they would not achieve further fuel consumption reductions. Most manufacturer cost estimates for "conventional" CVTs were considerably higher than the range in the NAS report. Although only two manufacturers commented on the incremental cost of "advanced" CVTs, both of these manufacturers provided estimates significantly lower than in the NAS report.

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. The NAS report projected that such transmissions could reduce fuel consumption by 3.0 to 5.0 percent at a RPE cost of $70 to $280. Manufacturers who commented on this technology provided similar estimates of potential fuel consumption reductions, but widely divergent cost estimates. GM also commented on [

]

Vehicle Technologies

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. For example, many modern freight tractors use fairings and somewhat rounded forward profiles to reduce aerodynamic drag at highway speeds. 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 RPE cost of $0 to $140. Manufacturers provided similar estimates of available fuel consumption reductions and potential cost, but also suggested that these reductions could be limited by functional requirements and basic design characteristics of some light trucks.

Rolling Resistance Reduction

Tire characteristics (e.g., materials, construction, tread design) influence durability, recycling costs, 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 could achieve fuel consumption reductions of 1.0 to 1.5 percent at a RPE cost of $14 to $56. Manufacturer estimates of available incremental fuel consumption reductions and potential cost increases were considerably lower, in part because of the extent to which rolling resistance reductions have already been adopted.

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. The NAS report projected that 42 V electrical systems could reduce fuel consumption by 1.0 to 2.0 percent at a cost of $70 to $280. Two manufacturers estimated somewhat lower costs, and one manufacturer indicated much higher costs. However, because 42 V systems enable, but do not themselves yield fuel consumption reductions, three manufacturers estimated that 42 V systems would have little or no direct impact on fuel consumption.

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 RPE cost of $210 to $350. Two manufacturers estimated that ISGs could achieve fuel consumption reductions in this range. However, because of theoretical limits on the extent to which further fuel consumption reductions can be attributed to reductions in pumping losses (at idle), one manufacturer estimated much lower available incremental fuel consumption reductions for ISGs. All responding manufacturers provided considerably higher incremental cost estimates for ISGs.

Electric Power Steering

As mentioned above, 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 $105 to $150. Manufacturer estimates of available fuel consumption reductions were somewhat lower, although one manufacturer indicated that electric power steering would not likely be able to meet truck power requirements on vehicles with higher front axle loadings. Manufacturer cost estimates covered a somewhat wider range.

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. Depending on the sophistication of the system, the NAS report estimated a fuel consumption improvement of 15 to 30 percent at a RPE cost $3,000 to $5,000 for a "mild" hybrid, which does not utilize an electric motor to propel the vehicle. Honda is currently selling two hybrid passenger cars in the U.S., the Insight and a version of the Civic. Toyota is selling the Prius, which uses Toyota's Integrated Hybrid System and utilizes an electric motor in addition to all the components of a hybrid such as the Insight. In the Prius, the electric motor is used for vehicle propulsion at low speeds (under 15 mph) and to provide additional acceleration at highway speeds. Ford (Escape) and DaimlerChrysler (Ram 1500, Durango) have announced plans or have shown prototype hybrid light trucks. These are believed to be "mild" hybrids.

On January 6, 2003, GM announced plans to introduce two new hybrid electric propulsion systems on light trucks. These two new systems are in addition to the Parallel Hybrid Truck option (PHT), which was previously announced for MY 2004 Chevrolet Silverado and GMC Sierra full-size pickups and included in GM's May 2002 submission. The first of the recently announced hybrid propulsion options (ParadiGM) is planned for Saturn VUE SUVs, providing up to a 50% fuel economy improvement. The second recently announced hybrid system is a belt alternator starter (BAS), which would improve fuel economy by about [

] Chevrolet Equinox SUV. Beyond 2007, GM has announced plans to: [

].

As noted above, the fuel consumption improvement and cost depends on the extent of the hybridization. Manufacturers provided ranges for fuel consumption improvements and cost for systems that are not necessarily comparable. The manufacturers' estimates range above and below the NAS estimate.

Effect of Weight and Performance Reductions on Light Truck Fuel Economy

We believe 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 expect 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 does not include any CAFE gains through weight reduction not currently planned by manufacturers. Under this approach our CAFE standards will not affect motor vehicle safety.

Weight Reduction

The term weight reduction encompasses a variety of techniques with a variety of costs and lead times. These include downsizing, material substitution, component redesign, and alternate configurations. Downsizing reduces the weight and vehicle size, such as overhang, width, or height, and may result in a cost savings. Material substitution involves using lower density materials in vehicle components, such as replacing steel parts with aluminum or plastic. Lead-time varies with application, and the new components may be more costly. Component redesign is an on-going process to reduce costs and/or weight of components, while improving performance and reliability. Alternate configurations include such things as unit bodies, and front-wheel drive designs. Alternate configurations are not always suitable for the load requirements or after-market body installations of light trucks and also require major vehicle redesigns.

Although not a technology for weight reduction, the model mix of the light truck fleet can affect its average weight. The shifting of the light truck fleet mix to different size and configurations has been significant in recent years. (See Table V-1.) The popularity of compact vans and pickups and standard vans has diminished in favor of SUVs of all sizes. However, the total share of standard size vehicles has increased only slightly, but with a significant increase in average fleet weight.

Table V-1
Light Truck Model Sales Mix (percent)

MY	Compact Vans	Standard Vans	Compact Pickups	Standard Pickups	Compact SUVs	Standard SUVs	Avg.Test Wt., lb.
1995	19.9	8.8	17.5	22.2	26.1	5.5	4338
2001	14.3	2.6	12.9	22.7	33.1	14.4	4501

The NAS report projected a fuel consumption reduction of 3 to 4 percent for each 5 percent weight reduction (while maintaining the same acceleration performance) at a RPE cost of $210 to $350. Some manufacturers projected lower fuel consumption improvements, apparently on the basis that the engines are sized for loaded vehicle performance and would not be reduced in size if vehicle weight were reduced. Cost estimates ranged on both sides of the NAS estimate. The cost of reducing weight is difficult to determine and is dependent upon the methods used.

For example, a change in design that reduces weight on a new model may or may not save money. On the other hand, material substitution can result in an increase in price per application of the technology if more expensive materials are used. For example, weight can be reduced by using more expensive aluminum body parts instead of steel.

Performance Reduction

Performance reduction is more of a technique than a technology. However, many of the fuel economy technologies that have been introduced into vehicles over the past 20 years have been at least partially employed to improve vehicle acceleration or other performance characteristics, rather than to increase fuel efficiency. There is often a trade-off between performance and fuel economy. A 10 percent reduction in engine horsepower to equivalent test weight ratio (with no change in overall drivetrain gearing) will result in about 2 percent reduction in fuel consumption and a 10 percent increase in 0-60 mph acceleration time for the average MY 2001 light truck. Small reductions in performance can be achieved with little engineering cost impact by reducing the overall drivetrain gear ratio. Larger reductions would entail reducing the size or performance of the engine. All of these tradeoffs necessarily involve costs to the extent that reduced engine size or performance reduces the value of the vehicle to the consumer.

The agency examined the impact of some weight and performance reductions on light truck fuel economy as a sensitivity analysis. All of the estimates below were based on the MY 2005 GM fleet, as projected in GM's May 2002 submission, since GM projected a relatively low average fuel economy, a full line of vehicles, and provided enough detailed information to make the estimates. Several scenarios were examined. These calculations are hypothetical in that it is likely not practical to achieve the changes in either weight or performance level in the lead time remaining before these vehicles go into production. They do show the relative magnitude of these types of changes in fleet characteristics, however.

1. Performance

If the value of the average engine horsepower times average N/V[1] divided by average test weight (HP*N/V /TWT)--a representation of vehicle performance that considers vehicle weight and gearing--for the GM projected MY 2005 fleet is returned to the MY 2001 level, the MY 2005 CAFE would increase by 0.67 mpg.

In this case, the power density of GM engines would increase from 0.72 hp/cubic inch displacement in MY 2001, when the entire light truck fleet averaged 0.81 hp/cubic inch, to 0.91 hp/cubic inch in MY 2005.

Although returning the performance of GM's light truck fleet to MY 2001 levels can cause a significant increase to their MY 2005 projected CAFE level, the probability of GM being able to achieve the changes in either weight or performance level in the lead time remaining before these vehicles go into production is very small. The vast majority of GM's MY 2005 light truck designs are locked in.

[1] N/V = Revolutions per minute (RPM) at top gear/mph. The lower the number the better.

2. Average Weight Reduction of 100 lbs on Entire Fleet

On average, a 10 percent reduction in weight results in a 3 percent fuel economy improvement if performance is not returned to the original level. On average, a 10 percent reduction in weight results in a 6 percent fuel economy improvement if performance is returned to the original level. If the entire MY 2005 fleet of GM light trucks was reduced in weight by 100 lbs and the performance of the fleet was not returned to the original level by reducing engine size, engine power, or gearing, the CAFE would increase by 0.12 mpg.

If the performance were restored to the original level for MY 2005, CAFE would increase by 0.25 mpg.

VI. MANUFACTURER SPECIFIC CAFE CAPABILITIES

On February 7, 2002, NHTSA issued a Federal Register notice requesting information—including detailed information regarding manufacturer product plans—to assist the agency in developing a proposal regarding CAFE standards for some or all of model years 2005 to 2010. General Motors, Ford, and DaimlerChrysler, which account for over 75 percent of the light trucks sold in the U.S., provided information for MY 2005 to 2007, however significantly less specific information was provided for MY 2008 to 2010. The remaining light truck manufacturers either provided no information or general comments without specific data. For these manufacturers we utilized information from a NHTSA database for the 2001 model year. 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-1 shows the market share assumed for the analysis for each of the manufacturers and it shows the MY 2001 CAFE levels for each of the manufacturers without taking into account any alternative fueled vehicle credits. In addition, it shows our estimates of the fuel economy levels for each manufacturer for MY 2005, MY 2006, and MY 2007 under three different assumptions. The first set of estimates show what we believe the manufacturers' fuel economy would be without them having any knowledge of the proposed fuel economy standards, and without taking into account fuel economy adjustments for alternative fueled vehicles. In other words, what would be their planned level of fuel economy, not counting alternative fueled vehicles, knowing that there will be CAFE standards, but not knowing what those fuel economy levels will be.

DaimlerChrysler, Ford, and GM were the only companies that provided specific CAFE estimates. Some manufacturers provided pieces of information, but not an overall CAFE. In some cases we estimate that their CAFE will decline from the MY 2001 level because of new model introductions or market shifts. Other manufacturers provided no information, and their fuel economy was assumed to remain level at the MY 2001 level.

The second set of estimates is our baseline fuel economy levels for the analysis (called the **ADJUSTED BASELINE** throughout the analysis). These levels are the same as the numbers in the top part of Table VI-1 for each manufacturer, except that we assumed for the analysis that each manufacturer below the current standard level of 20.7 mpg would apply technology to achieve 20.7 mpg[1]. Our rationale for this adjustment of the baseline is that the costs and benefits of achieving 20.7 mpg have already been analyzed and estimated in previous analyses. The methodology in this analysis is to apply technologies to the manufacturers plans and get them up to 20.7 mpg. The costs of these technologies are estimated, but they are not considered part of this rule. We then estimate the costs and benefits of going from the adjusted baseline to the level of the standard (some manufacturers are above the level of the standard already and are assumed to remain at that level, and 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).

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[1] Note that a manufacturer could be complying with the current standard of 20.7 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.

The third set of estimates presents CAFE levels projected to occur following the application of technologies we predict the manufacturers could utilize in response to CAFE standards for these three model years.

The agency has performed two separate analyses which both project how manufacturers could respond to changes in the CAFE levels required by the final rule. 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 identified by the NAS to the entire industry on a truckline-by-truckline basis. The Stage Analysis was only performed for DaimlerChrysler, Ford, and General Motors, and emphasized particular technologies identified by the manufacturer.

The final rule CAFE standards were developed using the Stage analysis. However, because the analysis conducted using the technology application algorithm covered the entire industry, this analysis was used to estimate the overall economic impact of the final rule as measured in terms of benefits and costs, 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.

The agency did not consider wholesale performance reductions, mix shifts, or weight reductions. However, the manufacturers can choose to use these and/or any other approaches to get to 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.

Table VI-1
Estimated Fuel Economy Levels*

Estimated mpg Before Standards are Known (Baseline)					
	Sales %	MY 2001	MY 2005 Estimate	MY 2006 Estimate	MY 2007 Estimate
BMW	0.88	19.2	21.77	21.77	21.77
DC	24.43	19.9	21.32	21.53	22.24
Ford	27.36	20.3	20.79	21.12	21.40
GM	25.38	20	20.37	20.44	20.63
Honda	3.61	24.9	24.85	24.85	24.85
Hyundai	0.52	25.2	25.02	25.02	25.02
Isuzu	1.61	21.1	21.12	21.12	21.12
Kia	1.19	22.9	19.55	19.55	19.55
Nissan	4.71	20.7	20.81	20.81	20.81
Porsche	0.20		13.21	13.21	13.21
Subaru	0.26		22.48	22.48	22.48
Suzuki	0.53	22	22.01	22.01	22.01
Toyota	8.88	22.1	22.12	22.13	22.13
VW	0.44	20.5	16.68	16.68	16.68
Average		20.5	21.03	21.05	21.05
Estimated mpg After 20.7 MPG Standard with Technology (Adj. Baseline)					
	Sales %		MY 2005 Estimate	MY 2006 Estimate	MY 2007 Estimate
BMW	0.88		21.77	21.77	21.77
DC	24.43		21.32	21.53	22.24
Ford	27.36		20.79	21.12	21.40
GM	25.38		20.70	20.70	20.82
Honda	3.61		24.85	24.85	24.85
Hyundai	0.52		25.02	25.02	25.02
Isuzu	1.61		21.12	21.12	21.12
Kia	1.19		20.87	20.91	20.72
Nissan	4.71		20.81	20.81	20.81
Porsche	0.20		14.75	16.27	16.27
Subaru	0.26		22.48	22.48	22.48
Suzuki	0.53		22.01	22.01	22.01
Toyota	8.88		22.12	22.13	22.13
VW	0.44		20.18	20.58	20.78
Average			21.13	21.31	21.60

Estimated mpg After Standards with Technology Based on the Technology Application Assessment					
	Sales %		MY 2005 Estimate	MY 2006 Estimate	MY 2007 Estimate
BMW	0.88		21.77	21.77	22.22
DC	24.43		21.32	21.60	22.24
Ford	27.36		21.00	21.68	22.20
GM	25.38		21.03	21.63	22.21
Honda	3.61		24.85	24.85	24.85
Hyundai	0.52		25.02	25.02	25.02
Isuzu	1.61		21.12	21.60	22.20
Kia	1.19		21.11	21.74	22.30
Nissan	4.71		21.01	21.61	22.41
Porsche	0.20		14.75	16.27	16.27
Subaru	0.26		22.48	22.48	22.48
Suzuki	0.53		22.01	22.01	22.20
Toyota	8.88		22.12	22.13	22.23
VW	0.44		20.18	20.58	21.24
Average			21.29	21.78	22.31

* All of the fuel economy estimates exclude the impacts of alternative fuel credits.

Sales Projections

Taken together, the sales projections provided by the individual companies to NHTSA yielded unrealistically high industry-wide light truck sales volumes (*e.g.*, more than nine million units in 2007). Therefore, we assumed that (1) overall sales volumes would match projections in the Department of Energy, Energy Information Administration (EIA's) Annual Energy Outlook 2002, (2) each manufacturer's share of the overall light truck market would match that manufacturer's assumed share of the market (as shown in Table VI-1), and (3) as a share of the total projected light truck sales for each manufacturer, sales projections for each truckline would be the same as provided in response to NHTSA's *Federal Register* notice (or, for manufacturers who did not provide data requested in this notice, mid-year estimates for the 2001 model year).

Table VI-2
Projected Sales

Model Year	Millions of vehicles
2005	7.654
2006	7.795
2007	7.921

Technology Assumptions

Potential retail price equivalent (RPE) and fuel consumption impacts of different technologies are discussed in Chapter V. Within the range of values anticipated for each technology, for the Preliminary Economic Assessment, we selected RPE and fuel consumption impacts considered most plausible during the model years under consideration. These expected impacts are summarized in Table VI-3a. As discussed in chapters III and IV, we have decided to use the National Academy of Sciences estimates of fuel consumption improvements and costs. These are shown in Table VI-3b. These tables also present our expectations regarding the year in which technology might be available for widespread application to light trucks:

Table VI-3a

NHTSA PEA Assumptions

Expected Fuel Consumption and Cost (RPE) Impacts and Availability of Technologies

	FC (gpm)			Cost			Availability		
Technology	**pessimistic**	**expected**	**optimistic**	**optimistic**	**expected**	**pessimistic**	**optimistic**	**expected**	**pessimistic**
Production-Intent Engine Technology									
Engine Friction Reduction	0.5%	1.5%	2.0%	$10	$35	$100	2005	2005	2005
Low Friction Lubricants	0.3%	0.5%	1.0%	$1	$3	$10	2005	2005	2005
Multi-Valve, Overhead Camshaft	2.0%	2.5%	3.5%	$50	$232	$500	2005	2005	2007
Variable Valve Timing	0.5%	1.0%	2.0%	$75	$89	$150	2005	2005	2007
Variable Valve Lift & Timing	1.0%	2.0%	2.5%	$150	$222	$350	2005	2005	2005
Cylinder Deactivation	1.0%	3.5%	4.0%	$150	$221	$450	2005	2005	2008
Engine Accessory Improvement	0.5%	1.0%	2.0%	$5	$20	$50	2005	2005	2007
Engine Supercharging & Downsizing	0.0%	4.5%	6.0%	$350	$560	$700	2005	2005	2007
Production-Intent Transmission Technology									
5-Speed Automatic Transmission	0.5%	2.0%	3.0%	$75	$154	$300	2005	2005	2005
Continuously Variable Transmission	3.5%	5.0%	7.5%	$225	$398	$500	2005	2005	2005
Automatic Transmission w/ Aggressive Shift Logic	0.0%	0.5%	2.0%	$20	$35	$70	2005	2005	2007
6-Speed Automatic Transmission	0.0%	2.0%	3.0%	$20	$140	$200	2005	2005	2008
Production-Intent Vehicle Technology									
Aero Drag Reduction	0.5%	1.5%	2.0%	$0	$45	$150	2005	2005	2008
Improve Rolling Resistance	0.0%	0.5%	1.0%	$0	$11	$30	2005	2005	2005
Emerging Engine Technology									
Intake Valve Throttling	0.5%	1.0%	3.0%	$110	$315	$400	2005	2008	2011
Camless Valve Actuation	1.0%	2.0%	4.5%	$350	$420	$500	2008	2008	2011
Variable Compression Ratio	2.0%	3.5%	6.0%	$260	$300	$350	2008	2008	2011
Emerging Transmission Technology									
Automatic Shift Manual Transmission (AST/AMT)	2.0%	3.0%	5.0%	$0	$175	$350	2007	2007	2011
Advanced CVTs	0.0%	1.0%	2.5%	$130	$195	$240	2008	2008	2011
Emerging Vehicle Technology									
42 Volt Electrical Systems	0.0%	0.5%	1.0%	$60	$150	$200	2005	2005	2005
Integrated Starter/Generator	1.0%	4.5%	5.5%	$400	$534	$650	2005	2005	2005
Electric Power Steering	1.0%	2.0%	2.0%	$70	$150	$200	2005	2005	2008
Vehicle Weight Reduction									

Table VI-3b

NAS Assumptions

Technology	FC Low	High	Cost Low	High	Availability
Production-Intent Engine Technology					
Engine Friction Reduction	1.0%	5.0%	$ 35	$ 140	2002
Low Friction Lubricants	1.0%	1.0%	$ 8	$ 11	2002
Multi-Valve, Overhead Camshaft	2.0%	5.0%	$105	$ 140	2002
Variable Valve Timing	2.0%	3.0%	$ 35	$ 140	2002
Variable Valve Lift & Timing	1.0%	2.0%	$ 70	$ 210	2002
Cylinder Deactivation	3.0%	6.0%	$112	$ 252	2002
Engine Accessory Improvement	1.0%	2.0%	$ 84	$ 112	2002
Engine Supercharging & Downsizing	5.0%	7.0%	$350	$ 560	2002
Production-Intent Transmission					
5-Speed Automatic Transmission	2.0%	3.0%	$ 70	$ 154	2002
Continuously Variable Transmission	4.0%	8.0%	$140	$ 350	2002
Automatic Transmission w/ Aggressive	1.0%	3.0%	$0	$ 70	2002
6-Speed Automatic Transmission	1.0%	2.0%	$140	$ 280	2002
Production-Intent Vehicle Technology					
Aero Drag Reduction	1.0%	2.0%	$ 0	$ 140	2002
Improve Rolling Resistance	1.0%	1.5%	$ 14	$ 56	2002
Emerging Engine Technology					
Intake Valve Throttling	3.0%	6.0%	$210	$ 420	2007-2012
Camless Valve Actuation	5.0%	10.0	$280	$ 560	2007-2012
Variable Compression Ratio	2.0%	6.0%	$210	$ 490	2007-2012
Emerging Transmission Technology					
Automatic Shift Manual Transmission	3.0%	5.0%	$70	$ 280	2007-2012
Advanced CVTs	0.0%	2.0%	$350	$ 840	2007-2012
Emerging Vehicle Technology					
42 Volt Electrical Systems	1.0%	2.0%	$70	$ 280	2007-2012
Integrated Starter/Generator	4.0%	7.0%	$210	$ 350	2007-2012
Electric power Steering	1.5%	2.5%	$105	$ 150	2007-2012
Vehicle Weight Reduction	3.0%	4.0%	$ 210	$ 350	2007-2012

FC = Fuel Consumption Improvement

Table VI-3c

Average of NAS Assumptions[2]

And Cost per Fuel Consumption Improvement

Technology	FC (gpm)	Cost Average	Cost Per Percent
Production-Intent Engine Technology			
Engine Friction Reduction	3.0%	$88	$29
Low Friction Lubricants	1.0%	$10	10
Multi-Valve, Overhead Camshaft	3.5%	$ 123	35
Variable Valve Timing	2.5%	$ 88	35
Variable Valve Lift & Timing	1.5%	$ 140	93
Cylinder Deactivation	4.5%	$ 182	40
Engine Accessory Improvement	1.5%	$ 98	65
Engine Supercharging & Downsizing	6.0%	$ 455	76
Production-Intent Transmission			
5-Speed Automatic Transmission	2.5%	$ 112	45
Continuously Variable Transmission	6.0%	$ 245	41
Automatic Transmission w/ Aggressive	2.0%	$ 35	18
6-Speed Automatic Transmission	1.5%	$ 210	140
Production-Intent Vehicle Technology			
Aero Drag Reduction	1.5%	$70	47
Improve Rolling Resistance	1.3%	$ 35	27
Emerging Engine Technology			
Intake Valve Throttling	4.5%	$ 315	70
Camless Valve Actuation	7.5%	$ 420	56
Variable Compression Ratio	4.0%	$ 350	88
Emerging Transmission Technology			
Automatic Shift Manual Transmission	4.0%	$ 175	44
Advanced CVTs	1.0%	$ 595	595
Emerging Vehicle Technology			
42 Volt Electrical Systems	1.5%	$ 175	117
Integrated Starter/Generator	5.5%	$280	51
Electric power Steering	2.0%	$ 128	64
Vehicle Weight Reduction	3.5%	$ 280	80

[2] "Effectiveness and Impact of Corporate Average Fuel Economy Standards", National Research Council, 2002, page 44.

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. Using the estimated technology characteristics and assumptions presented above, the algorithm repeatedly evaluates each technology that could be applied to each truckline in the manufacturer's product line and selects the application that is the most attractive in terms of the ratio between (1) the RPE increase that would result from applying a given technology to a given truckline, less the value of the resultant fuel savings and (2) the resultant change in CAFE fines. For this analysis we assumed that paying fines, rather than applying technologies to improve fuel efficiency, would not be used by the manufacturers, unless all available technologies were exhausted, because we wanted to estimate the impact on cost and benefits of meeting the final rule.

Mathematically, this is expressed as follows:

$$\frac{S_j\left[C_{ij}-\frac{k_{MY}}{1-R_b}\left(\frac{1}{MPG_{i-1,j}}-\frac{1}{MPG_{i,j}}\right)\right]}{\Delta FINE} \quad (0.1)$$

where

S_j is the sales for truck model j,

C_{ij} is the cost (RPE increase) to implement technology i on truckline j,

$MPG_{i-1,j}$ is the (rated) fuel economy after the previous technology application (*i-1*) to the current truckline *j*,

$MPG_{i,j}$ is the (rated) fuel economy after the current technology application (*i*) to the current truckline *j*,

R_b is the loss of fuel economy the vehicle buyer expects to observe under real-world driving conditions compared to the rated fuel economy, and

$\Delta FINE$ is the reduction in fines if technology *i* is applied to truckline *j*,

and k_{MY} is a constant that, for a given model year *MY*, estimates the value to the vehicle buyer of reductions in a vehicle's fuel consumption rate (gallons/mile). This constant is calculated as follows:

$$k_{MY} = \sum_{v=0}^{v=PB} \frac{SURV_v M_v P_{b,MY+v}}{\left(1+r_b\right)^{v+0.5}} \tag{0.2}$$

where

v is the truck's vintage,

PB is the payback period that applies to the purchase decision,

M_v is the average annual mileage accumulation by a truck of vintage v,

$SURV_v$ is the probability that a truck of vintage v will remain in service,

r_b is the rate at which truck buyers discount future fuel savings, and

$P_{b,MY+v}$ is the fuel price the buyer expects to pay in year $MY+v$

To estimate k_{MY}, we assumed a payback period of 4.5 years and a discount rate of seven percent. While the algorithm is in a cost-effective régime (i.e., while expression 0.1 yield a value less than 1), the payback period only comes into consideration when we are trying to determine which model is going to get the technology first, not which technology comes first.[3] Our assumptions regarding fuel prices and age-specific vehicle survival and mileage accumulation rates are discussed in Chapter VIII.

The technologies in Table VI-7 were ranked 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. 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-7, the model repeatedly selects the appropriate technology application for a particular make/model that yields the highest fuel savings at the lowest cost. 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 RPE 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 RPE increases (at the truckline and corporate level). Final calculated levels are outputs of the algorithm.

[3] When the algorithm enters a cost-ineffective régime, it is currently designed to shift to a cost-minimizing mode.

In order to estimate the potential net effects of the final rule, we applied the above-mentioned technology assumptions and technology application algorithm to 21.0, 21.6, and 22.2 MPG in MY 2005, 2006, and 2007, respectively. Not all of the manufacturers' fuel economy levels reached 20.7 mpg as shown in Table VI-1 under "Estimated mpg before standards are known". Therefore, for some of those manufacturers, technologies were applied to get them up to the adjusted baseline of the current 20.7 mpg standard. Tables VI-4 to VI-6 for MY 2005, MY 2006, and MY 2007 respectively, show for several key technologies the calculated levels of utilization by each manufacturer to meet the current 20.7 mpg, without considering alternative fueled vehicles, and to get them to the level of the final rule for that particular model year. These summary results are based on projected technology utilization at the truckline level. The costs and benefits are only included in the analysis for those technologies that take the manufacturer's fleet average from the adjusted baseline to the level of the final rule.

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-3c to determine the sequence that a manufacturer might follow when deciding which technologies to apply. Table VI-7 presents this "application path". It provides the technologies in the order in which we chose them to be implemented into the vehicle fleet. These are not always chosen on a cost per percent improvement in mileage. First, we examined those technologies that are available in MY 2005 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 not applied to 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 even if the CAFE standard remains at 20.7 MPG. 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 eight 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.[4]

[4] 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.

Table VI-4a

Calculated Technology Utilization for MY 2005 (20.7 MPG Standard)

Manufacturer	Low Friction Lubricants	Improve Rolling Resistance	Engine Friction Reduction	Multi-Valve, Overhead Camshaft	Variable Valve Timing	Cylinder Deactivation	Electric Power Steering	Engine Accessory Improvement	5-Speed Automatic Transmission	6-Speed Automatic Transmission	Auto. Trans. w/ Aggressive Shift Logic	Continuously Variable Transmission	Auto. Shift Manual Trans. (AST/AMT)	Aero Drag Reduction	Variable Valve Lift & Timing	Engine Supercharging & Downsizing	42 Volt Electrical Systems	Integrated Starter/Generator	Camless Valve Actuation	Intake Valve Throttling	Variable Compression Ratio	Advanced CVTs	Moderate HEV
Toyota																							
General Motors	43%	54%	21%																				
DaimlerChrysler																							
Ford																							
Nissan																							
Isuzu																							
BMW																							
Suzuki																							
Honda																							
Kia	100%	100%	100%		12%		12%	12%	12%														
Hyundai																							
Volkswagen	25%	25%	25%				25%	25%		24%				25%	25%		25%	25%					
Porsche																							
Subaru																							

Table VI-4b

Calculated Technology Utilization for MY 2005 (21.0 MPG Standard)

Manufacturer	Low Friction Lubricants	Improve Rolling Resistance	Engine Friction Reduction	Multi-Valve, Overhead Camshaft	Variable Valve Timing	Cylinder Deactivation	Electric Power Steering	Engine Accessory Improvement	5-Speed Automatic Transmission	6-Speed Automatic Transmission	Auto. Trans. w/ Aggressive Shift Logic	Continuously Variable Transmission	Auto. Shift Manual Trans. (AST/AMT)	Aero Drag Reduction	Variable Valve Lift & Timing	Engine Supercharging & Downsizing	42 Volt Electrical Systems	Integrated Starter/Generator	Camless Valve Actuation	Intake Valve Throttling	Variable Compression Ratio	Advanced CVTs	Moderate HEV
Toyota																							
General Motors	43%	54%	54%	17%																			
DaimlerChrysler																							
Ford		62%	10%																				
Nissan	50%	38%																					
Isuzu																							
BMW																							
Suzuki																							
Honda																							
Kia	100%	100%	100%		23%		23%	23%	23%														
Hyundai																							
Volkswagen	25%	25%	25%				25%	25%		24%				25%	25%		25%	25%					
Porsche																							
Subaru																							

Table VI-5a

Calculated Technology Utilization for MY 2006 (20.7 MPG Standard)

Manufacturer	Low Friction Lubricants	Improve Rolling Resistance	Engine Friction Reduction	Multi-Valve, Overhead Camshaft	Variable Valve Timing	Cylinder Deactivation	Electric Power Steering	Engine Accessory Improvement	5-Speed Automatic Transmission	6-Speed Automatic Transmission	Auto. Trans. w/ Aggressive Shift Logic	Continuously Variable Transmission	Auto. Shift Manual Trans. (AST/AMT)	Aero Drag Reduction	Variable Valve Lift & Timing	Engine Supercharging & Downsizing	42 Volt Electrical Systems	Integrated Starter/Generator	Camless Valve Actuation	Intake Valve Throttling	Variable Compression Ratio	Advanced CVTs	Moderate HEV
Toyota																							
General Motors	49%	43%	10%																				
DaimlerChrysler																							
Ford																							
Nissan																							
Isuzu																							
BMW																							
Suzuki																							
Honda																							
Kia	100%	100%	100%		12%		12%	12%	12%														
Hyundai																							
Volkswagen	100%	100%	25%	16%			25%	25%		24%				25%	25%		25%	25%					
Porsche						100%		100%						100%	100%		100%	100%					
Subaru																							

Table VI-5b

Calculated Technology Utilization for MY 2006 (21.6 MPG Standard)

Manufacturer	Low Friction Lubricants	Improve Rolling Resistance	Engine Friction Reduction	Multi-Valve, Overhead Camshaft	Variable Valve Timing	Cylinder Deactivation	Electric Power Steering	Engine Accessory Improvement	5-Speed Automatic Transmission	6-Speed Automatic Transmission	Auto. Trans. w/ Aggressive Shift Logic	Continuously Variable Transmission	Auto. Shift Manual Trans. (AST/AMT)	Aero Drag Reduction	Variable Valve Lift & Timing	Engine Supercharging & Downsizing	42 Volt Electrical Systems	Integrated Starter/Generator	Camless Valve Actuation	Intake Valve Throttling	Variable Compression Ratio	Advanced CVTs	Moderate HEV
Toyota																							
General Motors	49%	58%	58%	41%	19%	16%																	
DaimlerChrysler	39%																						
Ford			62%	17%	10%																		
Nissan	74%	100%	62%																				
Isuzu	100%	100%																					
BMW																							
Suzuki																							
Honda																							
Kia	100%	100%	100%		68%		68%	68%	46%			21%		21%									
Hyundai																							
Volkswagen	100%	100%	25%	16%			25%	25%		24%				25%	25%		25%	25%					
Porsche						100%		100%						100%	100%		100%	100%					
Subaru																							

Table VI-6a

Calculated Technology Utilization for MY 2007 (20.7 MPG Standard)

Manufacturer	Low Friction Lubricants	Improve Rolling Resistance	Engine Friction Reduction	Multi-Valve, Overhead Camshaft	Variable Valve Timing	Cylinder Deactivation	Electric Power Steering	Engine Accessory Improvement	5-Speed Automatic Transmission	6-Speed Automatic Transmission	Auto. Trans. w/ Aggressive Shift Logic	Continuously Variable Transmission	Auto. Shift Manual Trans. (AST/AMT)	Aero Drag Reduction	Variable Valve Lift & Timing	Engine Supercharging & Downsizing	42 Volt Electrical Systems	Integrated Starter/Generator	Camless Valve Actuation	Intake Valve Throttling	Variable Compression Ratio	Advanced CVTs	Moderate HEV
Toyota																							
General Motors	34%	30%	9%																				
DaimlerChrysler																							
Ford																							
Nissan																							
Isuzu																							
BMW																							
Suzuki																							
Honda																							
Kia	100%	100%	100%		12%		12%	12%	12%														
Hyundai																							
Volkswagen	100%	100%	100%	18%	29%		100%	100%		17%			82%	100%	71%		70%	53%					
Porsche						100%		100%						100%	100%		100%	100%					
Subaru																							

Table VI-6b

Calculated Technology Utilization for MY 2007 (22.2 MPG Standard)

Manufacturer	Low Friction Lubricants	Improve Rolling Resistance	Engine Friction Reduction	Multi-Valve, Overhead Camshaft	Variable Valve Timing	Cylinder Deactivation	Electric Power Steering	Engine Accessory Improvement	5-Speed Automatic Transmission	6-Speed Automatic Transmission	Auto. Trans. w/ Aggressive Shift Logic	Continuously Variable Transmission	Auto. Shift Manual Trans. (AST/AMT)	Aero Drag Reduction	Variable Valve Lift & Timing	Engine Supercharging & Downsizing	42 Volt Electrical Systems	Integrated Starter/Generator	Camless Valve Actuation	Intake Valve Throttling	Variable Compression Ratio	Advanced CVTs	Moderate HEV
Toyota	53%																						
General Motors	47%	57%	57%	42%	38%	15%	2%	22%	15%	3%	3%			7%	3%								
DaimlerChrysler	15%																						
Ford			71%	27%	25%																		
Nissan	74%	100%	100%				11%	□%					11%	11%									
Isuzu	100%	100%	90%																				
BMW	89%	89%																					
Suzuki	85%																						
Honda																							
Kia	100%	100%	100%		89%		89%	89%	46%			43%		43%									
Hyundai																							
Volkswagen	100%	100%	100%	18%			100%	100%		17%			82%	100%	100%		100%	100%					
Porsche						100%		100%						100%	100%		100%	100%					
Subaru																							

Table VI-7

Technology Application Path[5]

	Technology	Year Available	Cost per Percent Improvement
1	Low Friction lubricants	2005	$10
2	Improve Rolling Resistance	2005	$27
3	Engine Friction Reduction	2005	$29
4	Multi-valve overhead camshaft	2005	$35
5	Variable Valve Timing	2005	$35
6	Cylinder Deactivation	2005	$40
7	Electric Power Steering	2005	$64
8	Engine Accessory Improvement	2005	$65
9	5-speed Automatic Transmission	2005	$45
10	6-speed Automatic Transmission	2005	$140
11	Automatic Transmission with Aggressive Shift Logic	2005	$18
12	Continuously Variable Transmission	2005	$41
13	Automatic Shift Manual Transmission	2007	$44
14	Aero Drag Reduction	2005	$47
15	Variable Valve Lift and Timing	2005	$93
16	Engine Supercharging and Downsizing	2005	$76
17	42 Volt Electrical Systems	2005	$117
18	Integrated Starter/Generator	2005	$51
19	Camless Valve Actuation	2008	$56
20	Intake Valve Throttling	2008	$70
21	Variable Compression Ratio	2008	$88
22	Advanced CVTs	2008	$595

[5] The technology application path does not always go from cheapest to most expensive technology. Some technologies are dependent upon other technologies and must come later. In other cases, the technologies follow a natural progression before introduction; a 5 speed comes before a 6 speed automatic transmission.

Stage Analysis

Manufacturers could respond to the new CAFE standards in many different ways. Considering the uncertainties involved in forecasting manufacturer response, NHTSA has examined the new standards using two analytical approaches. The second method—the stage analysis—relied heavily on the staged manual application of different technologies at the truckline level, emphasizing particular technologies identified by the manufacturer. This method was used to develop one set of technology assumptions for DaimlerChrysler, Ford, and GM, which account for most of the light truck market and provided detailed information regarding product plans and fuel economy technologies. As discussed in Chapter VII, although the details of these two methods differ, they yielded cost estimates of similar magnitude for the new CAFE standards.

Stage Analysis for DaimlerChrysler, Ford and GM

This section discusses various technologies that could be used to improve DaimlerChrysler, Ford, and GM's automotive fuel efficiency. These manufacturers have the largest share of the light truck market and offer a full line of vehicles. Some of these cited technologies have been used for over a decade, e.g., OHC, engine friction reduction, and low friction lubricants. Some have only recently been produced on passenger cars, e.g., 5-speed and 6-speed automatic transmissions and variable valve timing. Some 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 used by NHTSA is not a rigid methodology to achieve these levels of fuel economy improvement. 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. Also, this analysis does not include the many minor types of improvements in electronic controls and engine valving 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 2005-2007.

The analysis is divided into two stages: a more conservative application of technologies which are deemed to be available for use by MY 2005 which would not require significant changes in transmission and/or engine technology (Stage I); and, 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 (Stage II). Whereas the agency in the NPRM employed an analysis that shifted 6.0L and larger engines identified in product plans for models to smaller and more fuel-efficient engines (Stage III), the final rule is not based on any engine shifts. The possibility that forcing through regulation substantial deviation from product offerings based on projected consumer demand may impose unreasonable constraints on the market leads us to conclude that it is not appropriate to include such engine shifts in the Stage analysis.

The Stage I analysis includes technologies that manufacturers state as being available for use by MY 2005 or earlier, but they are choosing not to use them in their product plans.

The Stage II analysis includes two major categories of technological improvements to the manufacturers fleets, tied as nearly as possible to planned model change and engine introduction years. The first of the categories is transmission improvements, which consists of the introduction of 5-speed and 6-speed transmissions in vehicle classes larger than compact pickup trucks and compact SUVs, and the introduction of CVTs in the compact pickup truck and compact SUV class. Replacing a 4-speed automatic transmission with a 5-speed or 6-speed transmission was estimated to yield a 3 percent fuel economy improvement, while replacing a 4-speed automatic transmission with a CVT estimated to yield a 6 percent fuel economy improvement.

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 the introduction of integrated starter/generators. Considering that the individual benefits of some of these technology introductions may not be additive, replacing an overhead valve engine with multi-valve overhead camshafts was estimated to yield a 3 percent fuel economy improvement, using 3 or more valves on an existing overhead cam engine was estimated to yield a 2 percent fuel economy improvement, applying variable valve lift and timing to multi-valve overhead camshaft engines was estimated to yield an additional 2 percent fuel economy improvement, and the application of integrated starter/generators to existing engines was estimated to yield a 4 percent fuel economy improvement.

DaimlerChrysler

(a) Stage I and Stage II

In their submission, DaimlerChrysler 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 the estimated fuel economy, the baseline technology it is measured against, when the technology would be available for use, its potential applications, where it is currently employed in DaimlerChrysler's light truck fleets, where the technology could potentially be used, and potential reasons that limit the implementation rate of the technology. NHTSA found that DaimlerChrysler has utilized an extensive amount of technology across its fleet. This use of technology results in DaimlerChrysler having an estimated CAFE value for MY 2005-2007 that either meets or exceeds those of Ford and GM. Thus, NHTSA is not recommending the use of additional technology in either Stage I or Stage II.

(b) Stage III

The Stage III analysis in the PEA included projections of the potential CAFE increase that could result form moving the sales of vehicles equipped with 6.0L or larger engines to almost identical models equipped with 5.3L or larger engines. As stated above, the possibility that forcing through regulation substantial deviation from product offerings based on projected consumer demand may impose unreasonable constraints on the market leads us to conclude that it is not appropriate to include such engine shifts in the Stage analysis.

Although DaimlerChrysler could take efforts to increase the CAFE of its light truck fleet, the agency doesn't project the need for these actions to occur. Thus, this analysis doesn't change the levels that DaimlerChrysler provided in their docket submission (see Table VI-1).

Table VI-8
DaimlerChrysler Potential Technology
CAFE Improvements, mpg

Model Year	**Baseline Mpg**	**Stage I and II Improvements**	**Potential CAFE, mpg**
2005	21.3	0	21.3
2006	21.6	0	21.6
2007	22.2	0	22.2

Ford

(a) Stage I

In their May 8, 2002, 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.

In its response to the NPRM, Ford provided a revised product plan indicating lower projected CAFE values (see Table VI-9) and stated that some of the adjustments that NHTSA made to Ford's CAFE in the PEA were not feasible.

Table VI–9

Ford Projected CAFE Levels

Model Year	May 2002 Submission	February 2003 Submission
2005	20.9	[ ]
2006	21.6	[ ]
2007	22.0	[ ]

In response to this new information, the agency has revised its analysis of Ford's capability as follows:

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 one technology by MY 2005 [ ], with an additional two technologies employed by MY 2006 that would be carried over to MY 2007 [ ], and one technology that could be added for MY 2007 [ ] 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 2005, Ford could use [ ] on all of its models that could utilize [

.] We did not carry over the benefits for this technology to further years due to the fact that Ford is redesigning many of these vehicles in MY 2006-2007 and is believed to have accounted for the inclusion of [ ] in its fuel economy estimates. While Ford objected to the inclusion of pickups and SUVs in the application of this technology due to harsh driving conditions and appearance issues, the agency still believes that this is a cost effective technology for improving fuel economy.

Starting with MY 2006, Ford could use a [

] on all of its models. Ford objected to the use of this technology in MY 2007, due to lead time issues. However, the agency believes that this technology also is cost effective and can be implemented by MY 2006.

Starting with MY 2006, Ford could use [ ] on all of its models that could utilize [

] Ford acknowledged this technology existed and on which vehicles it could be used in its May 2002 submission, but didn't quantity any applications, nor did it identify vehicles for which this technology is planned for implementation.

In MY 2007, Ford could use [ ] on all [

] Ford didn't discuss this technology in its response to the NPRM. GM has indicated the vehicles for which this technology is appropriate in their submissions, including its current use on the Saturn Vue.

[ ] were not projected for use in the PEA, thus Ford hasn't commented on NHTSA's application of these technologies to Ford's fleet.

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

Table VI-10
Ford Light Truck Stage I Improvements

MY	[ ]	[ ]	[ ]	[ ]	Total mpg
2005	.160	0	0	0	.160
2006	0	.317	.121	0	.438
2007	0	.321	.143	.281	.745

(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 2005-2007. Our analysis showed that in MY 2007, Ford could offer one technology. Our analysis also projected that the sales of one model would remain constant, if not increase, by MY 2007.

In MY 2007, Ford could equip all of its [ ] with a [ ]. This is a change from the PEA, which projected the application of [ ] In its May 2002 submission, Ford projected the use of a specific [ ], and on the [ ]. Since that time, Ford has revised its projections to decrease the number of [ ] for its [ ] light truck fleet. However, Ford stated in their response to the NPRM that it had sufficient capacity to produce the quantity of [

] that we projected. In addition, Ford stated that implementing this technology for use on [ ], as projected in the PEA, would create certification problems and marketing issues in offering a [ ] in an entry level model. The agency believes that is feasible that these [could be used on [ ], since the projected sales of these vehicles are less than the sales of the vehicles for which NHTSA previously applied them to in its NPRM.

Additionally, it is possible that [

].

The improvements discussed above for Stage II are summarized for the Ford light truck fleet in the following table.

Table VI-11
[Whole Table Confidential]

Table Ford Light Truck Stage II Engine Improvements				
Model Year	Affected Vehicles	Technologies	Percent Improvement	CAFE Impr., Mpg
2007	[]	[]	[]	
2007	[]	[]	[]	

]

(c) Stage III

The Stage III analysis in the PEA included projections of the potential CAFE increase that could result form moving the sales of vehicles equipped with 6.0L or larger engines to almost identical models equipped with 5.3L or larger engines. As stated above, forcing through regulation substantial deviation from product offerings based on projected consumer demand may impose unreasonable constraints on the market leads us to conclude that it is not appropriate to include such engine shifts in the Stage analysis.

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-12
Potential Ford CAFE Improvements, mpg

Model Year	Baseline Mpg	Stage I Improvements	Stage II Improvements	Total	Potential CAFE, mpg.
2005	20.799	.160	0	.160	20.959
2006	21.121	.438	0	.438	21.559
2007	21.399	.675	.084	.829	22.228

GM

In their May 2002 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 2005-2007.

In its response to the NPRM, GM revised its projected fleet description, its CAFE values, and provided a detailed breakout of the incremental CAFE changes between the two submissions (See Table VI–13). In explaining the differences in projected CAFE values between its May 2002 submission and its February 2003 submission, GM provided a detailed breakdown of the effects on CAFE due to the changes that it made in these plans.

Table VI–13

GM Projected CAFE Levels

Model Year	May 2002 Submission	February 2003 Submission
2005	20.0	[]
2006	20.1	[]
2007	20.8	[]

(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 comments regarding the technology applications used in the PEA. Our revised analysis shows that GM could employ five technologies by MY 2005 with an additional two technologies employed by MY 2006. The five technologies would carryover to MY 2006-2007, while the additional two technologies available for MY 2006 would carryover to MY 2007. 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 2005, GM could use [ ]on all of its vehicles. GM objected to this improvement because it already is using [ ] equal to or better than its competitors and because the [ ]. The agency believes that the [ ]. It also believes that progress in [ ] will occur by MY 2005, which is consistent with the findings of the NAS report.

Starting with MY 2005, GM could use [ ] These are vehicles that typically are used for lighter duty applications and have lower towing capacities than full-sized trucks and SUVs. In the PEA, NHTSA had applied this technology to all GM light trucks beginning in MY 2005. GM objected to this, citing validation issues for [ ] The agency agrees, in part, with GM's argument and now applies the technology only to vehicles that tend to be lighter than full-sized trucks and SUVs.

Starting with MY 2005, GM could use [ ] GM, in its February 14, 2003, submission indicated that [ ] will be included on [ ] for MY 2005-2007 and would not be as cost effective on other models because of system integration issues. The agency deleted the technology for models on which GM plans to include it. Nevertheless, the agency believes that this technology should be included on all other models and was characterized as an engine accessory improvement in the technology application algorithm.

Starting with MY 2005, GM could use a [ ] In the PEA, this technology was applied, beginning in MY 2006, to these same models and [ ] for a [ ] improvement. GM commented that it was planning to use [ ] The agency therefore removed this technology from consideration on the [ ], used GM's revised FE improvement value, but applied this technology one year earlier on the basis that this is a technology that could be added to these vehicles within a shorter lead time.

Additionally, starting with MY 2005, GM could include [ ] on all [ ] models [.] In the PEA NHTSA also applied this technology to the [ ] model, however GM's Feb. 14 comments indicated that this model is projected to include this technology.

Starting with MY 2006, GM could employ [.] In the PEA the agency included this technology on [ ], but GM commented that these models already use this technology.

Additionally, starting with MY 2006, GM could include an [.] This is a technology that wasn't applied in the PEA, but GM's May 2002 submission indicated that it is feasible on these models by [ ]. This is a technology that is relatively inexpensive and could be added to these vehicles within a shorter lead time.

In this analysis, the agency didn't project the use of [ ] GM commented that this technology was applied to more engines in the PEA than was appropriate or feasible and that [ ] on the other engines would compromise low-end torque or require the use of premium fuel If this technology were projected onto engines that were appropriate for its use, the CAFE improvement would be very small.

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

Table VI-14
GM Stage I Technology CAFE Improvements, mpg

MY	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	**Total mpg**
2005	.265	.034	.105	.135	.001			.540
2006	.266	.037	.122	.163	.002	.082	.099	.771
2007	.268	.042	.116	.156	.002	.073	.101	.758

(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 2005-2007. Our analysis showed that GM could employ two technologies by MY 2005, and an additional technology by MY 2006. One of the technologies introduced in MY 2005 would only carry over into MY 2006, because the engines that could use this technology are scheduled to be replaced in MY 2007, and indications are that this specific technology application would no longer be applied in the vehicle redesign. The other technologies would carry over into MY 2007 and would continue to be employed in future model years. To determine the possible fuel economy increase attributable to each of these technologies, NHTSA looked at the NAS study's percentage increase in fuel economy for each technology.

Starting with MY 2005, GM could use [.] This would be a further technological advance on an engine that has [ ] today. Several other manufacturers employ this technology today. In [ ], the use of this technology would be limited to [ ] models. Starting with [ ], all vehicles equipped with [ ] could use this technology.

Starting with MY 2005, GM could use [ ], which are used on the [.] The use of [] on these engines would only carry over into MY 2006, because [.] However, the application of this technology for only two years is reasonable because these engines are [ ]. Therefore, some of the hardware and design development has been completed for this technology.

Starting with MY 2006, GM could add [.]

Starting with MY 2006, GM could use [.] These are engines that are adaptable to the technology because of their [ ].

In MY 2007, GM could use [.] These are new engines not discussed by GM in any of its submissions, but according to information published in *Automotive Engineering International (March 2003)*, NHTSA believes that these will be [ ].

Starting with MY 2006, GM could use [

.] Although one of the [

] the agency notes that [

.]

In MY 2007, GM could use [

.] In its February 2003 submission, GM indicated that [ ] are planned as an option on the MY 2007 [ ], but didn't include in its fleet description. Considering that [ ] are already in GM's product plan for MY 2007 [ ], the agency believes there is sufficient lead time for GM to equip all of its [ ] models with [ ] by MY 2007. The [ ] is a model that is expected to be similar in weight to the Saturn VUE, which employs a [

] models. Although one of the [

] the agency notes that [

.] The agency has also estimated a different fuel economy improvement for the application of [ ] to the [ ] models. The above [ ] fuel economy improvement attributed to the [ ] is the NAS midpoint value for replacing a [.] According to GM's February submission, the [ ] models will be equipped with [

.] Thus, to arrive at the fuel economy improvement for applying [ ] to the [

] models, the agency subtracted the NAS midpoint value for replacing a [

] from the NAS midpoint value for replacing a [

] to arrive at an expected fuel economy improvement of [.]

No use of the above technologies was projected in the PEA, consequently, GM didn't comment on them. They are technologies that GM employs on some models today, except for [.] In this analysis, the agency has elected to use these technologies in place of [

] and some [.] GM had extensive comments about the difficulty of introducing [ ] and [.]

Starting with MY 2006, GM could offer [

.] GM indicates that the lead-time for applying [.] These vehicles were chosen because of their poor fuel economy, the fact that these vehicles often are used primarily for carrying cargo, and because the usage of these vehicles lends itself to benefit the most from the application of [ ] under city driving conditions. GM commented that the [ ] applications in the PEA on MY 2005 and MY 2006 [

] was inappropriate because [

.] GM noted, however, that the new [ ] would be introduced on a mid-size SUV. This application appears in [

.] In this analysis, the agency has expanded the usage of the [

], to additional vehicles that are not planned for redesign before [ ].

Starting with MY 2006, GM could use [

.]

Starting with MY 2007, GM could use [

.]

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 2005-2007. NHTSA believes that if GM did not respond to the market pressures and expected consumer demand for [ ] on these vehicles, then GM could potentially lose many sales, which would have an adverse affect on GM's competitive position in the market. In commenting on the PEA analysis, GM claimed that competitors' [ ], and, thus, GM vehicles would not see much of an advantage for switching to [.] Nevertheless, a [ ] the engine to operate at the higher efficiency points more of the cycle time by offering more [.] [.]

GM commented about lead time for this technology, including plant conversion, introducing it prior to major model redesigns/changes, and introductions on several model lines at once. To partially accommodate these concerns, in this analysis, the projected use of [ ] is delayed until MY 2006; it was projected to be applied to MY 2005 vehicles in the PEA. GM may determine that [ ] would be more practical in these applications. If so, this technology may accomplish the same CAFE improvement at a lower implementation rate.

The improvements discussed above for Stage II are summarized for the GM light truck fleet in the following table.

Table VI-15
GM Light Truck Stage II Improvements

Model Year	Affected Engine/ Transmission	Technologies	Percent Impr.	CAFE Impr., mpg
2005	[ ]	[ ]	1.5	.033
2006	[ ]	[ ]	2.5	.1005
2006	[ ]	[ ]	2.5	.0066
2006	[ ]	[ ]	[ ]	.166
2006	[ ]	[ ]	2.5	.065
2006	[ ]	[ ]	6.0	.031
2007	[ ]	[ ]	2.5	.0079
2007	[ ]	[ ]	1.5	.0934
2007	[ ]	[ ]	[ ]	.090

2007	[ ]	[ ]	2.5	.035
2007	[ ]	[ ]	2.5	.168
2007	[ ]	[ ]	2.5	.119
2007	[ ]	[ ]	2.5	005
2007	[ ]	[ ]	6.0	034
2007	[ ]	[ ]	3.5	034

(c) Stage III

The Stage III analysis in the PEA included projections of the potential CAFE increase that could result form moving the sales of vehicles equipped with 6.0L or larger engines to almost identical models equipped with 5.3L or larger engines. As stated above, forcing through regulation substantial deviation from product offerings based on projected consumer demand may impose unreasonable constraints on the market leads us to conclude that it is not appropriate to include such engine shifts in the Stage analysis. Nonetheless, market forces may yet independently favor further reassessment of product plans for which there remains adequate lead time.

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-16

Potential GM CAFE Improvements, mpg

Model Year	Baseline Mpg	Stage I	Stage II	Total	Potential CAFE, mpg
2005	[]	[]	[]	[]	[]
2006	[]	[]	[]	[]	[]
2007	[]	[]	[]	[]	[]

(d) Hybrid Vehicles

On January 6, 2003, GM announced plans to introduce two new hybrid electric propulsion systems on light trucks. These two new systems are in addition to the Parallel Hybrid Truck option (PHT), which was previously announced for MY 2004 Chevrolet Silverado and GMC Sierra full-size pickups and included in GM's May submission. The first of the recently announced hybrid propulsion options (ParadiGM) is planned for [

] Saturn VUE SUVs, providing up to a 50% fuel economy improvement. The second recently announced hybrid system is a belt alternator starter (BAS), which would improve fuel economy by about [

] Chevrolet Equinox small utility for about [ ] vehicles.

At this point, [

.] GM's own analysis of its light truck CAFE improvement due to these new hybrid programs announced was [ ] (The PHT full-size pickup program had previously been announced and was included in the prior submission.) This calculation is based on planning volumes of [ ] annually for the Saturn VUE hybrid and [ ] annually for the Chevrolet Equinox hybrid.

Beyond 2007, GM has announced plans to: [

]. The total hybrid volume when applied to all planned models is forecast to be [

.]

The potential improvements to the GM light truck CAFE, including hybrid vehicle sales, are summarized in the following table. Due to rounding, the individual improvements may not equal the potential CAFE for GM.

Table VI –17

Potential GM CAFE Improvements, mpg
Based on the Stage Analysis

Model Year	**Baseline Mpg**	**Potential Total Additions to CAFE, per NHTSA Analysis**	**CAFE Improvement due to Hybrid Vehicles**	**Potential CAFE, mpg**
2005	[]	[]	[]	20.95
2006	[]	[]	[]	21.60
2007	[]	[]	[]	21.99

The above detailed analysis of the fuel economy potential for DaimlerChrysler, Ford and GM shows one way that these manufacturers could meet a certain level of fuel economy. The agency did not have as detailed information on the other manufacturers. However, we did develop a method to estimate a potential technology application path to get them up to the level of the final rule. This same methodology was applied uniformly to all manufacturers, including DaimlerChrysler, Ford and GM, to get a consistent estimate of the benefits and costs. The next section describes the model and algorithm used to apply technologies.

The following table contains the final light truck CAFE standards.

Table VI-18
CAFE levels

Model Year	**CAFE, mpg**
2005	21.0
2006	21.6
2007	22.2

VII. COST IMPACTS AND LEAD TIME

Some commenters identified deficiencies in and/or expressed disagreement with the PEA analysis performed using the technology application algorithm. In particular, GM indicated that (1) technology cost assumptions had been improperly coded in the relevant input file, (2) some technologies were applied in one model year but then not applied in the following model year, (3) the analysis omitted hybrid-electric vehicles included in baseline product plans, (4) aerodynamic drag reduction was applied to only some versions of a given nameplate, (5) cylinder deactivation was inappropriately applied to many 6-cylinder engines and also to DOHC engines, and (6) automatically shifted manual transmissions were mistakenly added to vehicles with manual transmissions. Also, UCS argued that "a faster acceleration of technology introduction than assumed by NHTSA appears to be possible," (UCS, p. 6), while the Alliance argued that "technologies cannot be incorporated in every vehicle at the same time." Manufacturers and environmental organizations also disagreed on the treatment of hybrid vehicles. While manufacturers agreed with NHTSA's exclusion of hybrid vehicles from the analysis, some environmental organizations identified this as a serious omission. Finally, as discussed in Chapter III, many commenters took issue with differences between the RPE increase and fuel consumption benefit assumptions used for the analysis and those used by the NAS.

The revised analysis presented below responds to these concerns and incorporates some additional technical changes as follows:

Technology Retail Price Equivalent (RPE) Increases: Technology RPE increase assumptions had been improperly coded in the input files used to perform the analysis reported in the PEA. If values reported in Table V-3 of the PEA had been appropriately coded and these programming errors had not been made, the estimated total incremental RPE resulting from the proposal would have increased from the reported $0.7 billion to $1.1 billion. However, as discussed below, RPE assumptions have been revised to reflect those reported by the NAS.

Technology Carryover: The analysis reported in the PEA sometimes added a technology to a specific truckline in one model year, but then did not "carry over" the technology to the subsequent model year. The technology application algorithm has been modified to identify a truckline's predecessor and "carry over" any technologies applied to that predecessor. If this modified algorithm and the above-mentioned corrections had been used for the analysis, the total incremental RPE would have increased to $1.2 billion.

Hybrid Vehicles: The analysis has been modified to include hybrid vehicles reported in manufacturers' product plans, and to include hybrid powertrains as an available technology that would, after the application of other available technologies, increase RPE by $5,000 and reduce fuel consumption by 25%.

Technology RPE and Fuel Consumption Assumptions: The analysis reported in the PEA used RPE increase and fuel consumption reduction assumptions reported in Table V-3 of the PEA. The analysis has been revised to reflect estimates included in the NAS report. Consistent with this revision, the analysis also follows a revised sequence or "path" (see Table VI-4) when applying technologies.

Product Plans: Ford, and General Motors provided updated product plans in response to the NPRM. BMW provided an updated product plan in conjunction with its filing for a voluntary carryback plan. The revised analysis uses these updated plans, which yield baseline CAFE levels different from those reflected in the PEA. The analysis also takes account of recent product announcements by other manufacturers, in particular Porsche and Volkswagen.

Technology Applicability: Some further changes to the technology application algorithm have been made in response to additional concerns raised by GM. [

.]^C

In addition to these technical comments, GM observed that the analysis performed using this technology application algorithm differed from the "stage" analysis in both the specific technologies considered and the methodology used to determine which technologies might be applied to any given truckline. NHTSA agrees that these analyses are different, but does not agree that it is inappropriate to consider both analyses when evaluating the rule's economic effects. Rather, given the range of possible means of complying with CAFE standards, NHTSA believes it is useful to be able to compare the projections of the two analyses.

As discussed above, the stage analysis relied primarily on the application of engineering judgment as a basis for projecting which technologies would most likely be applied to each truckline in an effort to comply with the CAFE standard under consideration. The stage analysis considered some technologies identified by the NAS report, but also placed significant emphasis on specific technologies identified by individual manufacturers. GM correctly stated that because the PEA did not estimate the cost of technologies applied under the stage analysis, that analysis could not easily be compared to the analysis performed using the technology application algorithm. However, the revised stage analysis does include estimates of RPE increases, which can be compared to RPE increases estimated using the revised technology application algorithm.

The technology application algorithm currently focuses on the technologies identified in the NAS report. Modification of the algorithm to accommodate manufacturer-specific technology assumptions may be pursued as a longer-term effort, but could not be completed for purposes of the current rulemaking. Although the list of technologies considered by NAS is clearly not comprehensive, it has been subjected to wide and thorough review by manufacturers, academic and other researchers, government experts, and interested nongovernmental organizations. Indeed, NHTSA considers the incremental RPE and fuel consumption estimates developed by NAS for these technologies to be the most reliable available at this time.

Most of the technologies considered in the stage analysis either have a counterpart in the NAS report or are examples of broader technology types identified there. In particular, while the stage analysis considers the manufacturer-specific application of [

]^{C}, these technologies are all examples of engine accessory improvements treated by NAS as a technology group. It also appears that both [ ]^{C} and low rolling resistance tires are specific examples of reduced rolling resistance as described by the NAS. Most of the other technologies considered in the stage analysis, such as low-friction lubricants, correspond directly to a technology included in the NAS list.

The more important difference between the two analyses is methodological. Unlike the stage analysis, which relies primarily on the manual application of engineering judgment, the technology application algorithm uses automation to uniformly apply a common logic (that is defined using engineering and economic judgment) to all manufacturers. This automated approach enables efficient and consistent analysis of the entire industry.

The technology application algorithm has, however, been modified to more closely reflect the engineering judgment applied under the stage analysis. For example, both analyses apply cylinder deactivation only to engines with at least eight cylinders and apply similar limits to the suitability of low-friction lubricants. In addition, for technologies with direct counterparts in the analysis performed using the technology application algorithm, the stage analysis has been revised to make the same assumptions regarding RPE increases and fuel consumption reductions.

Although these efforts have been made in order to make the two analyses more consistent, differences in represented technologies and implementation methods are such that the two approaches will predict different specific technological responses to CAFE standards. However, because a myriad of responses are, in fact, plausible, NHTSA maintains that it is valuable to consider more than one approach when attempting to forecast the industry's response to new CAFE standards. Also, from a practical perspective, the stage analysis, which was only applied to Ford and GM, provides a basis for judging the general reasonableness of the technology application algorithm, which was applied to all manufacturers. While the two analyses yield somewhat different technology application forecasts for those manufacturers examined in the stage analysis, they yield RPE increases of similar magnitude, as indicated below in Table VII-1.

Table VII-1
A Comparison of the RPE for Two Different Analyses
(in millions of year 2000 dollars)

	Ford	GM
MY 2005		
Stage Analysis	$46	$103
Tech. Appl. Algorithm	$63	$96
Difference (%)	37%	-7%
MY 2006		
Stage Analysis	$129	$416
Tech. Appl. Algorithm	$179	$284
Difference (%)	39%	-32%
MY 2007		
Stage Analysis	$351	$485
Tech. Appl. Algorithm	$253	$461
Difference (%)	-28%	-5%
MY 2005 – MY 2007		
Stage Analysis	$527	$1,004
Tech. Appl. Algorithm	$495	$841
Difference (%)	-6%	-16%

Throughout the rest of the analysis, the costs are estimated using the technology application algorithm for all manufacturers. In Chapter XII, we provide a sensitivity analysis using the costs from the Stage analysis.

Table VI-4 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.

The first row of Table VII-2 shows the average baseline mpg for the industry resulting from product plans submitted by the vehicle manufacturers. The second row of the table 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 current standard of 20.7 mpg (before using fuel economy adjustments for sales of alternative fueled vehicles), called the "Adjusted Baseline" mpg level. The third row of Table VII-2 reports the estimated mpg level for the industry with the CAFE standard of 21.0 mpg for MY 2005, 21.6 mpg for MY 2006 and 22.2 mpg for MY 2007 in effect. 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 20.7 mpg. Similarly, the industry average fuel economy levels under the standard exceed the mpg levels it would require because some manufacturers' projected fuel economy levels for future model years already exceed even the higher level of the standard, and are assumed to remain at those higher levels for MYs 2005-07.

Table VII-2

Baseline and Estimated mpg Levels for the Final Rule

	MY 2005	MY 2006	MY 2007
Baseline Manufacturers' Average	21.03 mpg	21.05 mpg	21.05 mpg
Adjusted Baseline With a 20.7 mpg Minimum	21.13 mpg	21.31 mpg	21.60 mpg
Estimated Levels after Applying Technology to meet Final Rule	21.29 mpg	21.78 mpg	22.31 mpg
Final Rule	21.0 mpg	21.6 mpg	22.2 mpg

Tables VII-3 and VII-4 present two sets of estimated costs. Some of the manufacturers are not planning on meeting the current level of 20.7 mpg for MY 2005-07 without using fuel economy adjustments for alternative fueled vehicles. So, the first column in the tables is the estimated costs of using technology to bring the manufacturer's fleets up to 20.7 mpg. These costs have been estimated, but they are not considered to be part of the costs of meeting the final rule requirements. Those costs, and commensurate benefits, are considered part of the costs and benefits of complying with previously issued rules. The cost estimates to bring those manufacturers with fleet averages below 20.7 mpg up to the level of 20.7 mpg, on an average per vehicle basis, are $14 for MY 2005, $13 for MY 2006, and $15 for MY 2007. These are average industry cost estimates over all vehicles sold, not just for those manufacturers with a baseline below 20.7 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 above 20.7 mpg. These estimates represent the costs to bring the manufacturer's plans that are below 20.7 mpg back up to 20.7 mpg, for each model year individually.

The second column under each model year heading in Tables VII-3 and VII-4 show the costs of applying technology necessary to move from each manufacturer's planned fuel economy levels up to the level of the final rule. Thus, if a manufacturer's product plans resulted in a fuel economy level of 20.2 mpg during each model year, this cost represents the cumulative cost of technologies necessary to bring that manufacturer's fleet average up to 21.0 mpg in MY 2005, 21.6 mpg in MY 2006 and 22.2 mpg in MY 2007. The difference between this cost and that for ensuring that each manufacturer meets the current 20.7 mpg standard is the estimated incremental cost to the industry for meeting the final rule during each model year.

Tables VII-3 and VII-4 show the costs of meeting the final rule as compared to a baseline of the manufacturers' plans. Since the manufacturer's plans for MY 2005, 2006 and 2007 are different, the baseline changes in each year (as shown in Table V-1). Thus, we don't provide a cumulative number comparing MY 2007 to a baseline. Each individual year is analyzed compared to the manufacturer's plans for that year (adjusted by bringing those manufacturers with an average mpg below 20.7 mpg, back up to 20.7 mpg).

The average incremental cost per vehicle is estimated to be $22 for MY 2005, $67 for MY 2006, and $106 for MY 2007. The total incremental cost is estimated to be $170 million for MY 2005, $537 million for MY 2006, and $862 million for MY 2007.

Table VII-3
Estimated Incremental Costs over Manufacturer's Plans
Average Cost per Vehicle

	MY 2005		**MY 2006**		**MY 2007**	
CAFE Std. (MPG)	20.7	21.0	20.7	21.6	20.7	22.2
BMW						$40
Daimler Chrysler				$4		
Ford		$30		$84		$116
General Motors	$42	$91	$29	$172	$21	$251
Honda						
Hyundai						
Isuzu				$45		$123
Kia	$181	$230	$181	$463	$181	$597
Nissan		$18		$96		$215
Porsche			$1,033	$1,033	$1,033	$1,033
Subaru						
Suzuki						$8
Toyota						$5
Volkswagen	$331	$331	$385	$385	$1,224	$1,326
Total Fleet Ave.	$14	$36	$13	$80	$15	$121
Incremental Cost of the Final Rule		$22		$67		$106

Table VII-4
Total Incremental Cost

(In Millions)

	MY 2005		MY 2006		MY 2007	
CAFE Std. (MPG)	20.7	21.0	20.7	21.6	20.7	22.2
BMW						$3
Daimler Chrysler				$7		
Ford		$63		$179		$253
General Motors	$81	$177	$56	$341	$43	$504
Honda						
Hyundai						
Isuzu				$6		$16
Kia	$16	$21	$17	$43	$17	$56
Nissan		$6		$35		$80
Porsche			$16	$16	$16	$16
Subaru						
Suzuki						$0
Toyota						$5
Volkswagen	$11	$11	$14	$14	$45	$49
Total Fleet	$109	$279	$103	$643	$121	$984
Incremental Cost of the Final Rule		$170		$537		$862

The Impact of Higher Prices on Sales

The potential impact of higher prices, brought about by the fuel economy standards, on sales was examined on a manufacturer specific basis, since the estimated cost of improving fuel economy 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.[1,2,3] Thus, for every one percent increase in price, sales would be expected to decrease by one percent. The theory behind price elasticity is to estimate the impact on sales if the price for the exact same product increases; in other words, the value of the product doesn't change. This doesn't apply here, because vehicle price increases result from improving fuel economy by adding new technologies. So, if we assumed that consumers do not value improved fuel economy at all, then the estimated impact on sales from price elasticity could be valid.

Based on the Automotive News 2002 Market Data Book, light truck sales volumes for MY 2001 were matched with base vehicle average prices for 2002 to determine an average light truck price per manufacturer. The average price for all light trucks using this method was $25,200. While this method does not give an exact price, the results are reasonable and specific to individual manufacturers. For example, the average price for BMW was $40,820, the average price for GM was $26,766, and the average price for Suzuki was $21,540. Average prices and estimated sales volumes are needed because price elasticity is an estimate of how a percent increase in

[1] Kleit, A.N. (1990). "The Effect of Annual changes in Automobile Fuel Economy Standards." *Journal of Regulatory Economics*, vol. 2, pp 151-172.
[2] Bordley, R. (1994). "An Overlapping Choice Set Model of Automotive Price Elasticities," *Transportation Research B*, vol 28B, no 6, pp 401-408.
[3] 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.

price affects the percent decrease in sales. Thus, a sample calculation for General Motors for MY 2007 is an estimated retail price increase of $229/$26,766 average price is a 0.8556 percent price increase. GM sales are estimated to be 2.022 million for MY 2007. With a price elasticity of –1.0, a 0.8556 percent decrease in sales could result in an estimated loss of sales of 17,301 (2,022,000 * .008556).

Table VI-5 shows the estimated total loss in sales, if we assumed that consumers did not value at all an improvement in fuel economy. Sales loss is only estimated for those cases where there is an incremental cost for the standard above the cost of attaining the 20.7 mpg baseline. The highest potential impact on sales would occur in MY 2007.

Table VI-5
Potential Impact on Sales by Manufacturer

	MY 2005	MY 2006	MY 2007
BMW	0	0	57
Daimler/Chrysler	0	329	84
Ford	2,448	6,980	9,795
General Motors	3,577	10,706	17,301
Honda	0	0	0
Hyundai	0	0	0
Isuzu	0	252	700
Kia	168	986	1,474
Nissan	322	1,752	3,986
Porsche	0	0	0
Subaru	0	0	0
Suzuki	0	0	19
Toyota	0	0	138
VW	0	0	42
Total	6,516	21,005	33,595

As mentioned earlier, these impacts are overstated since they assume that consumers don't value fuel economy at all. In addition, some jobs will be created to engineer, design, and in some cases install the fuel-efficient technologies into the light trucks. An estimate of the number of jobs created by using new technologies could not easily be made by the agency. Since the calculated impacts on sales are so small, and they are overstated, the agency is not adjusting its sales estimates to take into account these potential impacts.

The analysis has focused on the potential that people will not buy light trucks if prices are raised. However, consumers have the option of purchasing competitors' light trucks, used light trucks, or ones with fewer accessories, or holding onto their current vehicles. If potential consumers purchase a competitor's light truck, due to relative price increases between manufacturers, then the overall loss in sales is less. The agency also decided not to make any adjustments to its schedule of truck survivability and scrappage due to these small increases in price and the effect they might have on consumers' decisions to keep their current light trucks.

Lead Time

Tables VI-3a and 3b provides the agency's and the NAS estimate of when a particular technology is available to be used by some manufacturers. Even though a particular technology is projected to be available in MY 2005, or MY 2007, not all manufacturers may be able to apply that technology on all vehicles by that date. Those are generic dates when technology is projected to be available for some manufacturers, and is not applicable to all manufacturers. For some manufacturers, unless they had planned on using that technology, they are probably too far behind in its development to introduce that technology by the MY 2005 date. Also, as explained in Chapter VI, the analysis using the technology application algorithm limited the penetration rate of each technology based on the rates shown in Tables VI-15, 16, and 17.

In Chapter X, the marginal costs of improving fuel economy per percent improvement were discussed and estimated to be in the $37 to $39 range per percent improvement. Six technologies were below this cost per percent improvement range.

Theoretically, one could argue that these six technologies should be applied across the board to all manufacturers in the MY 2005-2007 time frame. However, this is not possible in all cases. For example, aerodynamic drag reductions can only be achieved when the front end sheet metal of a model is redesigned. Light trucks are not redesigned as often as passenger cars and one would only expect about half of the models to be redesigned in a three-year time frame, and a long lead time is needed for a redesign. Certain engine improvements can only be included with other specific engine updates.

The agency also discussed the potential to improve fuel economy through performance reductions. Although returning the performance of GM's light truck fleet to MY 2001 levels can cause a significant increase in its MY 2005 projected CAFE level, the probability of GM being able to achieve the changes in either weight or performance level in the lead time remaining before these vehicles go into production is very small. The vast majority of GM's MY 2005 light truck basic designs are locked in. Additionally, to effect this significant of a change in its MY 2005 light truck CAFE, GM might be forced to delay the introduction of many of its best-selling vehicles, which could cause GM to lose sales and have a negative economic effect on the company.

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, etc. Marginal cost/benefit is only one of many 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, Although some others may believe that higher CAFE numbers can be achieved, NHTSA's engineering judgment of maximum feasible average fuel economy level must take into account the four statutory criteria. These criteria lead us to believe that, given the short planning horizon, higher standards may have a negative economic effect on the automotive industry and may be beyond the industry's short-term technical potential.

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 by MY 2005, were not applied to any additional vehicles, above the manufacturer's plans, due to technology uncertainties and costs. Diesel engines, which are more efficient than internal combustion engines and are included in a few manufacturer projections, were not applied to any additional vehicles due to the uncertainty surrounding the ability of diesel engines to meet upcoming EPA emission standards and to permeate the market in the short lead time.

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.

NHTSA's technology assumptions, shown in Tables VI-15, 16, and 17 represent the agency's engineering judgment about the availability and the potential for each technology to meet the final rule on a manufacturer specific basis. The agency took into consideration both the NAS estimates and the confidential estimates that were provided by DaimlerChrysler, Ford, GM, Honda, Nissan and Toyota. To arrive at the estimated lead times, NHTSA analyzed each manufacturer's estimated lead time for a specific technology against the others that provided estimates and against the NAS estimate.

VIII. CONSUMER 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 25 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 25-year life span in the fleet) with the current CAFE standard for light trucks remaining in effect through model year 2007, and with the final rule for model years 2005, 2006, and 2007 in effect. Future impacts are estimated in both undiscounted terms and by their present value discounted to the calendar year when each model was produced, using a 7 percent discount rate.[1]

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 light truck sales for future years (see Table VIII-1) were obtained from the Energy Information Administration's (EIA) *Annual Energy Outlook 2002* (*AEO 2002*), a standard government reference for forecasts of energy production and consumption in different sectors of the U.S.

[1] 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.

economy.[2] Actual fuel economy levels for each future model year's light trucks under the current CAFE standard and with alternative standards in effect were estimated using the model of fuel economy technology application described in Chapter VI. Under both the current standard and the final rule, the average actual fuel economy for all new light trucks manufactured during each model year is expected to slightly exceed the prevailing standards. 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.

Table VIII-1
Sales Projections

Model Year	Light Truck Sales Projection
2005	7,654,300
2006	7,795,300
2007	7,921,500

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 25 years. These "survival rates" are estimated from the experience with recent model-year light trucks, adjusted to reflect expected continued improvements in the durability and economic lifetimes of future model year light-duty vehicles.[3] These survival rates

[2] U.S. Department of Energy, Energy Information Administration, *Annual Energy Outlook 2002*, Table 45, http://www.eia.doe.gov/oiaf/aeo/supplement/index.html.

[3] The survival rates were calculated from U.S. Department of Energy, Oak Ridge National Laboratory, *Transportation Energy Data Book Number 22*, Table 6.10, http://wwwta.ornl.gov/data/tedb22/Spreadsheets/Table6.xls

are slightly different than the survival rates used in past NHTSA analyses, since they reflect recent increases in durability and more recently manufactured light truck models. The estimates of vehicle miles traveled were developed by EPA from recent survey data on vehicle use and also differ from past NHTSA analyses.[4] The total number of miles driven by light trucks of a single model year 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 age-specific estimates of annual miles driven per vehicle to the number of vehicles remaining in service at each age (see Table VIII-2).

Benefits from Fuel Savings

The main source of economic benefits from the final rule 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 are measured by the difference between total lifetime fuel use by light trucks of each model year with the current CAFE standard assumed to remain in effect for model years 2005-07, and with the final rule for those model years in effect. The sum of these annual fuel savings over each calendar year that light trucks from a single model year remain in service represents the cumulative fuel savings resulting from applying the levels of the final rule to vehicles produced during that model year.

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[4] Update of Fleet Characterization Data for Use in MOBILE6 – Final Report EPA420-P-98-016, (http://www.epa.gov/otaq/models/mobile6/m6flt002.pdf), June 1998 Tables 4-4 and 4-5. The estimates of annual use for age 0 and 1 vehicles were adjusted to reflect the fact that some vehicles are not in service for the full calendar year during which they are sold.

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 Traveled
-------	---------	-----------	---------
0*	3,375	1.000	3,375
1*	14,245	1.000	14,245
2	17,798	0.998	17,754
3	16,662	0.995	16,571
4	15,583	0.989	15,415
5	14,557	0.969	14,106
6	13,583	0.941	12,782
7	12,659	0.907	11,482
8	11,783	0.869	10,239
9	10,952	0.827	9,057
10	10,165	0.782	7,949
11	9,421	0.734	6,915
12	8,718	0.684	5,963
13	8,054	0.633	5,098
14	7,428	0.580	4,308
15	6,839	0.528	3,611
16	6,286	0.477	2,999
17	5,768	0.427	2,463
18	5,284	0.379	2,003
19	4,833	0.333	1,609
20	4,413	0.290	1,280
21	4,025	0.250	1,006
22	3,668	0.214	785
23	3,340	0.181	605
24	3,042	0.152	462
25	2,772	0.126	349
Lifetime			**152,032**

* Adjusted to reflect typical monthly sales patterns, which result in some vehicles being in service for less than twelve months. Age 0 vehicles are those sold in the calendar year preceding their model year.

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 achieve under the 20.7 mpg standard. With the final 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 final rule than with the current 20.7 mpg standard remaining in effect as a result of the fuel economy "rebound effect," which is discussed in detail in the following section.

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 final 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 25-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 final rule is estimated by applying the forecast of future fuel prices from the Energy Information Administration's *Annual Energy*

Outlook 2003 to each future year's estimated fuel savings. 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. Instead, any savings in state and federal fuel tax payments to fuel users reduce government revenues by an exactly equal amount, which is in turn likely to reduce federal and state spending for construction and maintenance of streets and highways. Because the value of the services they provide to road users – approximately the same group as fuel purchasers -- will decline as a result of reduced spending, the savings in fuel tax payments does not reflect a savings in resources to the economy from reduced fuel use.

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 final 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 the 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.

Table VIII-3
Adjustment of Forecast Retail Gasoline Price
to Reflect Social Value of Fuel Savings
(all figures in year 2000 dollars)

Year	AE0 2003 Fuel Price Forecast (2000$/gallon)	Total Federal and State Taxes (2000$/ gallon)	Fuel Price Excluding Taxes (2000$/gallon)	Value of Oil Import Externalities (200$/gallon)	Social Value of Fuel Savings (2000$/gallon)
			Yr 1 = 2005		
2005	1.37	0.377	0.99	0.083	1.07
2006	1.38	0.377	1.00	0.083	1.08
2007	1.38	0.377	1.00	0.083	1.09
2008	1.38	0.377	1.00	0.083	1.09
2009	1.39	0.377	1.01	0.083	1.10
2010	1.39	0.377	1.02	0.083	1.10
2011	1.38	0.377	1.00	0.083	1.09
2012	1.38	0.377	1.00	0.083	1.08
2013	1.37	0.377	0.99	0.083	1.08
2014	1.37	0.377	1.00	0.083	1.08
2015	1.37	0.377	0.99	0.083	1.08
2016	1.38	0.377	1.00	0.083	1.08
2017	1.40	0.377	1.02	0.083	1.10
2018	1.40	0.377	1.02	0.083	1.11
2019	1.40	0.377	1.03	0.083	1.11
2020	1.40	0.377	1.03	0.083	1.11
2021	1.40	0.377	1.03	0.083	1.11
2022	1.41	0.377	1.03	0.083	1.11
2023	1.42	0.377	1.04	0.083	1.13
2024	1.43	0.377	1.05	0.083	1.13
2025	1.46	0.377	1.08	0.083	1.17
2026	1.46	0.377	1.08	0.083	1.17
2027	1.46	0.377	1.08	0.083	1.17
2028	1.46	0.377	1.08	0.083	1.17
2029	1.46	0.377	1.08	0.083	1.17
2030	1.46	0.377	1.08	0.083	1.17

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 final 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 world oil price appears to be partly determined through the exercise of market power by the OPEC cartel, and because the U.S. is a sufficiently large purchaser of foreign oil supplies that its purchases can affect the world price. The combination of OPEC market power and 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. Only if OPEC exercises some 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

$1.00-3.00 per barrel in today's terms.[5] The Leiby study says that at current import levels, reducing U.S. demand by one barrel saves a total of about $2.00 (using the midpoint of this range) by reducing the price of all other oil we purchase. If we "credit" this $2.00 entirely to the one barrel, that's equivalent to $2.00/42 gallons, which is about 4.8 cents per gallon. 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 $2.00 per barrel beyond the direct savings in gasoline costs. This figure is equivalent to about $0.048 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.

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

[5] 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.

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 $2.00 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.

Overall, an estimate of approximately $1.50 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 $0.035 per gallon ($1.50 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 2004 standard of 20.7 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.[6] With both the base 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.[7] The reduction in fuel cost per mile driven 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

[6] 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.

[7] Gasoline price forecasts are also obtained from U.S. Department of Energy, Energy Information Administration, *Annual Energy Outlook 2003*, Table 12, http://www.eia.doe.gov/oiaf/aeo/supplement/index.html.

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 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.

With the current combination of relatively low fuel prices and significantly improved fuel economy levels, however, gasoline costs per mile driven are quite low by historical standards, and the potential of continued improvements in fuel economy to further reduce them is limited. 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, the share of gasoline costs in the total costs of driving has declined sharply, so that improving fuel economy will not produce 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 current 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 relatively narrow range of 10% to 20%, which imply that increasing vehicle use will offset 10-20% of the fuel savings resulting directly from an improvement in fuel economy. In the analysis of benefits from tighter CAFE standards for light-duty trucks, a rebound effect of 20% -- the upper end of the range spanned by most recent estimates – is employed.

The expected additional number of miles each vehicle is driven over its lifetime as a result of the rebound effect is 252 miles for light trucks produced during model year 2005, 736 miles for model year 2006 vehicles, and 1,088 miles for model year 2007 light trucks. Multiplying these figures by forecast light truck sales for each of those model years results in a total of 1.93 billion additional miles for all model year 2005 light trucks over their expected lifetimes, with corresponding figures of 5.73 and 8.62 billion additional miles for model year 2006 and 2007 vehicles. These estimates increase over the three model years because the increase in the required CAFE levels from the current standard 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 analyzes 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.

An example calculation of the consumer surplus benefit associated with increased driving of Model Year 2007 light trucks proceeds as follows: these vehicles are estimated to be driven a total of 784 million additional miles during calendar year 2010 due to the rebound effect, in response to a decline in fuel cost per mile driven from $0.0760 to $0.0735, or by $0.0025. Thus the additional consumer surplus received by owners of these vehicles during 2010 amounts to 1/2 of 784 million times $0.0025, or a total of $0.980 million. Similar calculations are performed for each year these vehicles are expected to remain in the fleet, and each year's benefit is then discounted to its present value as of the year those vehicles are produced and sold.

Added Costs from Congestion, Accidents, 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 accidents, 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 accidents 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 accidents. Drivers presumably take account of the potential costs they (and the other occupants of their vehicles) face from the possibility of being involved in an accident when they decide to make additional trips. However, they probably do not consider all of the potential costs they impose on occupants of other vehicles and on pedestrians when accidents occur, so any increase in these "external" accident costs must be considered as another cost of additional rebound-effect driving. Like increased delay costs, any increase in these external accident costs caused by added driving is likely to depend on the traffic conditions under which it takes place, since accidents are more frequent in heavier traffic, but their severity may be reduced by the slower speeds at which heavier traffic typically moves. Thus estimates of the increase in external accident 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, accident 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.[8] 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 accidents, 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, accident, and noise costs imposed by pickup trucks and vans are 4.0 cents, 2.15 cents, and 0.06 cents per vehicle-mile, respectively.[9] 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, accident, 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 accident costs for increased light-duty vehicle

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

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

use in the U.S. to be 3.5 and 3.0 cents per vehicle-mile.[10] These estimates incorporate careful adjustments of congestion and accident 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 accidents. While both the FHWA and RFF estimates of congestion accident 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 they 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 final rule include carbon monoxide, hydrocarbon compounds, nitrogen oxides, fine particulate matter, and sulfur dioxide. The increased use of light trucks that occurs through the rebound effect causes higher emissions of these "criteria" pollutants, since federal standards limit permissible emissions 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 per-mile emission rates developed using the U.S. Environmental Protection Agency's MOBILE6.2 motor vehicle emissions factor model. The resulting increases in emissions are

10 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.

converted to economic values using estimates of the economic costs (primarily from damages to human health) used by the federal Office of Management and Budget.[11]

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 final rule will reduce emissions of these same pollutants that are generated by gasoline production and distribution. 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.[12] 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 final rule will be reflected in reduced gasoline imports, and that the remaining 50 percent will reduce domestic refining.[13] The resulting reduction in domestic refining is

[11] White House Office of Management and Budget, Office of Information and Regulatory Affairs, "Report to Congress on the Benefits and Costs of Federal Regulations," 1998, p. 72. See also Office of Management and Budget, "Draft Report to Congress on the Costs and Benefits of Federal Regulations: Notice," Federal Register, Volume 67, No. 60, Thursday, March 28, 2002, p. 15041. The values used for VOC, NOx, and SO2 are the midpoints of the ranges used by OMB. 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.

[12] 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.

[13] 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.

assumed to leave the mix of imported and domestic crude petroleum feedstocks utilized in 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.[14] 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.[15] Our calculations assume that reductions in imports of gasoline in response to fuel savings from the final 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 during crude oil transportation and storage, refining, and gasoline 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 distribution.[16] The resulting reductions in air pollutant emissions from gasoline production and distribution are

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[14] Argonne National Laboratories, *The Greenhouse Gas and Regulated Emissions from Transportation (GREET) Model*, Version 1.6, February 2000, http://www.transportation.anl.gov/ttrdc/greet/index.html.

[15] 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 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.

[16] 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.

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.[17] Lowering fuel consumption reduces carbon dioxide emissions directly, because the primary source of these 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.[18] Reduced gasoline consumption also reduces carbon dioxide emissions that result from fuel combustion and 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 extending the upper limit of the range they can travel before requiring refueling, improving fuel

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[17] 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.

[18] 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.

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 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. 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 2007 from 20.7 to 22.2 mpg is estimated to increase the average CAFE rating for these models from 21.60 to 22.31 mpg, which raises their actual on-road fuel economy from 18.36 to 18.96 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 18.36 x 16 = 294 to 18.96 x 16 = 303 miles. For a light truck driven 12,000 miles/year, this reduces the number of required refuelings from 12,000/294 = 40.8 to 12,000/303 = 39.5, or by slightly more than one per year.

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 $20.50

(in year 2000 dollars)[19]. Assuming that locating a station and filling up takes five minutes, the value of time savings resulting from less frequent refueling amounts to slightly over $2.20 (calculated as 5/60 x 1.3 x $20.50) per vehicle per year for MY2007 light trucks. This calculation is repeated for each calendar year that light trucks of each model year affected by the final 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 about a quarter tank of gas before they fill up again.

Summary of Benefits from the Final Rule

Table VIII-4 reports the estimated values of the net changes in the economic costs of criteria pollutant emissions. These changes are the net result of the increased air pollutant emissions caused by added light truck driving and the reductions in emissions resulting from lower volumes of crude oil extraction, refining, transportation, and distribution. Table VIII-4(a) presents results for model year 2005, while Tables VIII-4(b) and (c) show comparable results for model year 2006 and 2007 light trucks. Negative values in these tables reflect net reductions in

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[19] The hourly wage rate during 2002 is estimated to be $21.20. 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 $11.20 for urban travel and $15.60 for intercity travel, and must be multiplied by vehicle occupancy (1.6) to obtain the estimate value of time per vehicle hour.

emissions and their resulting economic damages, which represent benefits from the final rule, while positive values represent increased emissions and damage costs.

Table VIII-4(a)
Value of Changes in Criteria Pollutant Emissions
Model Year 2005 Light Trucks

Pollutant	**Value of Emissions Savings (2000 $/ton)***	**Change in Emissions over Lifetime of Model Year 2005 Vehicles (Thousand Tons)**	**Undiscounted Economic Value (2000 $)**	**Present Discounted Value (2000 $)**
Carbon Monoxide (CO)	$20	21.71	-$430,000	-$220,000
Volatile Organic Compounds (VOC)	$1,440	0.48	-700,000	-180,000
Nitrogen Oxides (NOx)	$1,440	0.38	-540,000	-90,000
Fine Particulate Matter (PM 2.5)	$11,539	-0.05	520,000	310,000
Sulfur Dioxide (S02)	$7,654	-0.55	4,190,000	2,540,000
Total			**$3,040,000**	**$2,370,000**

* The mid-points of a range of values for some of the emission savings were used in the calculations for convenience. These values are a small part of the overall estimates in the analysis, so using mid-points does not affect the outcome. The range of values for emission savings for VOC and NOx are $519 to $2,360 per ton.

** 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 be larger than before discounting, as with the nitrogen oxide (NO_x) values.

Table VIII-4(b)
Value of Changes in Criteria Pollutant Emissions
Model Year 2006 Light Trucks

Pollutant	Value of Emissions Savings (2000 $/ton)*	Change in Emissions over Lifetime of Model Year 2006 Vehicles (Thousand Tons)	Undiscounted Economic Value (2000 $)	Present Discounted Value (2000 $)
Carbon Monoxide (CO)	$20	59.25	-$1,180,000	-$590,000
Volatile Organic Compounds (VOC)	$1,440	1.16	-1,680,000	-310,000
Nitrogen Oxides (NOx)	$1,440	0.28	-40,000	380,000**
Fine Particulate Matter (PM 2.5)	$11,539	-0.14	1,570,000	950,000
Sulfur Dioxide (S02)	$7,654	-1.63	12,440,000	7,560,000
Total			**$10,750,000**	**$7,990,000**

Table VIII-4(c)
Value of Changes in Criteria Pollutant Emissions
Model Year 2007 Light Trucks

Pollutant	Value of Emissions Savings (2000 $/ton)*	Change in Emissions over Lifetime of Model Year 2007 Vehicles (Thousand Tons)	Undiscounted Economic Value (2000 $)	Present Discounted Value (2000 $)
Carbon Monoxide (CO)	$20	84.84	-$1,700,000	-$840,000
Volatile Organic Compounds (VOC)	$1,440	1.52	-2,180,000	-300,000
Nitrogen Oxides (NOx)	$1,440	-0.41	600,000	1,200,000
Fine Particulate Matter (PM 2.5)	$11,539	-0.20	2,330,000	1,410,000
Sulfur Dioxide (S02)	$7,654	-2.42	18,490,000	11,240,000
Total			**$17,530,000**	**$12,710,000**

Table VIII-5 reports estimates of the value of lifetime fuel savings to vehicle buyers resulting from the stricter light truck CAFE standard. As it shows, the present discounted value of fuel savings over the typical lifetime of a model year 2005 light truck is estimated to be $53, while the corresponding savings are $166 for model year 2006 and $242 for model year 2007. Table VIII-6 shows the total savings in gallons of fuel over the lifetimes that light trucks manufactured during each model year affected by the final rule remain in the fleet. Finally, Table VIII-7 presents the social values of the estimated changes in fuel consumption, light truck use, air pollutant emissions, petroleum consumption externalities, congestion, accident, and noise externalities, and extended refueling range of light trucks.

Table VIII-5

Incremental Fuel Benefit to Consumers on a Societal Basis
over the Vehicle's Lifetime
Per Vehicle

Model Year	Estimated Fuel Economy Level (mpg)	Lifetime Fuel Cost ($2000) Present Discounted Value (7%)	Lifetime Fuel Savings ($2000) Present Discounted Value (7%)
Adjusted Baseline Manufacturer's Plans			
MY 2005	21.13	$7,955	
MY 2006	21.31	$7.903	
MY 2007	21.60	$7,806	
Final Rule Level			
MY 2005	21.29	$7,907	$48
MY 2006	21.78	$7,765	$138
MY 2007	22.31	$7,605	$201

Table VIII-6
Savings in Millions of Gallons of Fuel

Model Year	Estimated Fuel Economy Level (mpg)	Lifetime Fuel Use in Millions of Gallons	Lifetime Fuel Savings in Millions of Gallons (Undiscounted)	Lifetime Fuel Savings in Millions of Gallons (Discounted)
Adjusted Baseline Manufacturer's Plans				
MY 2005	21.13	72,473		
MY 2006	21.31	73,199		
MY 2007	21.60	73,390		
Final Rule Level				
MY 2005	21.29	72,041	432	263
MY 2006	21.78	71,926	1,273	774
MY 2007	22.31	71,498	1,892	1,151

Table VIII-7
Present Value of Lifetime Social Benefits (Costs)
(Millions of $2000)

Category	MY 2005	MY 2006	MY 2007
Fuel Savings	$263.9	$779.7	$1,160.8
Reduced Oil Import Externalities	18.5	54.7	81.3
Reduced Criteria Pollutant Emission	2.4	8.0	12.7
Consumer Surplus from Rebound Effect Driving	0.3	2.9	6.3
Increased Refueling Range	20.5	60.3	89.6
External Costs from Rebound Effect Driving (Congestion, Crashes, and Noise)	-87.4	-261.1	-395.6
Total	$218.2	$644.5	$955.2

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IX. NET BENEFITS/MARGINAL BENEFITS

This chapter adds together the costs of technologies needed to make improvements in fuel economy to meet the final rule with the potential benefits, expressed on a per vehicle basis and in total (millions of dollars). Table IX-1 provides the estimated costs and benefits from Chapters VII and VIII. These are average net benefits per vehicle from a societal perspective for all light trucks produced during each model year to which the standard is applicable. These are incremental costs and benefits compared to an adjusted baseline of manufacturers' production plans. We assumed each manufacturer achieves a minimum fuel economy level of 20.7 mpg. Table IX-2 shows the total cost and benefits in millions of dollars for the projected fleet of sales for each model year.

Table IX-1

Incremental Cost and Social Benefit Analysis
Per Average Vehicle - Over its Lifetime
(In Year 2000 Dollars)

	Costs	**Benefits**	**Net Benefits**
MY 2005	$22	$29	$7
MY 2006	$67	$83	$16
MY 2007	$106	$121	$15

Table IX-2

Incremental Total Cost Benefit Analysis
Over the Lifetime of the Fleet
(In Millions of Year 2000 Dollars)

	Costs	Benefits	Net Benefits
MY 2005	$170	$218	$48
MY 2006	$537	$645	$108
MY 2007	$862	$955	$93

Table IX-3 provides the costs and discounted benefits and compares each of these to the discounted lifetime fuel savings resulting from the standards.

Table IX-3

Incremental Total Cost Benefit Analysis
Over the Lifetime of the Fleet – Discounted Values
(In Millions of Year 2000 Dollars)

	Costs	Benefits	Net Benefits	Fuel Saved*
MY 2005	$170	$218	$48	263
MY 2006	$537	$645	$108	774
MY 2007	$862	$955	$93	1,151
	Dollars per gallon of fuel saved			
MY 2005	$0.65	$0.83	$0.18	
MY 2006	$0.69	$0.83	$0.14	
MY 2007	$0.75	$0.83	$0.08	

* Millions of gallons of fuel saved

<u>Marginal Benefits</u>

This discussion pulls together the societal benefits and miles per gallon improvement associated with those benefits to determine the marginal benefits of achieving additional improvements per percent improvement in mpg. These benefit estimates can then be compared to the values of

"Cost per Percent Improvement" in Table VI-4 to determine which technologies are cost beneficial in terms of marginal costs.

These calculations are:

The societal benefit of going from the MY 2005 baseline of 21.13 mpg to the average level represented by the final rule of 21.29 mpg is $29 per vehicle. The percent improvement in mpg is 21.29/21.13 = 1.0075, or a 0.75% improvement. $29/0.75% = $38.70 per 1 percent improvement.

The societal benefit of going from the MY 2006 baseline of 21.31 mpg to the average level represented by the final rule of 21.78 mpg is $83. The percent improvement in mpg is 21.78/21.31 = 1.0221, or 2.21%. $83/2.21% = $37.55 per 1 percent improvement.

Finally, the societal benefit of going from the MY 2007 baseline of 21.60 mpg to the average level represented by the final rule of 22.31 mpg is $121. The percent improvement in mpg is 22.31/21.60 = 1.0330, or 3.30%. $121/3.30% = $36.63 per 1 percent improvement.

Thus, any technology, which has a cost per percent improvement in fuel economy of less than $37 to $39, is cost beneficial for society. Table VI-4 provides the technologies on a cost per percent improvement in mpg basis and shows that there are six technologies that are cost/beneficial on a marginal cost basis.

Many of the more expensive technologies (on a cost per percent improvement in mpg) that are applied in this analysis are already in the manufacturer's plans. Many of these technologies are applied because of their improvement to performance and not solely because of their fuel economy improvement. Thus, these planned technology implementations are not included in the incremental cost and benefits analysis. Most of the six technologies found at the margin to be cost beneficial are being applied by NHTSA over and above the manufacturers plans. Thus, there are incremental net benefits, resulting from the application of these technologies that are over and above those reflected in the manufacturers' plans.

X. 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.

There were two comments to the docket indicating that small businesses could be affected by this final rule. The Recreational Vehicle Industry Association and the National Truck Equipment Association both indicated concern that the final rule could result in restrictions of products that are used by their members, many of which are small businesses. Since the agency sets a fuel economy standard, and the manufacturers are free to decide how they want to meet the standard, there is a slight possibility that product restrictions could occur. The agency is not assuming that the original manufacturers need to use or will use product restrictions to meet the standards. If one manufacturer uses product restrictions to meet the standard, it is likely that a competitor will offer a suitable substitute.

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.

These effects have been discussed in detail in previous sections of this Final Economic Assessment. This final rule will result in the expenditure by the private sector of more than $100 million annually. However, the agency is required by Congress to set fuel economy standards for light trucks at the maximum feasible level.

XI. SENSITIVITY ANALYSES

The agency has performed sensitivity analyses to see how sensitive the results are to changes in assumptions dealing with the discount rate, the magnitude of the rebound effect, and cost estimates from the Stage analysis.

Higher discount rates and a larger rebound effect both reduce the discounted present value of future benefits, but neither affects the cost estimates in the assessment. Both of these analyses are breakeven type analyses, which are designed to answer the questions: At what discount rate does the discounted present value of future benefits exactly match the costs to improve light truck fuel economy. Similarly, how large of a rebound effect would be required to reduce total benefits from improved fuel economy to the point where they exactly equal the costs of improving fuel economy. To perform these analyses we hold the cost constant and determine how high the discount rate, or rebound effect, must be to lower benefits enough to make the costs and benefits converge.

The analyses use the combined total costs and benefits in millions of dollars from the three years for comparison. The baseline estimates of costs and benefits are shown in Table XI-1. Table XI-2 shows that at a discount rate of 10.0 percent, the present value of benefits essentially equal the estimated total costs. The agency believes this discount rate (10 percent) is well above any reasonable estimate of the real discount rate that should be applied to future fuel savings and other benefits from the agency's actions.

Table XI-3 shows that a rebound effect of 23.5 percent would be required to reduce the benefits to a level that equals the estimated costs. Again, the agency believes this figure is above any reasonable estimate of the likely magnitude of the fuel economy rebound effect that reflects current and forecast fuel prices and light truck fuel economy levels.

The third sensitivity analysis uses the costs that were estimated for the stage analysis from Table VII-1 for Ford and GM, substitutes these numbers for the incremental cost estimates that would be in Table VII-4 for Ford and GM, and derives a new industry total. These estimates are then compared to the benefits. Using the Stage analysis cost estimates, benefits exceed costs in MY 2005 and MY 2006 and when all three model years are combined. Costs exceed benefits for MY 2007.

Table XI-1

Incremental Total Cost Benefit Analysis
Over the Lifetime of the Fleet - Discounted Values
(In Millions of Year 2000 Dollars)

	Costs	Benefits	Net Benefits
MY 2005	$170	$218	$48
MY 2006	$537	$645	$108
MY 2007	$862	$955	$93
Total	$1,569	$1,818	$249

Table XI-2
Assuming a 10.0% Discount Rate
Incremental Total Cost Benefit Analysis
Over the Lifetime of the Fleet - Discounted Values
(In Millions of Year 2000 Dollars)

	Costs	Benefits	Net Benefits
MY 2005	$170	$189	
MY 2006	$537	$558	
MY 2007	$862	$828	
Total	$1,569	$1,575	$6

Table XI-3
Assuming a 23.5% Rebound Effect
Incremental Total Cost Benefit Analysis
Over the Lifetime of the Fleet - Discounted Values
(In Millions of Year 2000 Dollars)

	Costs	Benefits	Net Benefits
MY 2005	$170	$189	
MY 2006	$537	$560	
MY 2007	$862	$829	
Total	$1,569	$1,578	$9

Table XI-4

Assuming Stage Analysis Costs
Incremental Total Cost Benefit Analysis
Over the Lifetime of the Fleet - Discounted Values
(In Millions of Year 2000 Dollars)

	Costs	**Benefits**	**Net Benefits**
MY 2005	$160	$218	$58
MY 2006	$619	$645	$26
MY 2007	$984	$955	-$29
Total	$1,763	$1,818	$55