VII. COST IMPACTS

Technology Costs

Table V-1 provides the technology cost estimates used in this analysis. These are meant to represent consumer costs for high-volume production of these technologies after sufficient experience with their application have resulted in all "learning curve" effects being fully realized. The method taken to get to this consumer cost estimate starts with an initial estimate of the incremental manufacturers' direct costs (or variable costs) for high-volume production of these technologies. In the case of some very new technologies, the agency may have only had cost estimates from low volume products and has assumed that the products have not matured in the development production cycle and that a "learning curve" will result in a reduction in the variable cost of the product by 20 percent. The technologies to which the learning curve factors were applied are shown in Table V-3. The variable costs are marked up by a factor of 1.5 to take into account fixed costs of R&D, burden, manufacturer's profits, and dealer's profits. The final results are shown in Table V-1.

The variable costs are incremental costs in material, labor, and variable burden for the product. For example, if a vehicle already has a 4-speed automatic transmission, the cost of applying a 5-speed transmission is assumed to be the incremental cost, calculated as the cost of applying a 5-speed transmission less the cost of applying the previously applied 4-speed automatic transmission.

The learning curve

For some of the technologies, we have included a learning factor. The "learning curve" describes the reduction in unit production costs as a function of accumulated production volume and small redesigns that reduce costs.

A typical learning curve can be described by three parameters: (1) the initial production volume before cost reductions begin to be realized; (2) the rate at which cost reductions occur with increases in cumulative production beyond this initial volume (usually referred to as the "learning rate"); and (3) the production volume after which costs reach a "floor," and further cost reductions no longer occur. Over the region where costs decline with accumulating production volume, an experience curve can be expressed as $C(Q) = aQ^{-b}$, where a is a constant coefficient, Q represents cumulative production, and b is a coefficient corresponding to the assumed learning rate. In turn, the learning rate L, which is usually expressed as the percent by which average unit cost declines with a doubling of cumulative production, and is related to the value of the coefficient b by $L = 100*(1 - 2^{-b})$[136].

Figure VII-1 illustrates a learning curve for a vehicle technology with an initial average unit cost of $100 and a learning rate of approximately 20 percent. In this hypothetical example, the initial

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

production volume before cost reductions begin to be realized is set at 12,000 units and the production volume at the cost floor is set at roughly 50,000 units.

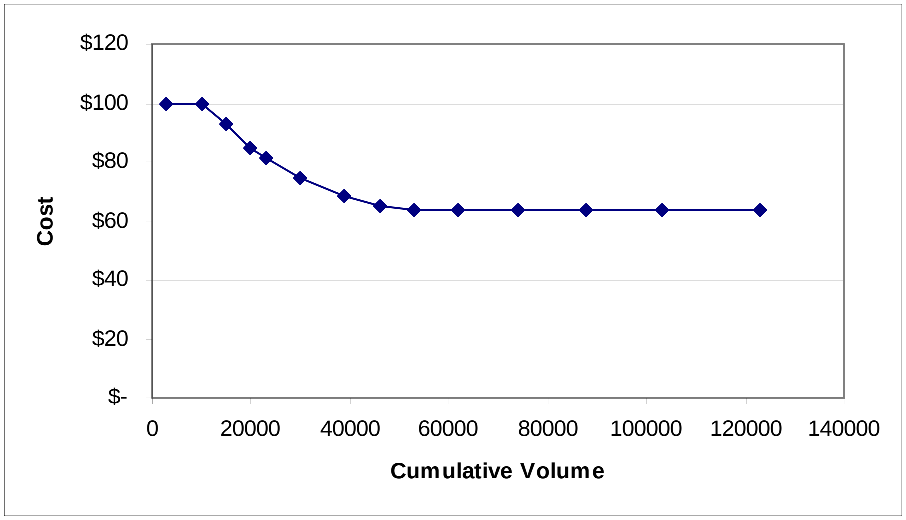

Figure VII-1 Typical Experience Curve

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

Table VII-1 summarizes estimates of learning rates derived from studies of production costs for various products.[137]

Table VII-1
Estimated Learning Rates and Associated Volumes for Various Products

Product(s)	Costs Affected	Threshold Volume	Learning Rate
Photovoltaic cells	Total costs	Not reported	20%
Wind turbines	Total costs	100 MW	20%
Gas turbines	Total costs	100 MW	10%
Semiconductors	Total costs	Not reported	13-24%
Automobile assembly	Assembly labor	Not reported	16%
Truck manufacturing	Total costs	Not reported	10%
Battery-electric LDV	Total costs	10,000 units	10%
Fuel cell hybrid LDV	Total costs	10,000 units	16%
Fuel cell LDV powertrain	Total costs	10,000 units	19%

In past rulemaking analyses, EPA has used a learning curve factor of 20 percent for each doubling of production volume. For this analysis, however, NHTSA has applied learning curve cost reductions on a manufacturer-specific basis, and have assumed that learning-based reductions in technology costs occur once during the time that a manufacturer applies the given technology to 25,000 cars or trucks, and are repeated a second time as it produces another 25,000 cars or trucks for the second learning step (car and truck volumes are treated separately for determining these sales volumes). The volumes chosen represent our best estimate for where learning would occur. As such, NHTSA believes that these estimates are better suited to this analysis than the more general approach used by EPA in past rules, because each manufacturer would be implementing technologies at its own pace in this rule, rather than assuming that all manufacturers implement each identical technology at the same time. The volumes chosen represent our best estimate for where learning would occur.

For this analysis, the agency has used engineering judgment to estimate the development production cycle and maturity level for each technology. After having produced 25,000 cars or trucks with a specific part or system, we believe that sufficient learning will have taken place such that costs will be lower by 20 percent for some technologies and 10 percent for others. After another 25,000 units for some technologies, another cost reduction will have been realized. When we applied a learning curve, we applied a 20 percent learning factor for all newly applied technologies except for diesel engines. We have applied a 10 percent factor for diesel costs here because we believe that the diesel technologies being considered are reaching their “learned” limit and, therefore, less learning reductions are available.[138]

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[137] Adapted from Williams, Figure 1, p. 14; Rumelt, Exhibit 5, p. 5; Linda Argote and Dennis Epple, “Learning Curves in Manufacturing,” *Science*, Vol. 247 (1990), pp. 920-924; and Philip Auerswald et al., “The Production Recipes Approach to Modeling Technological Innovation: An Application to Learning by Doing,” Journal of Economic Dynamics and Control, Vol. 24 (2000), pp. 389-450.

[138] Importantly, diesel technologies can still be considered to have some learning left given recent announcements by General Motors stating potential cost savings associated with their new 4.5 liter Duramax diesel V8 engine (see *Automotive News*, September 24, 2007).

For each of the technologies, we have considered whether we could project future cost reductions due to manufacturer learning. In making this determination, we considered whether or not the technology was in wide-spread use today or expected to be by the model year 2011 time frame, in which case no future learning curve would apply because the technology is already in wide-spread production by the automotive industry today, e.g., on the order of multi-millions of units per year. (Examples of these include 5-speed automatic transmissions and intake-cam phasing variable valve timing. These technologies have been in production for light-duty vehicles for more than 10 years.) In addition, we carefully considered the underlying source data for our cost estimate. If the source data specifically stated that manufacturer cost reduction from future learning would occur, we took that information into account in determining whether we would apply manufacturer learning in our cost projections. Thus, for many of the technologies, we have not applied any future cost reduction learning curve.

However, there are a number of technologies which are not yet in mass production for which we have estimated the initial cost will be reduced in the time frame of this rule due to manufacturer production learning. As indicated in Table V-3, we have applied the learning curve beginning in 2011 to one set of technologies, and for a number of additional technologies we did not apply manufacturer learning until 2014. The distinction between 2011 and 2014 is due to our source data for our cost estimates. For those technologies where we have applied manufacturer learning in 2011, the source of our cost estimate did not rely on manufacturer learning to develop the initial cost estimate we have used – therefore we apply the manufacturer learning methodology beginning in 2011.

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

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

curve beginning in 2014. Martec has recently submitted a study to the NAS Committee comparing the 2004 NESCAF study with new updated cost information. Given that this study had just been completely, the agency could not take it into consideration for the NPRM. However, the agency will review the new study and consider its findings in time for the final rule.

Manufacturers' actual costs for applying these technologies to specific vehicle models are likely to include significant additional outlays for accompanying design or engineering changes to each model, development and testing of prototype versions, recalibrating engine operating parameters, and integrating the technology with other attributes of the vehicle. Manufacturers may also incur additional corporate overhead, marketing, or distribution and selling expenses as a consequence of their efforts to improve the fuel economy of individual vehicle models and their overall product lines.

In order to account for these additional costs, the agency applies an indirect cost multiplier of 1.5 to its estimate of the vehicle manufacturers' direct costs for producing or acquiring each fuel economy-improving technology to arrive at a consumer cost. This estimate was developed by Argonne National Laboratory in a recent review of vehicle manufacturers' indirect costs. The Argonne study was specifically intended to improve the accuracy of future cost estimates for production of vehicles that achieve high fuel economy by employing many of the same advanced technologies considered in the agency's analysis.[139] Thus, its recommendation that a multiplier of 1.5 be applied to direct manufacturing costs to reflect manufacturers' increased indirect costs for deploying advanced fuel economy technologies appears to be appropriate for use in the agency's current analysis. Historically, NHTSA has used almost the exact same multiplier, a multiplier of 1.51, as the markup from variable costs or direct manufacturing costs to consumer costs. This markup takes into account fixed costs, burden, manufacturer's profit, and dealers profit. NHTSA's methodology for developing this markup factor was recently peer reviewed (see Docket No.27453-4).

Potential opportunity costs of improved fuel economy

An important concern is whether achieving the fuel economy improvements required by alternative CAFE standards would require manufacturers to compromise the performance, carrying capacity, safety, or comfort of their vehicles. If it did so, the resulting sacrifice in the value of these attributes to vehicle buyers would represent an additional cost of achieving the required improvements in fuel economy, and thus of manufacturers' compliance with stricter CAFE standards. While exact dollar values of these attributes to buyers are extremely difficult to infer from vehicle purchase prices, it is nevertheless clear that changes in these attributes can affect the utility that vehicle provide to their owners, and thus their value to potential buyers.

The agency has approached this potential problem by developing cost estimates for fuel economy-improving technologies that include any additional manufacturing costs that would be necessary to maintain the performance, comfort, capacity, or safety of any vehicle to which those technologies are applied. In doing so, the agency followed the precedent established by NAS in

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

its 2002 analysis of the costs and benefits of improving fuel economy by raising CAFE standards.[140] The NAS study estimated "constant performance and utility" costs for fuel economy technologies, and the agency has used these as the basis for developing the technology costs it employed in analyzing manufacturer's costs for complying with alternative standards.

NHTSA fully acknowledges the difficulty of estimating technology costs that include costs for the accompanying changes in vehicle design that are necessary to maintain performance, capacity, and utility. However, the agency believes its cost estimates for fuel economy technologies are generally sufficient to prevent significant reductions in consumer welfare.

The technology application algorithm implemented with the Volpe model was used as the basis for estimating costs for the fleet. We applied the technology application algorithm described in Chapter VI.

The agency did estimate the costs or fines to bring passenger car manufacturers up to the 27.5 mpg level in place for MY 2010 as shown in Table VII-2. Table VII-3 shows the estimates for those light truck manufacturers that are not planning on meeting the CAFE reform level for MY 2011, without using fuel economy adjustments for alternative fueled vehicles, up to the level required for them for MY 2011. These costs have been estimated, but they are not considered to be part of the costs of meeting the proposed requirements. Those costs, and commensurate benefits, are considered part of the costs and benefits of complying with previously issued rules.

Tables VII-4a through 4n for passenger cars and Tables VII-5a through 5n show the costs for light trucks (on an average cost-per-vehicle basis and on a total cost basis) of applying technology necessary to move each manufacturer's planned fuel economy levels up to the level of the alternative. Thus, if a manufacturer's product plans resulted in a fuel economy level of 22.2 mpg during each model year, the cost represents the cumulative cost of technologies necessary to bring that manufacturer's fleet average up to the levels of the alternative. The costs for several manufacturers are the fines that these manufacturers would have to pay on an average vehicle basis. We assume that the costs of fines will be passed on to consumers. The second part of each of these tables shows the estimated total manufacturer costs in millions of dollars. Fines are not included in the second part of these tables, since these are transfer payments and not technology costs.

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[140] National Academy of Sciences, ***Costs and Effectiveness of Increasing Corporate Average Fuel Economy Standards***, 2002.

Table VII-2

Estimated Incremental Costs or Fines over Manufacturer's Plans To get to Adjusted Baseline - Average Cost per Vehicle (2006$) Passenger Cars

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	58	59	60	61	61
Chrysler	-	-	-	-	-
Ferrari	710	710	710	710	710
Ford	-	-	-	-	-
Fuji (Subaru)	39	40	40	41	41
General Motors	-	-	-	-	-
Honda	-	-	-	-	-
Hyundai	-	-	-	-	-
Lotus	-	-	-	-	-
Maserati	638	638	638	638	638
Mercedes	255	323	328	356	359
Mitsubishi	-	-	-	-	-
Nissan	-	-	-	-	-
Porsche	334	353	355	454	458)
Suzuki	-	-	-	-	-
Toyota	-	-	-	-	-
Volkswagen	-	-	-	-	-
Total/Average	11	13	13	14	14

Table VII-3

Estimated Incremental Costs or Fines over Manufacturer's Plans To get to Adjusted Baseline - Average Cost per Vehicle (2006$) Light Trucks

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	499	761	745	727	720
Chrysler	9	9	9	9	9
Ferrari					
Ford	-	-	-	-	-
Fuji (Subaru)	35	34	33	32	32
General Motors	647	645	630	612	606
Honda	-	-	-	-	-
Hyundai	106	103	101	98	97
Lotus					
Maserati					
Mercedes	433	586	1,152	1,124	1,113
Mitsubishi	153	444	419	408	403
Nissan	1,105	1,181	1,147	1,111	1,097
Porsche	363	363	363	363	363
Suzuki	321	377	1,081	1,070	1,101
Toyota	6	5	5	5	5
Volkswagen	220	220	220	220	220
Total/Average	240	244	248	241	239

Table VII-4a
Estimated Incremental Costs or Fines over Adjusted Baseline
25% Below Optimized
Average Cost per Vehicle (2006$)
Passenger Cars

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	456	513	611	710	781
Chrysler	-	-	-	-	109
Ferrari	77	116	193	248	314
Ford	439	240	239	312	411
Fuji (Subaru)	509	537	912	2,825	3,764
General Motors	42	150	323	453	750
Honda	-	-	-	-	-
Hyundai	-	-	45	92	173
Lotus	363	391	462	506	556
Maserati	6	50	127	193	264
Mercedes	138	176	253	439	528
Mitsubishi	109	159	290	533	1,127
Nissan	-	-	24	116	219
Porsche	435	457	528	578	627
Suzuki	416	615	697	2,087	2,160
Toyota	-	-	-	-	-
Volkswagen	299	332	440	489	614
Total/Average	126	126	187	294	428

Table VII-4b
Estimated Incremental Costs or Fines over Adjusted Baseline
25% Below Optimized
Total Incremental Costs in Millions (2006$)
Passenger Cars

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	104.6	117.3	134.8	154.4	156.3
Chrysler	-	-	-	-	61.2
Ferrari	-	-	-	-	-
Ford	570.2	307.9	304.6	390.5	509.1
Fuji (Subaru)	23.1	23.8	70.5	339.2	472.6
General Motors	75.9	270.7	548.2	795.4	1,305.7
Honda	-	-	-	-	-
Hyundai	-	-	23.6	47.2	88.0
Lotus	-	-	-	-	-
Maserati	-	-	-	-	-
Mercedes	-	-	-	52.1	59.8
Mitsubishi	12.5	18.0	32.7	58.9	122.7
Nissan	-	-	16.4	79.1	147.6
Porsche	-	-	-	-	-
Suzuki	16.4	44.7	44.7	157.5	162.9
Toyota	-	-	-	-	-
Volkswagen	32.2	36.1	77.8	78.3	122.7
Total/Average	834.8	818.4	1,253.3	2,152.6	3,208.7

Table VII-4c
Estimated Incremental Costs or Fines over Adjusted Baseline
Proposed Optimized (7%)
Average Cost per Vehicle (2006$)
Passenger Cars

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	555	672	748	831	891
Chrysler	29	135	151	228	401
Ferrari	160	248	308	352	407
Ford	782	560	627	691	790
Fuji (Subaru)	630	730	1,077	2,968	3,890
General Motors	338	535	644	767	988
Honda	-	-	-	23	55
Hyundai	21	175	390	442	530
Lotus	490	594	638	660	688
Maserati	77	171	237	292	358
Mercedes	231	319	380	554	627
Mitsubishi	1,113	1,585	1,589	1,850	2,303
Nissan	37	164	259	331	575
Porsche	556	655	704	726	759
Suzuki	537	813	868	2,236	2,521
Toyota	-	-	-	-	5
Volkswagen	409	508	594	627	735
Total/Average	276	334	404	512	649

Table VII-4d
Estimated Incremental Costs or Fines over Adjusted Baseline
Proposed Optimized (7%)
Total Incremental Costs in Millions (2006$)
Passenger Cars

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	104.6	117.3	134.8	154.4	156.3
Chrysler	16.8	78.5	87.1	129.0	209.1
Ferrari	-	-	-	-	-
Ford	908.5	719.3	798.5	863.9	978.9
Fuji (Subaru)	23.1	23.8	70.5	339.2	472.6
General Motors	617.6	965.9	1,103.2	1,346.4	1,720.2
Honda	-	-	-	20.5	48.6
Hyundai	11.2	92.5	204.1	226.8	258.3
Lotus	-	-	-	-	-
Maserati	-	-	-	-	-
Mercedes	-	-	-	52.1	59.8
Mitsubishi	127.7	179.9	178.9	204.3	252.1
Nissan	26.1	114.9	179.6	225.2	387.6
Porsche	-	-	-	-	-
Suzuki	16.4	44.7	44.7	157.5	190.1
Toyota	-	-	-	-	5.9
Volkswagen	32.2	36.1	77.8	78.3	122.7
Total/Average	1,884.4	2,372.6	2,879.1	3,797.5	4,862.2

Table VII-4e
Estimated Incremental Costs or Fines over Adjusted Baseline
25% Above Optimized
Average Cost per Vehicle (2006$)
Passenger Cars

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	654	832	886	958	1,001
Chrysler	328	462	738	849	753
Ferrari	248	380	418	462	501
Ford	870	942	1,103	1,492	1,539
Fuji (Subaru)	751	922	1,242	3,122	4,022
General Motors	814	1,510	1,594	1,913	2,028
Honda	-	115	148	193	357
Hyundai	245	513	673	704	742
Lotus	622	798	814	820	825
Maserati	154	286	336	391	446
Mercedes	319	462	501	670	732
Mitsubishi	2,091	3,326	3,307	3,633	3,847
Nissan	520	1,065	1,142	1,195	1,394
Porsche	682	858	875	886	891
Suzuki	664	1,011	1,033	2,390	3,945
Toyota	-	-	7	42	83
Volkswagen	525	690	743	764	856
Total/Average	494	778	871	1,078	1,185

Table VII-4f
Estimated Incremental Costs or Fines over Adjusted Baseline
25% Above Optimized
Total Cost in Millions (2006$)
Passenger Cars

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	104.6	117.3	134.8	154.4	156.3
Chrysler	192.2	268.0	424.4	479.1	384.7
Ferrari	-	-	-	-	-
Ford	908.5	1,062.3	1,300.5	1,817.6	1,907.6
Fuji (Subaru)	23.1	23.8	70.5	339.2	472.6
General Motors	1,374.8	2,606.9	2,734.2	3,359.4	3,530.5
Honda	-	105.4	133.6	171.3	315.0
Hyundai	130.7	270.9	351.8	361.5	371.7
Lotus	-	-	-	-	-
Maserati	-	-	-	-	-
Mercedes	-	-	-	52.1	59.8
Mitsubishi	236.7	373.2	372.1	401.2	418.7
Nissan	367.3	744.8	791.4	812.9	939.8
Porsche	-	-	-	-	-
Suzuki	16.4	44.7	44.7	157.5	297.4
Toyota	-	-	9.4	54.9	107.0
Volkswagen	32.2	36.1	77.8	78.3	122.7
Total/Average	3,386.6	5,653.1	6,445.3	8,239.5	9,083.9

Table VII-4g
Estimated Incremental Costs or Fines over Adjusted Baseline
50% Above Optimized
Average Cost per Vehicle (2006$)
Passenger Cars

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	753	991	1,051	1,117	1,166
Chrysler	1,045	1,478	1,475	1,442	1,137
Ferrari	325	512	539	561	594
Ford	952	1,079	1,230	1,608	2,009
Fuji (Subaru)	872	1,120	1,468	3,364	4,297
General Motors	891	1,636	1,709	2,152	2,505
Honda	19	769	880	946	981
Hyundai	421	1,895	1,916	1,971	2,035
Lotus	754	1,012	1,062	1,100	1,155
Maserati	226	407	435	451	484
Mercedes	407	605	638	791	847
Mitsubishi	2,184	3,485	4,115	4,466	4,765
Nissan	753	1,492	2,005	2,343	2,498
Porsche	814	1,067	1,111	1,150	1,205
Suzuki	790	1,215	1,269	2,648	5,019
Toyota	-	115	138	172	223
Volkswagen	635	871	941	973	1,092
Total/Average	620	1,133	1,251	1,501	1,694

Table VII-4h
Estimated Incremental Costs or Fines over Adjusted Baseline
50% Above Optimized
Total Incremental Costs in Millions (2006$)
Passenger Cars

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	104.6	117.3	134.8	154.4	156.3
Chrysler	593.5	857.9	848.6	813.9	611.4
Ferrari	-	-	-	-	-
Ford	908.5	1,062.3	1,300.5	1,817.6	2,489.5
Fuji (Subaru)	23.1	23.8	70.5	339.2	472.6
General Motors	1,374.8	2,606.9	2,734.2	3,634.7	4,313.3
Honda	17.9	657.7	772.0	840.9	864.4
Hyundai	224.6	999.7	1,002.0	1,011.6	1,026.8
Lotus	-	-	-	-	-
Maserati	-	-	-	-	-
Mercedes	-	-	-	52.1	59.8
Mitsubishi	236.7	373.2	461.8	487.1	513.2
Nissan	478.1	951.1	1,355.5	1,593.9	1,684.4
Porsche	-	-	-	-	-
Suzuki	16.4	44.7	44.7	157.5	378.4
Toyota	-	154.4	183.8	225.5	288.5
Volkswagen	32.2	36.1	77.8	78.3	122.7
Total/Average	4,010.5	7,884.7	8,986.1	11,206.8	12,981.4

Table VII-4i
Estimated Incremental Costs or Fines over Adjusted Baseline
Optimized (3%)
Average Cost per Vehicle (2006$)
Passenger Cars

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	923	1,068	1,089	1,200	1,215
Chrysler	1,182	1,684	1,753	1,982	1,611
Ferrari	473	589	589	671	677
Ford	1,095	1,156	1,274	1,707	2,328
Fuji (Subaru)	1,092	1,225	1,523	3,414	4,308
General Motors	1,028	1,708	1,753	2,256	2,593
Honda	667	1,198	1,229	1,298	1,336
Hyundai	1,875	2,287	2,308	2,401	2,429
Lotus	963	1,095	1,095	1,111	1,122
Maserati	363	457	468	572	583
Mercedes	561	682	682	890	924
Mitsubishi	2,371	3,584	4,176	4,560	4,826
Nissan	907	1,574	2,054	2,661	2,824
Porsche	1,018	1,150	1,150	1,172	1,183
Suzuki	1,010	1,314	1,319	2,687	5,019
Toyota	78	232	234	350	373
Volkswagen	844	970	1,001	1,039	1,120
Total/Average	896	1,284	1,376	1,706	1,915

Table VII-4j
Estimated Incremental Costs or Fines over Adjusted Baseline
Optimized 3%
Total Incremental Costs in Millions (2006$)
Passenger Cars

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	104.6	117.3	134.8	154.4	156.3
Chrysler	593.5	977.3	1,008.6	1,116.0	861.3
Ferrari	-	-	-	-	-
Ford	908.5	1,062.3	1,300.5	1,817.6	2,831.4
Fuji (Subaru)	23.1	23.8	70.5	339.2	472.6
General Motors	1,374.8	2,606.9	2,734.2	3,634.7	4,313.3
Honda	616.0	1,079.8	1,113.3	1,154.4	1,177.7
Hyundai	976.4	1,206.9	1,206.9	1,232.4	1,235.9
Lotus	-	-	-	-	-
Maserati	-	-	-	-	-
Mercedes	-	-	-	52.1	59.8
Mitsubishi	236.7	373.2	461.8	487.1	513.2
Nissan	478.1	951.1	1,355.5	1,765.4	1,878.4
Porsche	-	-	-	-	-
Suzuki	16.4	44.7	44.7	157.5	378.4
Toyota	106.3	312.3	312.2	458.0	483.4
Volkswagen	32.2	36.1	77.8	78.3	122.7
Total/Average	5,466.7	8,791.5	9,820.9	12,447.1	14,484.5

Table VII-4k
Estimated Incremental Costs or Fines over Adjusted Baseline
Total Cost = Total Benefit
Average Cost per Vehicle (2006$)
Passenger Cars

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	956	1,310	1,331	1,381	1,402
Chrysler	1,204	2,062	2,734	2,766	2,299
Ferrari	490	765	765	776	781
Ford	1,123	1,349	1,466	1,828	2,449
Fuji (Subaru)	1,136	1,538	1,836	3,711	4,611
General Motors	1,050	1,889	1,935	2,355	2,692
Honda	978	1,548	1,594	2,071	2,115
Hyundai	1,891	3,371	3,529	4,003	4,039
Lotus	1,040	1,463	1,463	1,480	1,496
Maserati	385	633	649	660	666
Mercedes	583	886	886	1,022	1,056
Mitsubishi	2,382	3,804	4,396	4,741	5,013
Nissan	929	1,772	2,252	2,793	2,961
Porsche	1,089	1,502	1,502	1,518	1,529
Suzuki	1,060	1,644	1,649	3,006	6,030
Toyota	195	1,143	1,152	1,174	1,187
Volkswagen	871	1,245	1,276	1,287	1,373
Total/Average	966	1,685	1,829	2,159	2,367

Table VII-4l
Estimated Incremental Costs or Fines over Adjusted Baseline
Total Cost = Total Benefit
Total Incremental Costs in Millions (2006$)
Passenger Cars

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	104.6	117.3	134.8	154.4	156.3
Chrysler	593.5	1,113.5	1,515.9	1,527.5	1,200.0
Ferrari	-	-	-	-	-
Ford	908.5	1,062.3	1,300.5	1,817.6	2,831.4
Fuji (Subaru)	23.1	23.8	70.5	339.2	472.6
General Motors	1,374.8	2,606.9	2,734.2	3,634.7	4,313.3
Honda	903.8	1,224.0	1,274.4	1,797.9	1,815.9
Hyundai	976.4	1,706.0	1,796.7	2,054.8	2,054.8
Lotus	-	-	-	-	-
Maserati	-	-	-	-	-
Mercedes	-	-	-	52.1	59.8
Mitsubishi	236.7	373.2	461.8	487.1	513.2
Nissan	478.1	951.1	1,355.5	1,765.4	1,878.4
Porsche	-	-	-	-	-
Suzuki	16.4	44.7	44.7	157.5	440.9
Toyota	265.1	1,537.1	1,535.9	1,535.9	1,538.2
Volkswagen	32.2	36.1	77.8	78.3	122.7
Total/Average	5,913.2	10,795.8	12,302.7	15,402.5	17,397.6

Table VII-4m
Estimated Incremental Costs or Fines over Adjusted Baseline Technology Exhaustion
Average Cost per Vehicle (2006$)
Passenger Cars

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	1,017	1,475	1,683	1,788	1,969
Chrysler	1,254	2,155	3,026	3,102	2,739
Ferrari	556	919	1,084	1,155	1,287
Ford	1,172	1,503	1,791	2,213	2,961
Fuji (Subaru)	1,213	1,758	2,260	4,156	5,265
General Motors	1,105	2,027	2,243	2,735	3,187
Honda	1,180	1,855	2,083	2,605	2,788
Hyundai	1,968	3,558	3,892	4,728	4,934
Lotus	1,089	1,661	1,870	1,892	2,134
Maserati	435	743	919	1,012	1,133
Mercedes	644	1,045	1,227	1,423	1,595
Mitsubishi	2,470	4,008	4,770	5,165	5,607
Nissan	990	1,932	2,582	3,183	3,484
Porsche	1,139	1,700	1,903	1,936	2,167
Suzuki	1,131	1,864	2,072	3,446	6,684
Toyota	239	2,408	2,913	3,487	3,825
Volkswagen	948	1,449	1,678	1,721	1,994
Total/Average	1,038	2,032	2,406	2,889	3,264

Table VII-4n
Estimated Incremental Costs or Fines over Adjusted Baseline
Technology Exhaustion
Total Incremental Costs in Millions (2006$)
Passenger Cars

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	104.6	117.3	134.8	154.4	156.3
Chrysler	593.5	1,113.5	1,515.9	1,527.5	1,200.0
Ferrari	-	-	-	-	-
Ford	908.5	1,062.3	1,300.5	1,817.6	2,831.4
Fuji (Subaru)	23.1	23.8	70.5	339.2	472.6
General Motors	1,374.8	2,606.9	2,734.2	3,634.7	4,313.3
Honda	1,069.9	1,389.2	1,444.0	1,964.1	1,982.1
Hyundai	976.4	1,706.0	1,796.7	2,263.1	2,266.7
Lotus	-	-	-	-	-
Maserati	-	-	-	-	-
Mercedes	-	-	-	52.1	59.8
Mitsubishi	236.7	373.2	461.8	487.1	513.2
Nissan	478.1	951.1	1,355.5	1,765.4	1,878.4
Porsche	-	-	-	-	-
Suzuki	16.4	44.7	44.7	157.5	440.9
Toyota	265.1	3,171.3	3,764.8	4,517.6	4,872.6
Volkswagen	32.2	36.1	77.8	78.3	122.7
Total/Average	6,079.4	12,595.2	14,701.1	18,758.8	21,110.1

Table VII-5a
Estimated Incremental Costs or Fines over Adjusted Baseline
25% Below Optimized
Average Cost per Vehicle (2006$)
Light Trucks

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	149	220	303	297	303
Chrysler	251	396	682	599	563
Ferrari					
Ford	147	218	281	273	270
Fuji (Subaru)	160	618	2,088	2,031	2,016
General Motors	113	1,030	1,205	1,173	1,160
Honda	141	271	492	478	473
Hyundai	664	898	1,101	1,066	1,067
Lotus					
Maserati					
Mercedes	149	220	303	297	303
Mitsubishi	149	2,838	2,630	2,558	2,530
Nissan	177	340	1,049	1,016	1,003
Porsche	99	171	248	242	248
Suzuki	121	198	286	281	2,877
Toyota	202	367	477	464	459
Volkswagen	110	182	253	253	253
Total/Average	185	526	738	705	708

Table VII-5b
Estimated Incremental Costs or Fines over Adjusted Baseline
25% Below Optimized
Total Incremental Costs in Millions (2006$)
Light Trucks

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	0	0	0	0	0
Chrysler	417	618	1,193	1,077	1,023
Ferrari					
Ford	230	351	463	463	463
Fuji (Subaru)	5	54	232	232	232
General Motors	140	2,124	2,589	2,589	2,589
Honda	103	204	379	379	379
Hyundai	157	243	304	304	308
Lotus					
Maserati					
Mercedes	0	0	0	0	0
Mitsubishi	0	107	101	101	101
Nissan	57	149	474	474	474
Porsche	0	0	0	0	0
Suzuki	0	0	0	0	163
Toyota	239	447	594	594	594
Volkswagen	0	0	0	0	0
Total/Average	1,349	4,296	6,329	6,212	6,326

Table VII-5c
Estimated Incremental Costs or Fines over Adjusted Baseline
Proposed Optimized (7%)
Average Cost per Vehicle (2006$)
Light Trucks

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	154	248	319	330	347
Chrysler	329	439	905	838	815
Ferrari					
Ford	195	288	332	365	425
Fuji (Subaru)	171	646	2,110	2,061	2,108
General Motors	118	1,052	1,276	1,453	1,487
Honda	175	512	668	700	769
Hyundai	675	1,082	1,243	1,270	1,293
Lotus					
Maserati					
Mercedes	154	248	319	330	347
Mitsubishi	160	2,838	2,630	2,558	2,530
Nissan	182	596	1,283	1,251	1,307
Porsche	110	193	264	281	303
Suzuki	132	231	308	308	3,977
Toyota	262	522	603	774	815
Volkswagen	116	204	270	286	308
Total/Average	224	617	861	924	979

Table VII-5d
Proposed Optimized (7%)
Total Incremental Costs in Millions (2006$)
Light Trucks

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	-	-	-	-	-
Chrysler	546.1	663.6	1,583.3	1,507.1	1,481.1
Ferrari					
Ford	305.2	463.5	546.8	618.1	728.7
Fuji (Subaru)	5.2	53.8	231.5	235.0	242.9
General Motors	140.4	2,123.6	2,739.4	3,207.7	3,319.3
Honda	128.2	384.5	514.4	554.3	615.6
Hyundai	157.4	293.1	344.9	360.9	373.1
Lotus					
Maserati					
Mercedes	-	-	-	-	-
Mitsubishi	-	106.8	101.5	101.5	101.5
Nissan	57.0	261.4	579.5	583.6	617.3
Porsche	-	-	-	-	-
Suzuki	-	-	-	-	224.7
Toyota	309.6	635.3	752.1	991.8	1,056.5
Volkswagen	-	-	-	-	-
Total/Average	1,649.3	4,985.5	7,393.6	8,159.9	8,760.6

Table VII-5e
Estimated Incremental Costs or Fines over Adjusted Baseline
25% Above Optimized
Average Cost per Vehicle (2006$)
Light Trucks

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	171	286	336	374	429
Chrysler	490	610	1,162	1,173	1,541
Ferrari					
Ford	233	459	451	797	1,079
Fuji (Subaru)	187	690	2,126	3,316	3,280
General Motors	129	1,080	1,512	1,831	2,125
Honda	228	1,307	1,275	1,306	1,400
Hyundai	686	1,750	1,749	1,804	1,927
Lotus					
Maserati					
Mercedes	171	286	336	374	429
Mitsubishi	176	3,173	2,880	2,801	2,771
Nissan	193	882	1,551	1,529	1,995
Porsche	121	226	275	319	374
Suzuki	149	275	325	363	4,010
Toyota	312	1,020	1,028	1,335	1,628
Volkswagen	127	237	286	330	380
Total/Average	279	873	1,141	1,352	1,655

Table VII-5f
Estimated Incremental Costs or Fines over Adjusted Baseline
25% Above Optimized
Total Cost in Millions (2006$)
Light Trucks

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	0	0	0	0	0
Chrysler	813	919	2,032	2,109	2,800
Ferrari					
Ford	364	739	744	1,351	1,839
Fuji (Subaru)	5	54	232	378	378
General Motors	140	2,124	3,246	4,018	4,705
Honda	167	982	982	1,035	1,122
Hyundai	157	474	485	505	556
Lotus					
Maserati					
Mercedes	0	0	0	0	0
Mitsubishi	0	119	111	111	111
Nissan	57	382	700	705	937
Porsche	0	0	0	0	0
Suzuki	0	0	0	0	225
Toyota	369	1,241	1,282	1,690	2,109
Volkswagen	0	0	0	0	0
Total/Average	2,072	7,034	9,815	11,903	14,781

Table VII-5g
Estimated Incremental Costs or Fines over Adjusted Baseline
50% Above Optimized
Average Cost per Vehicle (2006$)
Light Trucks

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	176	314	358	424	501
Chrysler	597	731	1,408	1,657	1,932
Ferrari					
Ford	462	770	639	1,144	1,418
Fuji (Subaru)	193	723	2,148	2,982	3,376
General Motors	135	1,102	1,875	2,206	2,518
Honda	257	1,329	1,325	1,506	2,197
Hyundai	691	1,750	1,784	1,866	2,439
Lotus					
Maserati					
Mercedes	176	314	358	424	501
Mitsubishi	182	2,838	2,630	2,558	2,530
Nissan	199	1,028	1,337	1,355	1,963
Porsche	127	248	292	358	435
Suzuki	154	308	352	418	4,092
Toyota	563	1,279	1,276	1,535	2,033
Volkswagen	132	259	303	369	446
Total/Average	385	1,008	1,347	1,644	2,041

Table VII-5h
Estimated Incremental Costs or Fines over Adjusted Baseline
50% Above Optimized
Total Incremental Costs in Millions (2006$)
Light Trucks

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	0	0	0	0	0
Chrysler	990	1,097	2,463	2,979	3,432
Ferrari					
Ford	723	1,237	1,053	1,939	2,372
Fuji (Subaru)	5	54	232	340	389
General Motors	140	2,124	4,026	4,798	5,485
Honda	184	999	1,021	1,193	1,760
Hyundai	157	474	495	515	704
Lotus					
Maserati					
Mercedes	0	0	0	0	0
Mitsubishi	0	107	101	101	101
Nissan	57	451	604	609	896
Porsche	0	0	0	0	0
Suzuki	0	0	0	0	225
Toyota	666	1,555	1,591	1,911	2,605
Volkswagen	0	0	0	0	0
Total/Average	2,922	8,098	11,586	14,386	17,969

Table VII-5i
Estimated Incremental Costs or Fines over Adjusted Baseline
Optimized (3%)
Average Cost per Vehicle (2006$)
Light Trucks

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	160	253	336	363	380
Chrysler	329	439	1,092	1,022	1,095
Ferrari					
Ford	195	288	344	398	468
Fuji (Subaru)	176	651	2,121	2,326	2,362
General Motors	124	1,052	1,435	1,609	1,720
Honda	192	497	711	775	803
Hyundai	675	1,078	1,249	1,288	1,356
Lotus					
Maserati					
Mercedes	160	253	336	363	380
Mitsubishi	165	2,838	2,630	2,558	2,530
Nissan	182	596	1,283	1,276	1,765
Porsche	110	198	275	303	325
Suzuki	138	237	319	336	3,977
Toyota	262	522	668	837	891
Volkswagen	121	204	281	308	336
Total/Average	227	616	955	1,028	1,145

Table VII-5j
Estimated Incremental Costs or Fines over Adjusted Baseline
Optimized 3%
Total Incremental Costs in Millions (2006$)
Light Trucks

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	0	0	0	0	0
Chrysler	546	664	1,909	1,837	1,991
Ferrari					
Ford	305	463	567	675	801
Fuji (Subaru)	5	54	232	265	272
General Motors	140	2,124	3,081	3,552	3,840
Honda	141	374	548	614	644
Hyundai	157	292	341	357	391
Lotus					
Maserati					
Mercedes	0	0	0	0	0
Mitsubishi	0	107	101	101	101
Nissan	57	261	580	585	834
Porsche	0	0	0	0	0
Suzuki	0	0	0	0	225
Toyota	310	635	832	1,072	1,154
Volkswagen	0	0	0	0	0
Total/Average	1,662	4,974	8,190	9,058	10,253

Table VII-5k
Estimated Incremental Costs or Fines over Adjusted Baseline
Total Cost = Total Benefit
Average Cost per Vehicle (2006$)
Light Trucks

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	198	369	391	512	649
Chrysler	857	1,012	1,880	2,348	2,225
Ferrari					
Ford	647	1,388	1,201	1,772	1,965
Fuji (Subaru)	215	789	2,187	3,884	5,451
General Motors	151	1,140	2,178	2,475	2,834
Honda	279	2,295	2,238	2,850	3,630
Hyundai	713	1,907	1,984	2,096	2,929
Lotus					
Maserati					
Mercedes	198	374	391	512	655
Mitsubishi	204	3,743	3,513	3,417	3,380
Nissan	215	1,352	1,977	1,992	2,517
Porsche	143	297	325	435	567
Suzuki	182	374	385	517	4,263
Toyota	705	1,407	1,415	1,700	2,174
Volkswagen	154	308	330	446	578
Total/Average	501	1,325	1,770	2,171	2,509

Table VII-5l
Estimated Incremental Costs or Fines over Adjusted Baseline
Total Cost = Total Benefit
Total Incremental Costs in Millions (2006$)
Light Trucks

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	0	0	0	0	0
Chrysler	1,422	1,529	3,288	4,182	3,773
Ferrari					
Ford	995	2,213	1,979	2,948	3,150
Fuji (Subaru)	5	54	232	438	628
General Motors	140	2,124	4,631	5,258	5,944
Honda	184	1,725	1,725	2,258	2,907
Hyundai	157	502	549	564	818
Lotus					
Maserati					
Mercedes	0	0	0	0	0
Mitsubishi	0	141	136	136	136
Nissan	57	581	893	898	1,129
Porsche	0	0	0	0	0
Suzuki	0	0	0	0	225
Toyota	828	1,657	1,764	2,080	2,653
Volkswagen	0	0	0	0	0
Total/Average	3,788	10,525	15,196	18,762	21,364

Table VII-5m
Estimated Incremental Costs or Fines over Adjusted Baseline Technology Exhaustion
Average Cost per Vehicle (2006$)
Light Trucks

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	220	407	638	704	781
Chrysler	961	1,119	2,093	2,479	2,348
Ferrari					
Ford	664	1,410	1,912	2,127	2,299
Fuji (Subaru)	242	827	2,467	4,109	5,511
General Motors	168	1,162	2,349	2,585	2,905
Honda	301	2,300	3,049	3,499	4,076
Hyundai	735	1,940	2,220	2,266	3,045
Lotus					
Maserati					
Mercedes	220	413	644	710	787
Mitsubishi	231	3,743	3,513	3,505	3,755
Nissan	237	1,380	2,287	2,263	2,743
Porsche	165	325	528	578	660
Suzuki	209	413	671	743	4,400
Toyota	722	1,429	2,519	2,595	2,930
Volkswagen	176	341	545	594	677
Total/Average	536	1,364	2,255	2,507	2,785

Table VII-5n
Estimated Incremental Costs or Fines over Adjusted Baseline
Technology Exhaustion
Total Incremental Costs in Millions (2006$)
Light Trucks

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	0	0	0	0	0
Chrysler	1,567	1,674	3,323	4,180	3,827
Ferrari					
Ford	995	2,213	3,025	3,465	3,721
Fuji (Subaru)	5	54	232	438	628
General Motors	140	2,124	4,631	5,258	5,944
Honda	184	1,725	2,299	2,773	3,264
Hyundai	157	502	549	564	818
Lotus					
Maserati					
Mercedes	0	0	0	0	0
Mitsubishi	0	141	136	137	146
Nissan	57	581	968	973	1,202
Porsche	0	0	0	0	0
Suzuki	0	0	0	0	225
Toyota	828	1,657	3,113	3,263	3,703
Volkswagen	0	0	0	0	0
Total/Average	3,933	10,670	18,275	21,051	23,479

Financial Impacts of Raising CAFE Standards

The agency does not have the capability to predict the capital investment needs of the automobile industry to install fuel economy technologies, nor the capability to determine the level of capital investments available to specific manufacturers in the future. The analysis estimates the price increases in total for each manufacturer, under the assumption that prices would be increased and the manufacturer would get back that investment when the vehicles are sold. However, that methodology does not determine whether automobile manufacturers can pay for research and development, plant changes, and tooling necessary to get the technology into the vehicles in the first place. In essence this is a cash flow question. Do they have the cash reserves or can they borrow enough money to fund this process? The implicit assumption in the analysis is yes.

A significant portion of the capital needs will fall upon suppliers to the automobile manufacturers, those companies that develop and sell engines, transmissions, and other fuel economy technologies. So, the capital needs are spread out to both the suppliers and original equipment manufacturers.

The agency would like to have a more informed opinion on the ability of manufacturers to provide the capital investment needs for the various alternatives. In light of these unknowns, the agency is seeking information regarding the manufacturers financial capabilities in meeting this proposal and the alternatives examined. Specific questions are as follows:

QUESTIONS FOR VEHICLE MANUFACTURERS AND SUPPLIERS

1. For each of the model years 2011-2015, please provide the best possible estimate of the incremental capital investments required for your company to comply with the alternatives discussed in this analysis (25% Below Optimized, Optimized (7%), 25% Above Optimized, 50% Above Optimized, Optimized (3%), TC = TB, and Technology Exhaustion. Capital investments are defined here by asset class and consist of outlays for property, plant, machinery, equipment, and special tools used in the production process by vehicle manufacturers and suppliers. Incremental investments are defined as those directly attributed to the fuel economy improvements and would not be incurred in the absence of the new requirements.

2. To the degree possible, please provide the above utilizing the elements below for each model year presenting passenger cars and LTV'S separately (suppliers can supply data by model year). NHTSA understands that the adoption of flexible assembly in which production of passenger cars and many LTV'S are integrated onto the same line may make such distinctions infeasible, particularly in the out-years. In such cases, a combined PC/ LTV estimate for each element below will suffice. The agency further acknowledges that estimates of capital requirements for the out-years must contain, by nature, a high degree of uncertainty.

Asset Classification	**Capital Investment** (Incremental)	**Write-off Period**
New Property	$-	In years
Plant	$-	In years
Machinery& Equipment	$-	In years
Special Tooling	$-	In years

3. Please discuss whether you anticipate that your firm will to be able to raise the incremental capital investments necessary to meet the levels predicted in answer to the questions above. If the answer is no, what level appears likely to be achievable. What alternatives are available to raise the incremental capital investments necessary?

The Impact of Higher Prices on Sales

Higher fuel economy standards are expected to increase the price of passenger cars and light trucks. The potential impact of higher vehicle prices on sales was examined on a manufacturer-specific basis, since the estimated cost of improving fuel economy and the fuel economy improvement is different for each manufacturer. There is a broad consensus in the economic literature that the price elasticity for demand for automobiles is approximately –1.0.[141,142,143] Thus, every one percent increase in the price of the vehicle would reduce sales by one percent. Elasticity estimates assume no perceived change in the quality of the product. However, in this case, vehicle price increases result from adding technologies that improve fuel economy. If consumers do not value improved fuel economy at all, and consider nothing but the increase in price in their purchase decisions, then the estimated impact on sales from price elasticity could be applied directly. However, we believe that consumers do value improved fuel economy, because they reduce the operating cost of the vehicles. We also believe that consumers consider other factors that affect their costs and have included these in the analysis.

To estimate the average value consumers place on fuel savings at the time of purchase, we assume that the average purchaser considers the fuel savings they would receive over a 5 year timeframe. We chose 5 years because this is the average length of time of a financing agreement.[144] The present values of these savings were calculated using a 3 percent discount rate, which is more consistent with the real (after-inflation) rate that consumers receive from their own personal savings in banks, etc, than the 7 percent discount factor. We used a fuel price forecast (see Table VIII-3) that included taxes, because this is what consumers must pay. Fuel savings were calculated over the first 5 years and discounted back to a present value.

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

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

[143] 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.

[144] National average financing terms for automobile loans are available from the Board of Governors of the Federal Reserve System G.19 "Consumer Finance" release. See: http://www.federalreserve.gov/releases/g19/

The agency believes that consumers may consider several other factors over the 5 year horizon when contemplating the purchase of a new vehicle. The agency added these factors into the calculation to represent how an increase in technology costs might affect consumers' buying considerations.

First, consumers might consider the sales taxes they have to pay at the time of purchasing the vehicle. We took sales taxes in 2007 by state and weighted them by population by state to determine a national weighted-average sales tax of 5.5 percent.

Second, we considered insurance costs over the 5 year period. More expensive vehicles will require more expensive collision and comprehensive (e.g., theft) car insurance. According to the National Association of Insurance Commissioners (NAIC) the national average premium for collision + comprehensive insurance in 2000 was $389 while the average new car transaction price was $20,600. If we assume that this premium is proportional to the new car price, it represents about 1.9 percent of the new car price and insurance is paid each year for the five year period we are considering for payback. Discounting that stream of insurance costs back to present value using a 3 percent discount rate suggests that the present value of the component of insurance costs that vary with vehicle price is equal to about 8.0 percent of the vehicle's price.

Third, we considered that 70 percent of new vehicle purchasers take out loans to finance their purchase. The average new vehicle loan is for 5 years at a 6 percent rate[145]. At these terms the average person taking a loan will pay 16 percent more for their vehicle over the 5 years than a consumer paying cash for the vehicle at the time of purchase[146]. Discounting the additional 3.2 percent (16 percent / 5 years) per year over the 5 years using a 3 percent mid-year discount rate[147] results in a discounted present value of 14.87 percent higher for those taking a loan. Multiplying that by the 70 percent that take a loan, means that the average consumer would pay 10.4 percent more than the retail price for loans.

Fourth, we considered the residual value (or resale value) of the vehicle after 5 years and expressed this as a percentage of the new vehicle price. In other words, if the price of the vehicle increases due to fuel economy technologies, the resale value of the vehicle will go up proportionately. To estimate that value, we looked at 138 model year 2002 vehicles to compare their original MSRP values (based on www.nadaguides.com) to their current trade-in values (5 years later in 2007 based on www.edmunds.com). The sales weighted average residual value for this group of vehicles was 37.5 percent. Discounting the residual value back 5 years using a 3 percent discount rate (37.5 percent * .8755) gives an effective residual value at new of 32.8 percent.

These four factors together, the consumer considering he could get 32.8 percent back upon resale in 5 years, but will pay 10.4 percent more for loans, 5.5 percent more for taxes and 8.0 percent

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[145] New car loan rates in 2007 average about 7.8 percent at commercial banks and 4.5 percent at auto finance companies, so their average is close to 7 percent

[146] Based on www.bankrate.com auto loan calculator for a 5 year loan at 6 percent.

[147] The summation of 3.2 percent x 0.9853 in year one, 3.2 x 0.9566 in year two, 3.2 x 0.9288 in year three, 3.2 x 0.9017 in year 4, and 3.2 x 0.8755 in year five.

more in insurance, results in a 8.9 percent return on the increase in price for fuel economy technology (32.8 percent – 10.4 percent - 5.5 percent – 8.0 percent). Thus, the increase in price per vehicle is multiplied by 0.911 (1 – 0.089) before subtracting the fuel savings to determine the overall net consumer valuation the increase of costs on his purchase decision.

Using sales volumes from Automotive News and the Automotive News 2006 Market Data Book for base vehicle average prices for MY 2006, we determined an average passenger car and an average light truck price per manufacturer. The average base price for all passenger cars using this method was $22,857 and for all light trucks was $26,090. While this method does not give an exact price, the results are reasonable and specific to individual manufacturers[148]. These prices are in 2006 dollars. Average prices and estimated sales volumes are needed because price elasticity is an estimate of how a percent increase in price affects the percent decrease in sales.

A sample calculation for Ford passenger cars under the Optimized 7% alternative in MY 2011 is an estimated retail price increase of $782, which is multiplied by 0.911 to get a residual price increase of $712. The estimated fuel savings over the 5 years of $281 at a 3 percent discount rate results in a net cost to consumers of $431. Comparing that to the $21,821 average price is 2.39 percent price increase. Ford sales were estimated to be about 1,300,000 passenger cars for MY 2011. With a price elasticity of –1.0, a 2.39 percent increase in sales could result in an estimated loss in sales of 3,104 passenger cars at a 3 percent discount rate.

Sales increases occur when the value of improved fuel economy exceeds the consumer cost of added technology. Overall, the 25% Below Optimized and the proposed Optimized (7%) alternatives result in a gain in sales, while the other alternatives result in almost progressively larger losses in sales. Tables VII-6a through 6g show the estimated impact on sales for passenger cars and light trucks combined.

Our projections indicate that CAFE standards will result in sales increases for some manufacturers under some scenarios. These results rest on several assumptions about consumer behavior, in particular, how consumers value fuel economy increases. If consumers are completely unable to perceive any increases in fuel economy, then they would treat the vehicle price increases resulting from CAFE standards as pure price increases without any corresponding quality increase. Under those circumstances, one would expect vehicle sales to fall in accordance with the price elasticity of demand discussed earlier. Our projections of sales increases rest on the assumption that consumers will correctly perceive at least some of the increase in fuel economy and therefore be willing to pay somewhat more for a vehicle with greater fuel economy. Even if consumers value only a portion of the resulting fuel savings, there are instances where those fuel savings are nonetheless projected to be large enough to exceed the increased vehicle price, thus leading to an increase in sales. However, this assumption raises the following question: If some fraction of fuel economy improvements (as perceived and valued by vehicle purchasers) is large enough to exceed the increased vehicle cost (and result in an increase in vehicle sales), then what would be the nature of the market failure such that those levels of fuel economy would not exist but for a CAFE mandate? To better understand this issue, NHTSA

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[148] The base price does not include the more expensive lines of a model or purchased optional equipment; nor does it count discounts given. Thus, it is not an average light truck purchase transaction price, but a price that we can track.

seeks comment on the following questions: What evidence or data exist that indicate the extent to which consumers undervalue fuel economy improvements? Under what circumstances is it reasonable to expect that a mandated increase in fuel economy would lead to an increase in vehicle sales?

Note that there is no feedback loop between this sales analysis and the Volpe model. These sales estimates are not used to determine additional or less mileage traveled or fuel consumed. Also, see the earlier discussion about a market share model in Chapter V.

Table VII-6a
Potential Impact on Sales by Manufacturer
Passenger Cars and Light Trucks Combined
25% Below Optimized

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	-1,408	-1,528	-1,520	-1,497	-2,038
Chrysler	17,429	14,748	20,295	12,675	8,732
Ferrari	-5	-8	-13	-17	-21
Ford	10,813	16,693	24,406	25,835	26,704
Fuji (Subaru)	-1,913	-2,454	-5,948	-11,872	-14,118
General Motors	-3,797	-10,067	12,302	23,018	16,005
Honda	4,820	10,573	14,410	14,877	15,049
Hyundai	-4,103	1,475	4,404	7,216	9,698
Lotus	-32	-34	-40	-43	-46
Maserati	0	-3	-7	-11	-14
Mercedes	-864	-1,159	-1,645	-222	-328
Mitsubishi	29	-1,468	-1,456	-1,537	-2,044
Nissan	-2,089	1,330	132	2,673	5,279
Porsche	-512	-543	-631	-675	-725
Suzuki	-321	-50	-373	-1,497	-4,764
Toyota	11,977	20,734	26,551	27,361	27,659
Volkswagen	-2,195	-1,979	912	329	980
Total/Average	27,828	46,262	91,779	96,615	86,009

Table VII-6b
Potential Impact on Sales by Manufacturer
Passenger Cars and Light Trucks Combined
Proposed Optimized (7%) Alternative

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	-2,258	-2,910	-2,691	-2,540	-3,000
Chrysler	17,331	14,665	10,741	13,423	9,536
Ferrari	-11	-17	-21	-24	-27
Ford	8,551	19,365	26,032	29,032	33,226
Fuji (Subaru)	-2,629	-3,623	-6,938	-12,359	-14,611
General Motors	-2,230	-8,057	14,642	17,547	17,554
Honda	4,764	7,891	11,720	16,296	20,396
Hyundai	-2,120	5,283	4,690	5,361	5,893
Lotus	-43	-51	-55	-55	-57
Maserati	-4	-10	-13	-16	-20
Mercedes	-1,290	-1,837	-2,228	-779	-831
Mitsubishi	-719	-2,662	-2,588	-2,751	-3,134
Nissan	230	5,842	3,615	5,338	2,525
Porsche	-652	-771	-831	-845	-878
Suzuki	-485	-349	-616	-1,726	-6,925
Toyota	12,245	19,544	24,826	22,455	26,886
Volkswagen	-3,840	-4,587	-1,350	-1,659	-763
Total/Average	26,839	47,716	78,935	86,698	85,769

Table VII-6c
Potential Impact on Sales by Manufacturer
Passenger Cars and Light Trucks Combined
25% Supra Alternative

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	-3,123	-4,309	-3,862	-3,644	-4,025
Chrysler	9,912	6,334	-6,223	-6,195	-24,075
Ferrari	-17	-26	-29	-31	-33
Ford	7,370	16,682	19,573	12,529	7,087
Fuji (Subaru)	-3,367	-4,857	-7,907	-16,928	-19,038
General Motors	-30,508	-61,856	-45,558	-58,594	-66,337
Honda	4,722	1,920	3,970	9,350	9,244
Hyundai	1,088	1,979	830	612	2,889
Lotus	-54	-69	-70	-69	-69
Maserati	-9	-16	-19	-21	-24
Mercedes	-1,711	-2,535	-2,786	-1,355	-1,428
Mitsubishi	-1,815	-4,997	-4,703	-5,029	-5,234
Nissan	-5,783	-13,221	-16,419	-15,875	-22,833
Porsche	-799	-1,006	-1,025	-1,027	-1,033
Suzuki	-666	-672	-840	-2,024	-8,197
Toyota	11,809	5,470	10,213	10,327	16,675
Volkswagen	-5,569	-7,281	-3,531	-3,651	-2,513
Total/Average	-18,519	-68,461	-58,385	-81,627	-118,944

Table VII-6d
Potential Impact on Sales by Manufacturer
Passenger Cars and Light Trucks Combined
50% Supra Alternative

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	-3,972	-5,691	-5,271	-5,028	-5,478
Chrysler	-558	-7,331	-20,508	-31,632	-49,142
Ferrari	-23	-35	-37	-38	-39
Ford	-1,342	4,579	12,174	-1,025	-7,272
Fuji (Subaru)	-4,062	-6,079	-9,228	-16,956	-19,945
General Motors	-36,279	-72,169	-75,782	-95,110	-114,136
Honda	8,507	-14,076	-12,017	-6,609	-15,842
Hyundai	1,587	-19,379	-18,338	-19,135	-19,963
Lotus	-66	-87	-91	-92	-96
Maserati	-13	-23	-24	-25	-26
Mercedes	-2,113	-3,214	-3,427	-1,965	-2,052
Mitsubishi	-1,943	-4,681	-4,943	-5,341	-5,587
Nissan	-12,560	-25,212	-34,257	-39,264	-47,405
Porsche	-951	-1,247	-1,293	-1,324	-1,386
Suzuki	-824	-977	-1,170	-2,439	-9,160
Toyota	6,218	11,832	16,778	11,296	8,569
Volkswagen	-7,214	-9,970	-6,437	-6,670	-5,907
Total/Average	-55,606	-153,761	-163,872	-221,357	-294,866

Table VII-6e
Potential Impact on Sales by Manufacturer
Passenger Cars and Light Trucks Combined
Optimized (3%)

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	-5,396	-6,246	-5,557	-5,605	-5,683
Chrysler	10,327	7,841	-7,235	-6,240	-10,436
Ferrari	-33	-41	-40	-45	-45
Ford	6,495	16,042	25,196	27,749	30,897
Fuji (Subaru)	-5,227	-6,376	-9,419	-15,516	-17,566
General Motors	-45,165	-73,656	-53,602	-66,812	-74,776
Honda	37	-9,614	-6,242	-2,122	-840
Hyundai	-22,801	-20,020	-20,005	-20,067	-17,556
Lotus	-84	-95	-94	-93	-93
Maserati	-21	-26	-26	-31	-32
Mercedes	-2,772	-3,449	-3,581	-2,279	-2,156
Mitsubishi	-2,161	-4,807	-5,020	-5,457	-5,661
Nissan	-17,337	-25,420	-36,520	-47,914	-54,454
Porsche	-1,182	-1,333	-1,334	-1,340	-1,344
Suzuki	-1,043	-933	-1,151	-2,291	-8,889
Toyota	21,822	41,006	46,381	44,740	49,292
Volkswagen	-10,333	-11,415	-7,316	-7,598	-6,260
Total/Average	-74,873	-98,542	-85,566	-110,920	-125,605

Table VII-6f
Potential Impact on Sales by Manufacturer
Passenger Cars and Light Trucks Combined
Total Costs = Total Benefit Alternative

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	-5,733	-8,456	-7,659	-7,327	-7,635
Chrysler	-10,937	-23,499	-54,877	-75,745	-73,164
Ferrari	-34	-53	-52	-52	-52
Ford	-9,599	-21,475	-14,836	-30,982	-35,388
Fuji (Subaru)	-5,618	-8,643	-11,398	-21,785	-27,766
General Motors	-48,581	-92,408	-109,370	-126,542	-148,076
Honda	-10,825	-53,233	-53,413	-66,008	-77,005
Hyundai	-23,599	-46,485	-46,833	-53,290	-57,145
Lotus	-91	-126	-125	-124	-125
Maserati	-22	-36	-36	-36	-36
Mercedes	-2,935	-4,557	-4,569	-3,118	-3,226
Mitsubishi	-2,226	-5,991	-6,195	-6,590	-6,807
Nissan	-18,595	-37,982	-48,329	-58,123	-65,615
Porsche	-1,269	-1,746	-1,737	-1,742	-1,761
Suzuki	-1,194	-1,612	-1,674	-3,066	-10,532
Toyota	6,846	-26,703	-20,917	-30,747	-38,504
Volkswagen	-10,754	-15,514	-11,362	-11,204	-9,951
Total/Average	-145,167	-348,520	-393,382	-496,484	-562,788

Table VII-6g
Potential Impact on Sales by Manufacturer
Passenger Cars and Light Trucks Combined
Technology Exhaustion Alternative

Manufacturer	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
BMW	-6,280	-9,901	-10,977	-10,963	-12,440
Chrysler	-16,765	-30,229	-71,831	-89,064	-85,899
Ferrari	-39	-63	-74	-77	-85
Ford	-10,835	-23,723	-30,037	-35,235	-38,953
Fuji (Subaru)	-6,152	-10,007	-14,838	-25,105	-31,500
General Motors	-53,560	-103,483	-142,788	-160,265	-186,507
Honda	-16,012	-62,105	-76,863	-88,495	-101,441
Hyundai	-25,559	-50,981	-57,543	-69,209	-75,562
Lotus	-95	-144	-160	-159	-178
Maserati	-25	-42	-52	-56	-62
Mercedes	-3,242	-5,328	-6,511	-5,204	-5,764
Mitsubishi	-2,376	-6,250	-6,667	-7,222	-8,018
Nissan	-20,935	-43,571	-63,048	-74,077	-84,875
Porsche	-1,328	-1,975	-2,219	-2,226	-2,474
Suzuki	-1,335	-1,948	-2,798	-4,077	-11,575
Toyota	2,665	-115,685	-147,858	-175,571	-195,117
Volkswagen	-11,912	-18,533	-17,317	-17,503	-18,843
Total/Average	-173,784	-483,968	-651,580	-764,510	-859,291

Table VII-6h
Potential Impact on Sales
Passenger Cars versus Light Trucks by Alternative
MY 2015

	Passenger Cars	Light Trucks	Total
25% Below Optimized	22,237	63,773	86,009
Optimized (7%)	21,482	64,288	85,769
25% Above Optimized	-48,921	-70,024	-118,944
50% Above Optimized	-138,449	-156,417	-294,866
Optimized (3%)	-170,031	44,426	-125,605
TC = TB	-293,326	-269,462	-562,788
Technology Exhaustion	-557,905	-301,386	-859,291

Potential Impact on Employment

There are three potential areas of employment that fuel economy standards could impact. The first is the hiring of additional engineers by automobile companies and their suppliers to do research and development and testing on new technologies to determine their capabilities, durability, platform introduction, etc. The agency does not anticipate a huge number of incremental jobs in the engineering field. Often people would be diverted from one area to another and the incremental number of jobs might be a few thousand.

The second area is the impact that new technologies would have on the production line. Again, we don't anticipate a large number of incremental workers, as for the most part you are replacing one engine with another or one transmission with another. In some instances the technology is more complex, requiring more parts and there would be a small increase in the number of production employees, but we don't anticipate a large change.

The third area is the potential impact that sales gains or losses could have on production employment. This area is potentially much more sensitive to change than the first two areas discussed above. In the past, the agency and others have made estimates of the impact of sales losses on employment. In the final rule reducing the light truck fuel economy standard for MY 1985, the agency concluded that sales losses of 100,000 to 180,000 would result in employment losses of 12,000 to 23,000 (49 FR 41252, October 22, 1984).[149] In the final rule reducing the MY 1986 passenger car fuel economy standard, the agency concluded that while it was difficult to precisely estimate the impacts, "there would be a likelihood of sales losses well into the hundreds of thousands of units and job losses well into the tens of thousands. Sales and employment losses of these magnitudes would have significant adverse effects on the economy … " (50 FR 40538, October 4, 1985). In the final rule amending the passenger car standards for MY 1987 and 1988, the agency said that "… domestic car production may fall by more than 900,000 units. The short employment effects are substantial: over 130,000 jobs…" (51 FR 35598, October 6, 1986). These estimates imply a ratio between the number of vehicles sales lost and the number of employees laid off in the 1980s of between 6.9 (900,000/130,000) and 8.3 (100,000/12,000).

Certainly productivity has increased since that time. In order to get an estimate of potential job losses per sales loss, we examined more recent U.S. employment (original equipment manufacturers and suppliers) and U.S. production. Total employment in 2000 reached a peak in the Motor Vehicle and Equipment Manufacturing sector of the economy at 1,313,600. Since then there has been a decline to 1,108,000 in 2003 and to 1,098,000 in 2005[150]. Averaging those three years, the average U.S. domestic employee produces 10.5 vehicles. Thus, one could assume that projected sales loss divided by 10.5 would give an estimate of the potential employment loss.

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[149] The agency's decision to lower standards based on that amount of impacts identified in the 1985 rule was upheld by the DC Circuit in Public Citizen v. NHTSA, 848 F.2d 256.

[150] Based on "U.S. Automotive Industry Employment Trends", Office of Aerospace and Automotive Industries, U.S. Department of Commerce, March 30, 2005, and Ward's Automotive Yearbook, 2006, pgs. 215, 222, and 270.

Table VII-7
U.S. Light Duty Vehicle Production and Employment

	U.S. Light Vehicle Production	U.S. Employment	Production per Employee
2000	12,773,714	1,313,600	9.7
2003	12,087,028	1,108,000	10.9
2005	11,946,653	1,098,000	10.9
Total/Average	36,807,396	3,519,600	10.5

At this time, the agency considers these effects to occur in the short to medium term (meaning up to 5 years). Over the next few years, consumers can elect to defer vehicle purchases by continuing to operate existing vehicles. Eventually, however, the rising maintenance costs for aging vehicles will make replacements look more attractive.

However, vehicle owners may also react to persistently higher vehicle costs by permanently owning fewer vehicles, and keeping existing vehicles in service for somewhat longer. In this case, the possibility exists that there may be permanent sales losses, compared with a situation in which vehicle prices are lower.

The 25% Sub Optimizes and the proposed Optimized (7%) alternative would have positive impacts on employment. The other alternatives have negative impacts on employment. Combining the sales effect on passenger cars and light trucks, the impact on employment is estimated in the following table.

Table VII-8
Impact on Auto Industry Employment by Alternative
(Jobs)

Passenger Cars	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
25% Below Optimized	-409	1,151	1,835	2,632	2,118
Optimized (7%)	-327	1,941	2,148	2,689	2,046
25% Above Optimized	-25,822	-33,273	-31,777	-31,082	-32,614
50% Above Optimized	-5,407	-10,527	-10,782	-11,887	-13,186
Optimized (3%)	-9,972	-12,054	-12,381	-14,919	-16,193
TC = TB	-11,760	-22,413	-23,420	-26,578	-27,936
Technology Exhaustion	-13,587	-34,289	-40,892	-47,829	-53,134
Light Trucks					
25% Below Optimized	3,059	3,255	6,906	6,569	6,074
Optimized (7%)	2,883	2,604	5,370	5,568	6,123
25% Above Optimized	1,925	-1,767	-1,021	-3,334	-6,669
50% Above Optimized	111	-4,117	-4,825	-9,195	-14,897
Optimized (3%)	2,841	2,669	4,232	4,356	4,231
TC = TB	-2,066	-10,779	-14,045	-20,706	-25,663
Technology Exhaustion	-2,964	-11,803	-21,163	-24,982	-28,703
Passenger Cars and Light Trucks Combined					
25% Below Optimized	2,650	4,406	8,741	-9,201	8,191
Optimized (7%)	2,556	4,544	7,518	-8,257	8,169
25% Above Optimized	-1,764	-6,520	-5,561	7,774	-11,328
50% Above Optimized	-5,296	-14,644	-15,607	21,082	-28,082
Optimized (3%)	-7,131	-9,385	-8,149	10,564	-11,962
TC = TB	-13,825	-33,192	-37,465	47,284	-53,599
Technology Exhaustion	-16,551	-46,092	-62,055	72,810	-81,837

Table VII-9 provides further information relating to the stringency of the different alternatives. It looks at the largest 7 manufacturers and examines whether or not they run out of technologies that the agency believes they have available. As the alternatives get more stringent, more manufacturers run out of technologies.

Table VII-9
Number of Manufacturers That Run out of Technology

	Cars: Number of Manufacturers Exhausting Technology				
	2011	2012	2013	2014	2015
-25%	0	0	1	0	0
MC=MB	1	0	1	0	2
+25%	2	2	2	1	2
+50%	4	4	4	2	3
TC=TB	5	6	6	5	5
Technology Exhaustion	6	6	6	6	7

	Trucks: Number of Manufacturers Exhausting Technology				
	2011	2012	2013	2014	2015
-25%	3	2	0	1	0
MC=MB	3	2	0	1	0
+25%	3	3	0	4	3
+50%	4	3	0	4	5
TC=TB	6	6	2	6	6
Technology Exhaustion	7	6	6	6	6

VIII. BENEFITS

Economic Impacts from Higher CAFE Standards

Economic impacts from adopting a more stringent CAFE standard for passenger cars and light trucks were estimated separately for each model year over the lifespan of those vehicles in the U.S. vehicle fleet, extending from the initial year when a model is offered for sale through the year when nearly all vehicles from that model year have been retired or scrapped (assumed to be 26 years for passenger cars and 36 years for light trucks in this analysis). The principal 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 vehicles produced. Reducing gasoline consumption provides consumer benefits through decreased fuel costs, through reduced costs for externalities such as demand price inflation, economic disruption, and military security, through reduced economic and health impacts from criteria pollutants and green house gas emissions, through increased driving ranges for vehicles, and through consumer surplus from added driving. Offsetting a part of these benefits are added costs from congestion, crashes, and noise, as well as some offset to fuel consumption and pollution savings, all due to an increase in driving that results from lower driving costs (the rebound effect). Each of these impacts is measured by comparing their value under each alternative approach to their value under the adjusted baseline. Future impacts are estimated after discounting to the year the vehicle is sold to determine their present value.[151]

Basic Inputs for Analysis of Economic Impacts

The variety of impacts discussed above are a function of basic factors which determine their magnitude and define their value. These include the discount rate, the level of vehicle sales, the magnitude of the rebound effect, and the relationship between EPA measured fuel efficiency and actual on-road fuel efficiency.

The Discount Rate

Discounting future fuel savings and other benefits is intended to account for the reduction in their value to society when they are deferred until some future date rather than received immediately. The discount rate expresses the percent decline in the value of these benefits – as viewed from today's perspective – for each year they are deferred into the future. Discount rates are used in a variety of analyses that address different aspects of benefit valuation. These include: 1) selecting a set of standards 2) analyzing the impact of those standards 3) examining the impact of uncertainty surrounding our choice of rates used to analyze impacts, and 4) determining the sensitivity of standards selection to the discount rate. However, the agency must select one specific rate to set the standards. The agency uses a rate of 7 percent per year to discount the value of future fuel savings and other benefits when it analyzes the potential impacts of alternative passenger car and light truck CAFE standards. OMB Circular A-4 requires that the agency examine costs and benefits of proposed standards using discount rates of both 3 percent and 7 percent. The 3 percent rate generally represents the consumer rate of time preference while the 7 percent rate generally represents the economy-wide opportunity cost of capital. Benefits based on both of these rates are presented to value the benefits that are associated with the standards set in this proposal. The agency

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[151] 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.

uses discount rates ranging from 3 percent to 10 percent per year to analyze the uncertainty surrounding the future impacts of alternative standards.

There are several reasons for the agency's choice of 7 percent as the appropriate discount rate to determine the standards. First, OMB Circular A-4 indicates that this rate reflects the economy-wide opportunity cost of capital. The agency believes that a substantial portion of the cost of this regulation may come at the expense of other investments the auto manufacturers might otherwise make. Several large manufacturers are resource-constrained with respect to their engineering and product-development capabilities. As a result, other uses of these resources will be foregone while they are required to be applied to technologies that improve fuel economy.

Second, 7 percent also appears to be an appropriate rate to the extent that the costs of the regulation come at the expense of consumption as opposed to investment. The agency believes that financing rates on vehicle loans represent an appropriate discount rate, because they reflect the opportunity costs faced by consumers when buying vehicles with greater fuel economy and a higher purchase price. Most new and used vehicle purchases are financed, and because most of the benefits from higher fuel economy standards accrue to vehicle purchasers in the form of fuel savings, the appropriate discount rate is the interest rate buyers pay on loans to finance their vehicle purchases.[152]

According to the Federal Reserve, the interest rate on new car loans made through commercial banks has closely tracked the rate on 10-year treasury notes, but exceeded it by about 3 percent.[153] The official Administration forecast is that real interest rates on 10-year treasury notes will average about 3 percent through 2016, implying that 6 percent is a reasonable forecast for the real interest rate on new car loans.[154] In turn, the interest rate on used car loans made through automobile financing companies has closely tracked the rate on new car loans made through commercial banks, but exceeded it by about 3 percent.[155] (The agency believes it is important to consider rates on loans that finance used car purchases, because some of the fuel savings resulting from improved fuel economy accrue to used car buyers.) Given the 6 percent estimate for new car loans, a reasonable forecast for used car loans is thus 9 percent.

Because the benefits of fuel economy accrue to both new and used car owners, a discount rate between 6 percent and 9 percent is thus appropriate for evaluating future benefits resulting from higher fuel economy. Assuming that new car buyers discount fuel savings at 6 percent for 5 years (the average duration of a new car loan)[156] and that used car buyers discount fuel savings at 9 percent for 5 years (the average duration of a used car loan)[157], the single constant discount rate that yields equivalent present value fuel savings is very close to 7 percent.

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[152] Empirical evidence also demonstrates that used car purchasers do pay for greater fuel economy (Kahn, Quarterly Journal of Economics, 1986).

[153] See, http://www.federalreserve.gov/releases/g20/hist/fc_hist_tc.txt.

[154] See, http://www.federalreserve.gov/releases/h15/data/Monthly/H15_TCMNOM_Y10.txt.

[155] See, http://www.federalreserve.gov/releases/g20/hist/fc_hist_tc.txt.

[156] Id.

[157] Id.

However, the Agency recognizes that there are arguments for using 3 percent as well. Namely that OMB requests benefits to be estimated at both 3 percent as well as 7 percent and that the official Administration forecast is that real interest rates on 10-year treasury notes will average about 3 percent through 2016. Although the agency feels that the arguments for 7% are stronger, we have calculated results under both 3% and 7% to demonstrate the impact of the lower discount rate on the resulting standards.

Sales Projections

A critical variable affecting the total economic benefits from improving light truck fuel economy is the number of vehicles likely to be produced under stricter fuel economy. Projections of total passenger cars and light truck sales for future years (see Table VIII-1a and VIII-1b) were obtained from the Energy Information Administration's (EIA) *Annual Energy Outlook 2007* (*AEO 2007*), a standard government reference for projections of energy production and consumption in different sectors of the U.S. economy.[158] NHTSA estimated the sales by manufacturer, based on their market shares in the NHTSA MY2006 CAFE data base. These values will be used as multipliers to estimate the overall impacts (both costs and benefits) of changes in fuel economy standards.

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[158] U.S. Department of Energy, Energy Information Administration, *Annual Energy Outlook 2007*, Supplemental Table 47, http://www.eia.doe.gov/oiaf/aeo/supplement/suptab_47.xls.

Table VIII-1a
Sales Projections – Passenger Cars
(1,000s of vehicles)

	2011	2012	2013	2014	2015
BMW	187.2	185.2	183.6	180.2	178.6
Mercedes	184.9	182.9	181.3	177.9	176.3
Chrysler	571.9	551.9	569.0	554.0	546.7
Ferrari	1.7	1.7	1.7	1.7	1.6
Ford	1,430.5	1,415.3	1,402.9	1,376.8	1,364.7
Fuji (Subaru)	137.3	135.8	134.7	132.2	131.0
General Motors	2,014.0	2,000.9	1,985.3	1,951.0	1,935.0
Honda	916.6	906.8	898.9	882.2	874.4
Hyundai/Kia	477.5	472.4	468.3	459.6	455.5
Lotus	3.7	3.6	3.6	3.5	3.5
Maserati	2.3	2.3	2.3	2.2	2.2
Mitsubishi	75.7	74.9	74.2	72.8	72.2
Nissan	721.6	713.9	707.7	694.5	688.4
Porsche	16.1	15.9	15.7	15.5	15.3
Suzuki	64.5	63.8	63.2	62.0	61.5
Toyota	1,500.4	1,483.3	1,470.3	1,443.0	1,430.2
Volkswagen	274.0	271.1	268.7	263.7	261.4
Total	8,579.6	8,481.7	8,431.2	8,272.8	8,198.5

Table VIII-1b
Sales Projections – Light Trucks
(1,000s of vehicles)

	2011	2012	2013	2014	2015
BMW	66.5	68.4	70.1	72.1	72.9
Mercedes	21.4	22.0	22.6	23.2	23.5
Chrysler	1899.9	1,953.4	2,002.6	2,058.9	2,081.3
Ford	1559.6	1,644.6	1,686.0	1,733.4	1,752.3
Fuji (Subaru)	84.6	86.9	89.0	91.4	92.4
General Motors	2159.2	2,213.6	2,269.3	2,333.0	2,358.4
Honda	570.7	586.8	601.5	618.4	625.2
Hyundai	298.5	306.9	314.6	323.5	327.0
Mitsubishi	40.4	41.5	42.5	43.7	44.2
Nissan	446.3	417.3	429.6	443.6	449.2
Porsche	14.6	15.0	15.4	15.9	16.0
Suzuki	25.0	25.7	26.3	27.1	27.3
Toyota	963.1	990.2	1,015.2	1,043.7	1,055.1
Volkswagen	23.4	24.0	24.6	25.3	25.6
Total	8213.1	8,396.4	8,609.4	8,853.2	8,950.3

The "Rebound Effect"

The rebound effect refers to the tendency for owners to increase the number of miles they drive a vehicle in response to an increase in its fuel economy, as would result from more stringent fuel economy standards. The rebound effect occurs because an increase in a vehicle's fuel economy reduces its owner's fuel cost for driving each mile, which is typically the largest single component of the cost of operating a vehicle. Even with the vehicle's higher fuel economy, this additional driving uses some fuel, so the rebound effect will reduce the net fuel savings that result when the fuel economy standards require manufacturers to increase fuel economy. The rebound effect is usually expressed as the percentage by which annual vehicle use increases when average fuel cost per mile driven decreases in response to a change in the marginal cost of driving an extra mile, due either an increase in fuel economy or a reduction in the price of fuel.

The magnitude of the rebound effect is one of the determinants of the actual fuel savings that are likely to result from adopting stricter standards, and thus an important parameter affecting NHTSA's evaluation of alternative standards for future model years. The rebound effect can be measured directly by estimating the elasticity of vehicle use with respect to fuel economy itself, or indirectly by the elasticity of vehicle use with respect to fuel cost per mile driven.[159] When expressed as a positive percentage, either of these parameters gives the fraction of fuel savings that would otherwise result from adopting stricter standards, but is offset by the increase in fuel consumption that results when vehicles with increased fuel economy are driven more.

Research on the magnitude of the rebound effect in light-duty vehicle use dates to the early 1980s, and almost unanimously concludes that a statistically significant rebound effect occurs when vehicle fuel efficiency improves.[160] The most common approach to estimating its magnitude has been to analyze statistically household survey data on vehicle use, fuel consumption, fuel prices (often obtained from external sources), and other determinants of household travel demand to isolate the response of vehicle use to higher fuel economy. Other studies have relied on econometric analysis of annual U.S. data on vehicle use, fuel economy, fuel prices, and other variables to identify the response of total or average vehicle use to changes in fleet-wide average fuel economy and its effect of fuel cost per mile driven. Two recent studies analyzed yearly variation in vehicle ownership and use, fuel prices, and fuel economy among individual states over an extended time period in order to measure the response of vehicle use to changing fuel economy.[161]

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

In order to arrive at a preliminary estimate of the rebound effect for use in assessing the fuel savings, emissions reductions, and other impacts of alternative standards, NHTSA reviewed 22 studies of the rebound effect conducted from 1983 through 2005. We then conducted a detailed analysis of the 66 separate estimates of the long-run rebound effect reported in these studies,

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

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

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

which is summarized in the table below.[162] As the table indicates, these 66 estimates of the long-run rebound effect range from as low as 7 percent to as high as 75 percent, with a mean value of 23 percent.

Limiting the sample to 50 estimates reported in the 17 published studies of the rebound effect yields the same range but a slightly higher mean (24 percent), while focusing on the authors' preferred estimates from published studies narrows this range and lowers its average only slightly. The median estimate of the rebound effect in all three samples, which is generally regarded as a more reliable indicator of their central tendency than the average because it is less influenced by unusually small and large estimates, is 22 percent. As Table 13 indicates, approximately two-thirds of all estimates reviewed, of all published estimates, and of authors' preferred estimates fall in the range of 10-30 percent.

Table VIII-1c
Summary of Rebound Effect Estimates

Category of Estimates	Number of Studies	Number of Estimates	Range		Distribution		
			Low	High	Median	Mean	Std. Dev.
All Estimates	22	66	7%	75%	22%	23%	14%
Published Estimates	17	50	7%	75%	22%	24%	14%
Authors' Preferred Estimates	17	17	9%	75%	22%	22%	15%
U.S. Time-Series Estimates	7	34	7%	45%	14%	18%	9%
Household Survey Estimates	13	23	9%	75%	31%	31%	16%
Pooled U.S. State Estimates	2	9	8%	58%	22%	25%	14%
Constant Rebound Effect (1)	15	37	7%	75%	20%	23%	16%
Variable Rebound Effect: (1) Reported Estimates	10	29	10%	45%	23%	23%	10%
Updated to 2006 (2)	10	29	6%	46%	16%	19%	12%

(3) Three studies estimate both constant and variable rebound effects.

(4) Reported estimates updated to reflect 2006 values of vehicle use, fuel prices, fleet fuel efficiency, household income, and household vehicle ownership.

The type of data used and authors' assumption about whether the rebound effect varies over time have important effects on its estimated magnitude. The 34 estimates derived from analysis of U.S. annual time-series data produce a median estimate of 14 percent for the long-run rebound effect, while the median of 23 estimates based on household survey data is more than twice as large (31 percent), and the median of 9 estimates based on pooled state data matches that of the entire sample (22 percent). The 37 estimates assuming a constant rebound effect produce a median of 20 percent, while the 29 originally reported estimates of a variable rebound effect have a slightly higher median value (23 percent).

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

In selecting a single value for the rebound effect to use in analyzing alternative standards for future model years, NHTSA tentatively attaches greater significance to studies that allow the rebound effect to vary in response to changes in the various factors that have been found to affect its magnitude. However, it is also important to update authors' originally-reported estimates of variable rebound effects to reflect current conditions. Recalculating the 29 original estimates of variable rebound effects to reflect current (2006) values for retail fuel prices, average fuel economy, personal income, and household vehicle ownership reduces their median estimate to 16 percent.[163] NHTSA also tentatively attaches greater significance to the recent study by Small and Van Dender (2005), which finds that the rebound effect tends to decline as average fuel economy, personal income, and suburbanization of U.S. cities increase, but – in accordance with previous studies – rises with increasing fuel prices.[164]

Considering the empirical evidence on the rebound effect as a whole, but according greater importance to the updated estimates from studies allowing the rebound effect to vary – particularly the Small and Van Dender study – NHTSA has selected a rebound effect of 15 percent to evaluate the fuel savings and other effects of alternative standards for the time period covered by this rulemaking. However, we do not believe that evidence of the rebound effect's dependence on fuel prices or household income is sufficiently convincing to justify allowing its future value to vary in response to forecast changes in these variables. A range extending from 10 percent to at least 20 percent -- and perhaps as high as 25 percent -- appears to be appropriate for the required analysis of the uncertainty surrounding these estimates.

On-Road Fuel Economy Adjustment

Actual fuel economy levels achieved by vehicles in on-road driving fall significantly short of their levels measured under the laboratory-like test conditions used by EPA to establish its

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[163] As an illustration, Small and Van Dender (2005) allow the rebound effect to vary over time in response to changes in real per capita income as well as average fuel cost per mile driven. While their estimate for the entire interval (1966-2001) they analyze is 22 percent, updating this estimate using 2006 values of these variables reduces the rebound effect to approximately 10 percent. Similarly, updating Greene's 1992 original estimate of a 15 percent rebound effect to reflect 2006 fuel prices and average fuel economy reduces it to 6 percent. *See* David L. Greene, "Vehicle Use and Fuel Economy: How Big is the Rebound Effect?" The Energy Journal, 13:1 (1992), 117-143. In contrast, the distribution of households among vehicle ownership categories in the data samples used by Hensher et al. (1990) and Greene et al. (1999) are nearly identical to the most recent estimates for the U.S., so updating their original estimates to current U.S. conditions changes them very little. *See* David A. Hensher, Frank W. Milthorpe, and Nariida C. Smith, "The Demand for Vehicle Use in the Urban Household Sector: Theory and Empirical Evidence," Journal of Transport Economics and Policy, 24:2 (1990), 119-137; and David L. Greene, James R. Kahn, and Robert C. Gibson, "Fuel Economy Rebound Effect for Household Vehicles," The Energy Journal, 20:3 (1999), 1-21.

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

published fuel economy ratings for different models. In analyzing the fuel savings from alternative passenger car and light truck CAFE standards, the agency adjusts the actual fuel economy performance of each passenger car and light truck model downward from its rated value to reflect the expected size of this on-road fuel economy "gap." In December 2006, EPA adopted changes to its regulations on fuel economy labeling, which were intended to bring vehicles' rated fuel economy levels closer to their actual on-road fuel economy levels.[165]

Supplemental analysis reported by EPA as part of its Final Rule indicates that actual on-road fuel economy for light-duty vehicles averages 20 percent lower than published fuel economy levels.[166] For example, if the overall EPA fuel economy rating of a light truck is 20 mpg, the on-road fuel economy actually achieved by a typical driver of that vehicle is expected to be 16 mpg (20*.80). The agency has employed EPA's revised estimate of this on-road fuel economy gap in its analysis of the fuel savings resulting from alternative CAFE standards for MY 2011-2018 passenger cars and MY 2012-18 light trucks.

Benefits from Fuel Savings

The main source of economic benefits from a fuel economy standard is the value of the resulting fuel savings over the lifetimes of vehicles that are required to comply with the stricter standards. These fuel savings for each scenario are measured by the difference between the adjusted baseline fuel economy for each model year and the fuel economy levels corresponding to that alternative. The sum of these annual fuel savings over each calendar year that a vehicle remains in service represents the cumulative fuel savings resulting from applying the alternative to vehicles produced during that model year.

As previously noted, actual fuel economy levels achieved by vehicles in on-road driving fall significantly short of their levels measured under the laboratory-like test conditions used by EPA to establish its published fuel economy ratings for different models. In analyzing the fuel savings from alternative passenger car and light truck CAFE standards, the agency adjusts the actual fuel economy performance of each passenger car and light truck model downward from its rated value to reflect the expected size of this on-road fuel economy "gap." In December 2006, EPA adopted changes to its regulations on fuel economy labeling, which were intended to bring vehicles' rated fuel economy levels closer to their actual on-road fuel economy levels.[167]

Supplemental analysis reported by EPA as part of its Final Rule indicates that actual on-road fuel economy for light-duty vehicles averages 20 percent lower than published fuel economy

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[165] EPA, Fuel Economy Labeling of Motor Vehicles: Revisions To Improve Calculation of Fuel Economy Estimates; Final Rule, 40 CFR Parts 86 and 600, Federal Register, December 27, 2006, pp. 77872-77969, http://www.epa.gov/fedrgstr/EPA-AIR/2006/December/Day-27/a9749.pdf.

[166] EPA, *Final Technical Support Document: Fuel Economy Labeling of Motor Vehicle Revisions to Improve Calculation of Fuel Economy Estimates*, Office of Transportation and Air Quality EPA420-R-06-017 December 2006, Chapter II, http://www.epa.gov/fueleconomy/420r06017.pdf.

[167] EPA, Fuel Economy Labeling of Motor Vehicles: Revisions To Improve Calculation of Fuel Economy Estimates; Final Rule, 40 CFR Parts 86 and 600, Federal Register, December 27, 2006, pp. 77872-77969, http://www.epa.gov/fedrgstr/EPA-AIR/2006/December/Day-27/a9749.pdf.

levels.[168] The agency has employed EPA's revised estimate of this on-road fuel economy gap in its analysis of the fuel savings resulting from alternative CAFE standards for MY 2011-2018 passenger cars and MY 2012-18 light trucks.

The number of light vehicles manufactured during each model year that remains in service during each subsequent calendar year is estimated by multiplying the estimated proportions of vehicles expected to survive to each age up to 26 years for passenger cars (Table VIII-2a) and 36 years for light trucks (Table VIII-2b) by the number of cars and light trucks forecast to be produced during each year. These "survival rates," which are estimated from experience with recent model-year vehicles, are slightly different than the survival rates used in past NHTSA analyses since they reflect recent increases in durability and usage of more recent passenger car and light truck models.[169] Updated estimates of average annual miles driven by vehicle age were developed from the Federal Highway Administration's 2001 National Household Transportation Survey, and these also differ from the estimates of annual mileage employed in past NHTSA analyses.[170] The total number of miles driven by vehicles of a single model year during each year of its life span in the fleet in effect is estimated by multiplying these age-specific estimates of annual miles driven per vehicle by the number of vehicles projected to remain in service at each age.

Table VIII-2a and VIII-2b provide the new schedules of vehicle miles traveled and survivability based on updated analyses performed by NHTSA. These were developed from registration data for 1977 through 2003, and from a 2001 survey of household vehicle use. In this analysis, the maximum vehicle age was defined as the age when the number remaining in service has declined to approximately two percent of the vehicles originally produced. Based on and examination of recent registration data for older model years, typical maximum ages appear to be 26 years for passenger cars and 36 years for light trucks. Using the 36-year estimate of the maximum lifetimes of light trucks results in survival-weighted or "expected" lifetime mileage of 190,066 miles. Fuel savings and other benefits resulting from higher light truck CAFE standards are calculated over this expected 36 year lifetime and total mileage. In contrast, NHTSA's previous estimate of lifetime VMT in the 2006 final rule was 179,954 miles over a 36-year lifetime for light trucks. The resulting survival-weighted mileage over the 26-year maximum lifetime of passenger cars is 161,847 miles, and fuel savings and other benefits resulting from higher passenger car CAFE standards are calculated over this 26-year lifetime and total mileage. It should be noted, however, that survival-weighted VMT is extremely low (less than 1,000 miles per year) after age 20 for cars and age 25 for light trucks, and thus has little impact on lifetime fuel savings or other benefits from higher fuel economy, particularly after discounting those benefits to their present values.

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[168] EPA, *Final Technical Support Document: Fuel Economy Labeling of Motor Vehicle Revisions to Improve Calculation of Fuel Economy Estimates*, Office of Transportation and Air Quality EPA420-R-06-017 December 2006, Chapter II, http://www.epa.gov/fueleconomy/420r06017.pdf.

[169] The survival rates were calculated from R.L. Polk, National Vehicle Population Profile, 1977-2003; see NHTSA, "Vehicle Survivability and Travel Mileage Schedules," Office of Regulatory Analysis and Evaluation, NCSA, January 2006, pp. 9-11, Docket No. 22223-2218.

[170] See also NHTSA, "Vehicle Survivability and Travel Mileage Schedules," Office of Regulatory Analysis and Evaluation, January 2006, pp. 15-17.

The primary source of data for determining vehicles in operation is the National Vehicle Population Profile (NVPP) compiled by R.L. Polk and Company. The NVPP is an annual census, as of July 1 of each year, of passenger cars and light trucks registered for on-road operation in the United States. NVPP registration data was used from vehicle model years 1977 to 2003. Survival rates were averaged for the five most recent model years for vehicles up to 20 years old, and regression models were fitted to these data to develop smooth relationships between age and the proportion of cars or light trucks surviving to that age. The survival rates predicted by these models are used to develop the estimates of annual mileage and fuel consumption used to calculate fuel savings and other impacts of higher fuel economy.

The 2001 National Household Travel Survey (NHTS) sponsored by the Federal Highway Administration, Bureau of Transportation Statistics, and the National Highway Traffic Safety Administration attempted to develop up-to-date information on household vehicle ownership and use. The NHTS is the integration of two previous national travel surveys: the Federal Highway Administration-sponsored Nationwide Personal Transportation Survey (NPTS) and the Bureau of Transportation Statistics-sponsored American Travel Survey (ATS).[171] The 2001 NHTS was the source of updated information on annual miles driven by age for passenger cars and light trucks.

Finally, it should be noted that the estimates of average annual miles driven by passenger cars and light trucks, while new for NHTSA, are based on data collected during 2001-2002, and reflect the historically low gasoline prices that prevailed at the time the survey was conducted. To account for the effect on vehicle use of subsequent increases in fuel prices, the estimates of annual vehicle use derived from the NHTS are adjusted to reflect projected future gasoline prices using the rebound effect, which is discussed in detail later in this chapter. Two factors affect the cost of gasoline per mile driven - fuel prices per gallon, and fuel economy in miles-per-gallon. Because the intensity of vehicle use depends partly on the cost per mile of driving, the estimates of vehicle use developed from NHTS data reflect both fuel prices and fuel economy levels that prevailed during 2001 and 2002, when the survey was conducted. In analyzing the final rule, the agency adjusted the annual usage estimates derived from the NHTS data to reflect the effect of the higher EIA fuel prices that are forecast over the covered vehicles' expected lifetimes, which exceed those that existed during 2001-2002.

Specifically, the adjustment accounted for the difference between the average price per gallon of fuel forecast over the expected lifetimes of model year 2011-2015 passenger cars and light trucks and the average price that prevailed during 2000 and 2001. When expressed in percentage terms, this difference was assumed to represent the percent increase in fuel cost per mile driven between the time the survey was conducted and the time period when model year 2011-2015 passenger cars and light trucks would be in service.

The same elasticity of annual vehicle use with respect to fuel cost per mile that was used to estimate the increase in vehicle use resulting from improved fuel economy (see detailed discussion of the "rebound effect" earlier in this chapter), assumed to be –0.15, was applied to this percent difference to adjust the estimates of vehicle use derived from the survey to reflect the effect of higher future fuel prices. In contrast, this adjustment reduces model year 2011-2015 passenger cars' and light trucks' average annual usage at each age to account for the fact that fuel cost per mile driven is expected to be

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[171] For details on survey coverage and procedures, see http://nhts.ornl.gov/quickStart.shtml.

higher throughout their expected lifetimes than at the time the NHTS was conducted. The results of this adjustment are shown in Table VIII-2c for passenger cars and in Table VIII-2d for light trucks. The unadjusted average lifetime mileage is estimated to be 161,847 for passenger cars and 190,066 for light trucks. After adjusting for the rebound effect, the average lifetime mileage is estimated to be 152,274 for passenger cars and 178,824 for light trucks.

Table VIII-2a
Survival Rates and Unadjusted Annual Vehicle-Miles Traveled (VMT)
by Age for Passenger Cars

Vehicle Age	**Estimated Survivability (1977 to 2002 NVPP)**	**Estimated VMT (2001 NHTS)**	**Weighted Yearly Travel Miles**
1	0.9950	14,231	14,160
2	0.9900	13,961	13,821
3	0.9831	13,669	13,438
4	0.9731	13,357	12,998
5	0.9593	13,028	12,497
6	0.9413	12,683	11,938
7	0.9188	12,325	11,324
8	0.8918	11,956	10,662
9	0.5604	11,578	9,961
10	0.8252	11,193	9,237
11	0.7866	10,804	8,499
12	0.7170	10,413	7,466
13	0.6125	10,022	6,138
14	0.5094	9,633	4,907
15	0.4142	9,249	3,831
16	0.3308	8,871	2,934
17	0.2604	8,502	2,214
18	0.2028	8,144	1,652
19	0.1565	7,799	1,220
20	0.1200	7,469	896
21	0.0916	7,157	656
22	0.0696	6,866	478
23	0.0527	6,596	348
24	0.0399	6,350	253
25	0.0301	6,131	185
26	0.0227	5,940	135
Estimated Passenger Car Lifetime VMT			161,847

Table VIII-2b
Survival Rates and Unadjusted Annual Vehicle-Miles Traveled (VMT)
by Age for Light Trucks

Vehicle Age	**Estimated Survivability (1977 to 2002 NVPP)**	**Estimated VMT (2001 NHTS)**	**Weighted Yearly Travel Miles**
1	0.9950	16,085	16,004
2	0.9741	15,782	15,374
3	0.9603	15,442	14,829
4	0.9420	15,069	14,195
5	0.9190	14,667	13,479
6	0.8913	14,239	12,691
7	0.8590	13,790	11,845
8	0.8226	13,323	10,960
9	0.7827	12,844	10,053
10	0.7401	12,356	9,145
11	0.6956	11,863	8,252
12	0.6501	11,369	7,391
13	0.6042	10,879	6,573
14	0.5517	10,396	5,735
15	0.5009	9,924	4,971
16	0.4522	9,468	4,281
17	0.4062	9,032	3,669
18	0.3633	8,619	3,131
19	0.3236	8,234	2,665
20	0.2873	7,881	2,264
21	0.2542	7,565	1,923
22	0.2244	7,288	1,635
23	0.1975	7,055	1,393
24	0.1735	6,871	1,192
25	0.1522	6,739	1,026
26	0.1332	6,663	887
27	0.1165	6,648	774
28	0.1017	6,648	676
29	0.0887	6,648	590
30	0.0773	6,648	514
31	0.0673	6,648	447
32	0.0586	6,648	390
33	0.0509	6,648	338
34	0.0443	6,648	294
35	0.0385	6,648	256
36	0.0334	6,648	222
Estimated Lifetime Light Truck VMT			190,066

Table VIII-2c
Survival Rates and Adjusted Annual Vehicle-Miles Traveled (VMT)
by Age for Passenger Cars

Vehicle Age	**Estimated Survivability**	**Adjusted VMT**	**Weighted Yearly Travel Miles**
1	0.9950	13,389	13,322
2	0.9900	13,135	13,004
3	0.9831	12,860	12,643
4	0.9731	12,567	12,229
5	0.9593	12,257	11,758
6	0.9413	11,933	11,232
7	0.9188	11,596	10,654
8	0.8918	11,248	10,031
9	0.5604	10,893	9,372
10	0.8252	10,531	8,690
11	0.7866	10,165	7,996
12	0.7170	9,797	7,025
13	0.6125	9,429	5,775
14	0.5094	9,063	4,617
15	0.4142	8,702	3,604
16	0.3308	8,346	2,761
17	0.2604	7,999	2,083
18	0.2028	7,662	1,554
19	0.1565	7,337	1,148
20	0.1200	7,028	843
21	0.0916	6,734	617
22	0.0696	6,459	450
23	0.0527	6,206	327
24	0.0399	5,974	238
25	0.0301	5,768	174
26	0.0227	5,589	127
Adjusted Lifetime Passenger Car VMT			152,274

Table VIII-2d
Survival Rates and Adjusted Annual Vehicle-Miles Traveled (VMT)
by Age for Light Trucks

Vehicle Age	**Estimated Survivability**	**Adjusted VMT**	**Weighted Yearly Travel Miles**
1	0.9950	15,133	15,058
2	0.9741	14,849	14,464
3	0.9603	14,529	13,952
4	0.9420	14,178	13,356
5	0.9190	13,799	12,681
6	0.8913	13,396	11,940
7	0.8590	12,974	11,145
8	0.8226	12,535	10,312
9	0.7827	12,084	9,458
10	0.7401	11,625	8,604
11	0.6956	11,161	7,764
12	0.6501	10,697	6,954
13	0.6042	10,235	6,184
14	0.5517	9,781	5,396
15	0.5009	9,337	4,677
16	0.4522	8,908	4,028
17	0.4062	8,498	3,452
18	0.3633	8,109	2,946
19	0.3236	7,747	2,507
20	0.2873	7,415	2,130
21	0.2542	7,117	1,809
22	0.2244	6,857	1,539
23	0.1975	6,638	1,311
24	0.1735	6,464	1,122
25	0.1522	6,340	965
26	0.1332	6,269	835
27	0.1165	6,254	729
28	0.1017	6,254	636
29	0.0887	6,254	555
30	0.0773	6,254	483
31	0.0673	6,254	421
32	0.0586	6,254	367
33	0.0509	6,254	318
34	0.0443	6,254	277
35	0.0385	6,254	241
36	0.0334	6,254	209
Adjusted Lifetime Light Truck VMT			178,824

In interpreting the survivability and annual mileage estimates reported in Tables VIII-2a through VIII-2d, it is important to understand that vehicles are considered to be of age 1 during the calendar year that coincides with their model year   Thus for example, model year 2010 vehicles will be considered to be of age 1 during calendar year 2010. This convention is used in order to account for the fact that vehicles produced during a model year typical are first offered for sale in June through September of the preceding calendar year (for example, sales of a model year typically begin in June through September of the previous calendar year, depending on manufacturer). Thus virtually all of the vehicles produced during a model year will be in use for some or all of the calendar year coinciding with their model year, and they are considered to be of age 1 during that year.[172] As an illustration, virtually the entire production of model year 2008 vehicles will have been sold and placed in service by the end of calendar year 2008, so model year 2008 vehicles are defined to be of age 1 during calendar year 2008.Model year 2008 vehicles are subsequently defined to be of age 2 during calendar year 2009, age 3 during calendar year 2010, and so on, until they reach their maximum age of 36 years in calendar year 2043 (2008 + 35 = 2043).

To determine the impact of improved CAFE standards, fuel consumption is calculated using both current and revised CAFE levels. The difference between these estimates represents the net savings from increased CAFE standards. With the current CAFE standard assumed to remain in effect, total fuel consumption by each model year's vehicles during each calendar year they remain in service is calculated by dividing the total number of miles they are driven during that year by the average on-road fuel economy level they would achieve under the higher of either the manufacturer-specific standard or their production plans. With the final rule in effect, total fuel consumption by each model year's vehicles 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 vehicles are driven each year is different under the final rule than with the current standards remaining in effect as a result of the fuel economy "rebound effect," which is discussed in detail later in this chapter.

The economic benefits to vehicle owners that result from future fuel savings are valued in this analysis over the complete expected lifetimes of the vehicles affected by the 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 lifetime (26-year for passenger cars or 36 –year for light trucks) 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.

CAFE's most immediate impacts are on individual consumers, but regulating fuel economy also has a broader societal impact that must be considered. The agency believes that CAFE standards should reflect the true economic value of resources that are saved when less fuel is produced and

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[172] One complication arises because registration data are typically collected for July 1 of each calendar year, so not all vehicles produced during a model year will appear in registration data until the calendar year when they have reached age 2 (and sometimes age 3) under this convention.

consumed, higher vehicle prices, and, to the extent possible, any externalities that impact the broader society. Consumers' perceptions of these values may differ from their actual impacts, but they will nonetheless experience the full value of actual fuel savings just as they will pay the full increased cost when the vehicle is purchased.

Moreover, the first and any subsequent owners of a vehicle will together realize these savings throughout its entire on-road lifetime. While a vehicle's buyer may only experience fuel savings for the limited time he or she typically owns that vehicle, any subsequent purchasers and owners of that used vehicle will continue to experience the fuel savings resulting from its higher fuel economy throughout the remainder of its useful life. The agency restricts its analysis of the sales impacts of higher new vehicle prices to the length of time the buyers of new vehicles typically own the vehicles they purchase, under the assumption that their purchase decisions will be influenced only by the benefits they receive during the time they expect to own the vehicles they purchase new. The agency estimates the length of this period using the average term of new car loans, which has recently averaged almost exactly 5 years.[173] However, the agency believes that the value of fuel savings resulting from more efficient operation over the entire lifetime of vehicles should be reflected in its analysis of the societal impacts that will determine fuel economy standards.

The economic value of fuel savings resulting from the final rule is estimated by applying the forecast of future fuel prices from the Reference Case of the Energy Information Administration's *Annual Energy Outlook 2008 Early Release* to each future year's estimated fuel savings.[174] (The uncertainty analysis reported in Chapter X uses fuel price forecasts from the High and Low Oil Price Scenarios included in *AEO 2007* to examine the effects a range of possible fuel price scenarios, since High and Low Oil Price Scenario forecasts for AEO 2008 were not available at the time this analysis was conducted.) The *AEO 2008 Early Release* forecast of future fuel prices, which is reported in Table VIII-3, represents retail prices per gallon of fuel, which including Federal, State, and any applicable local 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, fuel taxes simply represent resources that are transferred from one segment of the population to another. Any reduction in State and Federal fuel tax payments by consumers will reduce government revenues by the same amount, thus ultimately reducing the value of government-financed services by approximately that same amount. The benefit derived from lower taxes to individuals is thus likely to be offset exactly by a reduction in the value of services provided to society.

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[173] This estimate is derived from Federal Reserve Board, Federal Reserve Statistical Release G. 19: Consumer Credit, November 7, 2007, http://www.federalreserve.gov/releases/g19/Current/.

[174] U.S. Department of Energy, Energy Information Administration, *Annual Energy Outlook 2008 Early Release*, Reference Case Table 12, http://www.eia.doe.gov/oiaf/aeo/excel/aeotab_12.xls.

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 this additional benefit to society for each gallon of fuel saved. This also allows the magnitude of these externalities to be easily compared to the value of the resources saved from reduced fuel production and use, which represents the most important component of the social benefits from saving gasoline. A discussion of these externality values is included in the next section of this chapter

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. While the Reference Case fuel price forecasts reported in *AEO 2008 Early Release* extend through 2030, the agency's analysis of the value of fuel savings over the 26-year maximum lifetimes of MY 2011-15 passenger cars and 36-year maximum lifetimes MY 2011-15 light trucks requires forecasts extending through calendar year 2050. The agency assumes that retail fuel prices will remain at the 2030 forecast values reported in the *AEO 2008* Reference Case forecast over the period from 2030 through 2052 (in constant-dollar terms). As Table VIII-3 shows, the projected retail price of gasoline expressed in 2006 dollars varies over the forecast period, declining from $2.69 in 2008 to $2.20 in 2016, and then increasing to $2.49 by 2030 and as assumed previously, remaining at that level through 2052.

Since gasoline taxes are a transfer payment and not a societal cost, the value of gasoline taxes is subtracted from the estimated gasoline price to estimate the value to society of saving gasoline. The agency has updated its estimates of gasoline taxes, using updated State tax rates reported for January 1, 2006. Expressed in 2006 dollars, Federal gasoline taxes are currently $0.172, while State and local gasoline taxes together average $0.262 per gallon, for a total tax burden of $0.434 per gallon.

Following the assumptions used by EIA in its National Energy Modeling System (NEMS), state and local gasoline taxes are assumed to keep pace with inflation in nominal terms, and thus to remain constant when expressed in constant 2006 dollars. In contrast, federal gasoline taxes are assumed to remain unchanged in nominal terms, and thus to decline throughout the forecast period when expressed in constant 2006 dollars. These differing assumptions about the likely future behavior of federal and state/local fuel taxes are consistent with recent historical experience, and reflect the fact that Federal motor fuel taxes and most State taxes are specified on a cents-per-gallon basis (some State taxes are levied as a percentage of the wholesale price of fuel), and typically require legislation to change.

Actual fuel economy levels achieved by light-duty vehicles in on-road driving fall somewhat short of their levels measured under the laboratory-like test conditions used by EPA to establish its published fuel economy ratings for different models. In analyzing the fuel savings from alternative CAFE standards, NHTSA has previously adjusted the actual fuel economy performance of each light truck model downward from its rated value to reflect the expected size of this on-road fuel economy “gap.” On December 27, 2006, EPA adopted changes to its regulations on fuel economy labeling, which were intended to bring vehicles' rated fuel economy levels closer to their actual on-road fuel economy levels.[175]

In its Final Rule, EPA estimated that actual on-road fuel economy for light-duty vehicles averages 20 percent lower than published fuel economy levels. For example, if the overall EPA fuel economy rating of a light truck is 20 mpg, the on-road fuel economy actually achieved by a typical driver of that vehicle is expected to be 16 mpg (20*.80). NHTSA has employed EPA's revised estimate of this on-road fuel economy gap in this analysis of the fuel savings resulting from alternative CAFE standards proposed in this rulemaking.

Table VIII-3
Adjustment of Forecast Retail Gasoline Price to Reflect Social Value of Fuel Savings

Year	**AE0 2008 Forecast of Retail Gasoline Price (2006 $/gallon)**	**Estimated Federal and State Taxes (2006 $/gallon)**	**Forecast Gasoline Price Excluding Taxes (2006 $/gallon)**	**Forecast Gasoline Price Including Externalities (2006 $/gallon)**
2011	$2.553	$0.420	$2.133	$2.428
2012	$2.477	$0.416	$2.061	$2.356
2013	$2.405	$0.412	$1.993	$2.288
2014	$2.389	$0.409	$1.980	$2.275
2015	$2.316	$0.405	$1.911	$2.206
2016	$2.255	$0.402	$1.853	$2.148
2017	$2.267	$0.399	$1.868	$2.163
2018	$2.293	$0.395	$1.898	$2.193
2019	$2.362	$0.392	$1.970	$2.265
2020	$2.420	$0.388	$2.032	$2.327
2021	$2.386	$0.385	$2.001	$2.296
2022	$2.406	$0.381	$2.025	$2.320
2023	$2.414	$0.378	$2.036	$2.331
2024	$2.409	$0.374	$.2.035	$2.330
2025	$2.425	$0.371	$2.054	$2.349
2026	$2.438	$0.371	$2.067	$2.362
2027	$2.451	$0.371	$2.080	$2.375
2028	$2.474	$0.371	$2.103	$2.398
2029	$2.498	$0.371	$2.127	$2.422
2030-2052	$2.514	$0.371	$2.143	$2.438

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[175] 71 FR 77871 (Dec. 27, 2006).

Other Economic Benefits from Reducing Petroleum Use

The agency believes that assessing the economic case for increasing the stringency of fuel economy standards requires a comprehensive analysis of the resulting benefits and costs to the U.S economy, rather than simply comparing the direct costs associated with petroleum use and fuel production to current fuel taxes. The benefits of more stringent fuel economy standards include the market value of the savings in resources from producing less fuel, together with the resulting reductions in the costs of economic externalities associated with petroleum consumption, and of environmental externalities caused by fuel consumption and production. Environmental externalities include adverse health impacts associated with criteria pollutants and environmental damage associated with greenhouse gases. The costs imposed on the U.S. economy by more stringent fuel economy regulation include those costs for manufacturing more fuel-efficient vehicles, as well as the increased external costs of congestion, crashes, noise and pollution from added driving caused by the rebound effect.

Vehicle buyers value improved fuel economy using retail fuel prices and miles per gallon, but may consider fuel savings only over the time they expect to own a vehicle, while the value to the U.S. economy of saving fuel is measured by its pre-tax price, and includes fuel savings over the entire lifetime of vehicles. Thus, it cannot simply be assumed that the interaction of manufacturers' costs and vehicle buyers' demands in the private marketplace will determine optimal fuel economy levels, and that these levels should only be adjusted by Federal regulation if the external costs of fuel production and use exceed current fuel taxes.

The Agency's analysis estimates the value of each category of benefits and costs separately, and it compares the total benefits resulting from each alternative level to its total costs in order to assess its desirability. This more complete accounting of benefits and costs to the U.S. economy from reducing fuel use is necessary to assess the case for fuel economy regulation generally, and for increasing the stringency of the current passenger car and light truck fuel economy standards in particular.

U.S. consumption and imports of petroleum products also impose costs on the domestic economy that are not reflected in the market price for crude petroleum, or in the prices paid by consumers of petroleum products such as gasoline. These costs include (1) higher prices for petroleum products resulting from the effect of U.S. oil import demand on the world oil price; (2) the risk of disruptions to the U.S. economy caused by sudden reductions in the supply of imported oil to the U.S.; and (3) expenses for maintaining a U.S. military presence to secure imported oil supplies from unstable regions, and for maintaining the strategic petroleum reserve (SPR) to cushion against resulting price increases. Higher U.S. imports of crude oil or refined petroleum products raise the magnitude of these external economic costs, thus increasing the true economic cost of supplying transportation fuels above the resource costs of producing them. Conversely, reducing U.S. imports of crude petroleum or refined fuels or reducing fuel consumption can reduce these external costs. Any reduction in their total value that results from improved vehicle fuel economy represents an economic benefit of raising fuel economy standards in addition to the value of fuel savings and emissions reductions itself.

Demand Costs

Increased U.S. oil imports can impose higher costs on all purchasers of petroleum products, because the U.S. is a sufficiently large purchaser of foreign oil supplies that changes in U.S. demand can affect the world price. The effect of U.S. petroleum imports on world oil prices is determined by the degree of OPEC monopoly power over global oil supplies, and the degree of monopsony power over world oil demand exerted by the U.S. The combination of these two factors means that increases in domestic demand for petroleum products that are met through higher oil imports can cause the price of oil in the world market to rise, which imposes economic costs on all other purchasers in the global petroleum market in excess of the higher prices paid by U.S. consumers.[176] Conversely, reducing U.S. oil imports can lower the world petroleum price, and thus generate benefits to other oil purchasers by reducing these "monopsony costs."

Although the degree of current OPEC monopoly power is subject to considerable debate, the consensus appears to be that OPEC remains able to exercise some degree of control over the response of world oil supplies to variation in world oil prices, so that the world oil market does not behave competitively.[177] 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.[178]

In analyzing benefits from its recent actions to increase light truck CAFE standards for model years 2005-07 and 2008-11, NHTSA relied on a 1997 study by Oak Ridge National Laboratories (ORNL) to estimate the value of reduced economic externalities from petroleum consumption and imports.[179] More recently, ORNL updated its estimates of the value of these externalities, using the analytic framework developed in its original 1997 study in conjunction with recent estimates of the variables and parameters that determine their value.[180] These include world oil prices, current and anticipated future levels of OPEC petroleum production, U.S. oil import

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[176] For example, if the U.S. imports 10 million barrels of petroleum per day at a world oil price of $80 per barrel, its total daily import bill is $800 million. If increasing imports to 11 million barrels per day causes the world oil price to rise to $81 per barrel, the daily U.S. import bill rises to $891 million. The resulting increase of $91 million per day ($891 minus $800 million) is attributable to increasing daily imports by only 1 million barrels. This means that the incremental cost of importing each additional barrel is $91, or $10 more than the newly-increased world price of $81 per barrel. This additional $10 per barrel represents a cost imposed on all other purchasers in the global petroleum market by U.S. buyers, in excess of the price they pay to obtain those additional imports.

[177] For a summary see Leiby, Paul N., Donald W. Jones, T. Randall Curlee, and Russell Lee, *Oil Imports: An Assessment of Benefits and Costs*, ORNL-6851, Oak Ridge National Laboratory, November 1, 1997, at 17. *Available at* http://dmses.dot.gov/docimages/pdf93/343894_web.pdf (last accessed Dec. 2, 2007).

[178] *Id.*, at 18-19.

[179] Leiby, Paul N., Donald W. Jones, T. Randall Curlee, and Russell Lee, *Oil Imports: An Assessment of Benefits and Costs*, ORNL-6851, Oak Ridge National Laboratory, November 1, 1997. *Available at* http://dmses.dot.gov/docimages/pdf93/343894_web.pdf (last accessed Dec. 2, 2007).

[180] Leiby, Paul N. "Estimating the Energy Security Benefits of Reduced U.S. Oil Imports," Oak Ridge National Laboratory, ORNL/TM-2007/028, Revised July 23, 2007. *Available at* http://pzl1.ed.ornl.gov/energysecurity.html (click on link below "Oil Imports Costs and Benefits") (last accessed Sept. 10, 2007).

levels, the estimated responsiveness of oil supplies and demands to prices in different regions of the world, and the likelihood of oil supply disruptions. ORNL's prepared its updated estimates of oil import externalities were for use by EPA in evaluating the benefits of reductions in U.S. oil consumption and imports expected to result from its recently-issued Renewable Fuel Standard Rule of 2007 (RFS)[181].

The updated ORNL study was subjected to a detailed peer review and its estimates of the value of oil import externalities were subsequently revised to reflect their comments and recommendations.[182] Specifically, reviewers recommended that ORNL increase its estimates of the sensitivity of oil supply by non-OPEC producers and oil demand by nations other than the U.S. to changes in the world oil price, as well as reduce its estimate of the sensitivity of U.S. gross domestic product (GDP) to potential sudden increases in world oil prices. After making the revisions recommended by peer reviewers, ORNL's updated estimates of the monopsony cost associated with U.S. oil imports range from $5.22 to $9.68 per barrel, with a most likely estimate of $7.41 per barrel. These estimates imply that each gallon of fuel saved as a result of adopting higher CAFE standards will reduce the monopsony costs of U.S. oil imports by $0.124 to $0.230 per gallon, with the actual value most likely to be $0.176 per gallon saved. This represents an economic benefit in addition to the value of savings in fuel production costs that would result from improving fuel economy.

Disruption and Adjustment Costs

The second component of external economic costs imposed by U.S. petroleum imports arises partly because an increase in oil prices triggered by a disruption in the supply of imported oil reduces the level of output that the U.S. economy can produce. The reduction in potential U.S. economic output depends on the extent and duration of the increases in petroleum product prices that result from a disruption in the supply of imported oil, as well as on whether and how rapidly these prices return to pre-disruption levels. Even if prices for imported oil return completely to their original levels, however, economic output will be at least temporarily reduced from the level that would have been possible without a disruption in oil supplies.

Because supply disruptions and resulting price increases tend to occur suddenly rather than gradually, they can also impose costs on businesses and households for adjusting their use of petroleum products more rapidly than if the same price increase had occurred gradually over time. These adjustments impose costs because they temporarily reduce economic output even below the level that would ultimately be reached once the U.S. economy completely adapted to higher petroleum prices. The additional costs to businesses and households reflect their inability to adjust prices, output levels, and their use of energy and other resources quickly and smoothly in response to rapid changes in prices for petroleum products.

Since future disruptions in foreign oil supplies are an uncertain prospect, each of these disruption costs must be adjusted by the probability that the supply of imported oil to the U.S. will actually be disrupted. The "expected value" of these costs – the product of the probability that an oil import disruption will occur and the costs of reduced economic output and abrupt adjustment to

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[181] Federal Register Vol.72, #83, May 1, 2007 pp.23,900-24,014

[182] *Peer Review Report Summary: Estimating the Energy Security Benefits of Reduced U.S. Oil Imports*, ICF, Inc., September 2007.

sharply higher petroleum prices – is the appropriate measure of their magnitude. Any reduction in these expected disruption costs resulting from a measure that lowers U.S. oil imports represents an additional economic benefit beyond the direct value of savings from reduced purchases of petroleum products.

While the vulnerability of the U.S. economy to oil price shocks is widely thought to depend on total petroleum consumption rather than on the level of oil imports, variation in imports is still likely to have some effect on the magnitude of price increases resulting from a disruption of import supply. In addition, changing the quantity of petroleum imported into the U.S. may also affect the probability that such a disruption will occur. If either the size of the likely price increase or the probability that U.S. oil supplies will be disrupted is affected by oil imports, the expected value of the costs from a supply disruption will also depend on the level of imports.

Businesses and households use a variety of market mechanisms, including oil futures markets, energy conservation measures, and technologies that permit rapid fuel switching to "insure" against higher petroleum prices and reduce their costs for adjusting to sudden price increases. While the availability of these market mechanisms has likely reduced the potential costs of disruptions to the supply of imported oil, consumers of petroleum products are unlikely to take account of costs they impose on others, so these costs are probably not reflected in the price of imported oil. Thus changes in oil import levels probably continue to affect the expected cost to the U.S. economy from potential oil supply disruptions, although this component of oil import costs is likely to be significantly smaller than estimated by studies conducted in the wake of the oil supply disruptions during the 1970s.

ORNL's updated and revised estimates of the increase in the expected costs associated with oil supply disruptions to the U.S. and the resulting rapid increase in prices for petroleum products amount to $4.54 to $5.84 per barrel, although its most likely estimate of $4.59 per barrel is very close to the lower end of this range. According to these estimates, each gallon of fuel saved will reduce the expected costs disruptions to the U.S. economy by $0.108 to $0.139, with the actual value most likely to be $0.109 per gallon. Like the reduction in monopsony costs, the reduction in expected disruption costs represents an economic benefit in addition to the value of savings in fuel production costs that would result from improving fuel economy.

Military Security and Strategic Petroleum Reserve Costs

The third component of the external economic costs of importing oil into the U.S. includes government outlays for maintaining a military presence to secure the supply of oil imports from potentially unstable regions of the world and to protect against their interruption. Some analysts also include outlays for maintaining the U.S. Strategic Petroleum Reserve (SPR), which is intended to cushion the U.S. economy against the consequences of disruption in the supply of imported oil, as additional costs of protecting the U.S. economy from oil supply disruptions.

NHTSA believes that while costs for U.S. military security may vary over time in response to long-term changes in the actual level of oil imports into the U.S., these costs are unlikely to decline in response to any reduction in U.S. oil imports resulting from raising future CAFE standards for light-duty vehicles. U.S. military activities in regions that represent vital sources of oil imports also serve a broader range of security and foreign policy objectives than simply protecting oil supplies, and as a consequence are unlikely to vary significantly in response to changes in the level of oil imports prompted by higher standards.

Similarly, while the optimal size of the SPR from the standpoint of its potential influence on domestic oil prices during a supply disruption may be related to the level of U.S. oil consumption and imports, its actual size has not appeared to vary in response to recent changes in oil imports. Thus while the budgetary costs for maintaining the Reserve are similar to other external costs in that they are not likely to be reflected in the market price for imported oil, these costs do not appear to have varied in response to changes in oil import levels. As a result, the agencies' tentative analysis of benefits from alternative CAFE standards does not include cost savings from either reduced outlays for U.S. military operations or maintaining a smaller SPR among the external benefits of reducing gasoline consumption and petroleum imports by means of tightening future standards. This view concurs with that of the recent ORNL study of economic costs from U.S. oil imports, which concludes that savings in government outlays for these purposes are unlikely to result form modest reductions in consumption of petroleum products and oil imports.

Thus NHTSA has tentatively included only the likely reductions in monopsony and disruption costs from lower U.S. petroleum imports in its estimate of the savings in external economic costs from reducing fuel consumption. The updated and revised ORNL estimates suggest that the combined reduction in monopsony costs and expected costs to the U.S. economy from oil supply disruptions resulting from lower fuel consumption total $0.232 to $0.370 per gallon, with a most likely estimate of $0.286 per gallon. This represents the additional economic benefit likely to result from each gallon of fuel saved by higher CAFE standards, *beyond* the savings in resource costs for producing and distributing each gallon of fuel saved. NHTSA tentatively employs this midpoint estimate in its analysis of the benefits from fuel savings projected to result from alternative CAFE standards for model years 2011-15. It also analyzes the effect on these benefits estimates from variation in this value over the range from $0.232 to $0.370 per gallon of fuel saved.

The Effect of Fuel Savings on Fuel Supply

Based on a detailed analysis of differences in fuel consumption, petroleum imports, and imports of refined petroleum products among the Reference Case, High Economic Growth, and Low Economic Growth Scenarios presented in the Energy Information Administration's *Annual Energy Outlook 2007,* the agency estimates that approximately 50 percent of the reduction in fuel consumption resulting from adopting higher CAFE standards is likely to be reflected in reduced U.S. imports of refined fuel, while the remaining 50 percent would be expected to be reflected in reduced domestic fuel refining. Of this latter figure, 90 percent is anticipated to reduce U.S. imports of crude petroleum for use as a refinery feedstock, while the remaining 10 percent is expected to reduce U.S. domestic production of crude petroleum. Thus on balance, each gallon of fuel saved as a consequence of higher CAFE standards is anticipated to reduce total U.S. imports of crude petroleum or refined fuel by 0.95 gallons.[183]

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[183] This figure is calculated as 0.50 + 0.50*0.9 = 0.50 + 0.45 = 0.95.

Emissions Reductions Resulting from Fuel Savings

NHTSA has estimated emissions reductions resulting from fuel savings for purposes of this PRIA. However, as indicated previously, NHTSA will consider the potential environmental impacts of the proposed standards and reasonable alternatives for purposes of NEPA through the NEPA process.

Criteria Pollutants

While reductions in domestic fuel refining and distribution that result from lower fuel consumption will reduce emissions of criteria pollutants, additional vehicle use associated with the rebound effect of higher fuel economy will increase emissions of these pollutants (see detailed discussion of the Rebound Effect earlier in this chapter). The net effect of stricter standards depends on the relative magnitudes of reduced emissions in fuel refining and distribution, and increased emissions from vehicle use. Because the relationship between emission rates (emissions per gallon refined of fuel or mile driven) from fuel refining and vehicle use differs for each specific criteria pollutant, the net effect of fuel savings from the proposed standards on total emissions of each pollutant is likely to differ. Predominant criteria pollutants emitted in fuel production and use include carbon monoxide (CO), hydrocarbon compounds (usually referred to as “volatile organic compounds,” or VOC), nitrogen oxides (NOx), fine particulate matter (PM), and sulfur dioxide (SO2).

For purposes of NHTSA’s PRIA, the increase in emissions of these pollutants from additional vehicle use due to the rebound effect is tentatively estimated by multiplying the increase in total miles driven by vehicles of each model year and age during future calendar years by age-specific emission rates per vehicle-mile for each pollutant. The agencies developed these emission rates using EPA’s MOBILE6.2 motor vehicle emissions factor model, with updated vehicle emission factors for some pollutants.[184] Emissions of these pollutants also occur during crude oil extraction and transportation, gasoline refining, and gasoline storage and distribution. The reduction in total emissions from each of these sources thus depends on the extent to which fuel savings result in lower imports of refined gasoline, or in reduced domestic gasoline refining.[185]

Based on analysis of changes in U.S. gasoline imports and domestic gasoline consumption forecast in AEO 2007, NHTSA tentatively estimates that 50 percent of fuel savings resulting from higher CAFE standards will result in reduced imports of refined gasoline, while the remaining 50 percent will reduce domestic refining.[186] The reduction in domestic refining is assumed to leave its sources of crude petroleum unchanged from the mix of 90 percent imports and 10 percent domestic production projected by AEO 2007.

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[184] U.S. Environmental Protection Agency, MOBILE6 Vehicle Emission Modeling Software, *available at* http://www.epa.gov/otaq/m6.htm#m60 (last accessed Sept. 10, 2007).

[185] 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.

[186] Estimates of the response of gasoline imports and domestic refining to fuel savings from stricter standards are variable and highly uncertain, but our preliminary analysis indicates that under any reasonable assumption about these responses, the magnitude of the net change in criteria pollutant emissions (accounting for both the rebound effect and changes in refining emissions) is extremely low relative to their current total.

NHTSA proposes to estimate reductions in criteria pollutant emissions from gasoline refining and distribution using emission rates obtained from Argonne National Laboratories' Greenhouse Gases and Regulated Emissions in Transportation (GREET) model.[187] The GREET model provides separate estimates of air pollutant emissions that occur in four phases of fuel production and distribution: crude oil extraction, crude oil transportation and storage, fuel refining, and fuel distribution and storage.[188] We tentatively assume that reductions in imports of refined fuel would reduce criteria pollutant emissions during fuel storage and distribution only. Reductions in domestic fuel refining using imported crude oil as a feedstock are tentatively assumed to reduce emissions during crude oil transportation and storage, as well as during gasoline refining, distribution, and storage, simply because less of it would be occurring. Similarly, reduced domestic fuel refining using domestically-produced crude oil is tentatively assumed to reduce emissions during all phases of gasoline production and distribution.[189]

The net changes in emissions of each criteria pollutant are calculated by comparing the increases in their emissions that result from increased vehicle use to the reductions that result from lower domestic fuel refining and distribution. The net change in emissions of each criteria pollutant is converted to an economic value using estimates of the economic costs per ton emitted (which result primarily from damages to human health) developed by EPA and submitted to the federal Office of Management and Budget for review. For certain criteria pollutants, EPA estimates different per-ton costs for increases in emissions from vehicle use than for reductions in emissions from fuel refining, reflecting differences in their typical geographic distributions, contributions to ambient pollution levels, and resulting population exposure. The per unit costs for each criteria pollutant is summarized in Table VIII-B.

Greenhouse Gases

NHTSA has taken the economic benefits of reducing CO_2 emission into account in this rulemaking, both in developing proposed CAFE standards and in assessing the economic benefits of each alternative that was considered. As noted above, the 9th Circuit found in CBD that NHTSA had been arbitrary and capricious in deciding not to monetize the benefit of reducing CO_2 emissions, saying that the agency had not substantiated the conclusion in its April 2006 final rule that the appropriate course was not to monetize (i.e., quantify the value of) carbon emissions reduction at all.

To this end, NHTSA reviewed published estimates of the "social cost of carbon emissions" (SCC). The SCC refers to the marginal cost of additional damages caused by the increase in expected climate impacts resulting from the emission of each additional metric ton of carbon,

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[187] Argonne National Laboratories, *The Greenhouse Gas and Regulated Emissions from Transportation (GREET) Model*, Version 1.6, April 2005, *available at* http://www.transportation.anl.gov/software/GREET/index.html (last accessed Sept. 10, 2007).

[188] Emissions that occur during vehicle refueling at retail gasoline stations (primarily evaporative emissions of volatile organic compounds, or VOCs) are already accounted for in the "tailpipe" emission factors used to estimate the emissions generated by increased light truck use. GREET estimates emissions in each phase of gasoline production and distribution in mass per unit of gasoline energy content; these factors are then converted to mass per gallon of gasoline using the average energy content of gasoline.

[189] 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.

which is emitted in the form of CO_2.[190] It is typically estimated as the net present value of the impact over some time period (100 years or longer) of one additional ton of carbon emitted into the atmosphere. Because accumulated concentrations of greenhouse gases in the atmosphere and the projected impacts on global climate are increasing over time, the economic damages resulting from each additional ton of CO_2 emissions in future years are believed to be greater as a result. Thus estimates of the SCC are typically reported for a specific year, and these estimates are generally larger for emissions in more distant future years.

There is substantial variation among different authors' estimates of the SCC, much of which can be traced to differences in their underlying assumptions about several variables. These include the sensitivity of global temperatures and other climate attributes to increasing atmospheric concentrations of greenhouse gases, discount rates applied to future economic damages from climate change, whether damages sustained by developing regions of the globe should be weighted more heavily than damages to developed nations, how long climate changes persist once they occur, and the economic valuation of specific climate impacts.[191]

Taken as a whole, recent estimates of the SCC may underestimate the true damage costs of carbon emissions because they often exclude damages caused by extreme weather events or climate response scenarios with low probabilities but potentially extreme impacts, and may underestimate the climate impacts and damages that could result from multiple stresses on the global climatic system. At the same time, however, many studies fail to consider potentially beneficial impacts of climate change, and do not adequately account for how future development patterns and adaptations could reduce potential impacts from climate change or the economic damages they cause.

Given the uncertainty surrounding estimates of the SCC, the use of any single study may not be advisable since its estimate of the SCC will depend on many assumptions made by its authors. The Working Group II's contribution to the Fourth Assessment Report of the United Nations Intergovernmental Panel on Climate Change (IPCC)[192] notes that:

> The large ranges of SCC are due in the large part to differences in assumptions regarding climate sensitivity, response lags, the treatment of risk and equity, economic and non-economic impacts, the inclusion of potentially catastrophic losses, and discount rates.

Although the IPCC does not recommend a single estimate of the SCC, it does cite the Tol (2005) study on four separate occasions (pages 17, 65, 813, 822) as the only available survey of the peer-reviewed literature that has itself been subjected to peer review. Tol developed a

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[190] Carbon itself accounts for 12/44, or about 27%, of the mass of carbon dioxide (12/44 is the ratio of the molecular weight of carbon to that of carbon dioxide). Thus each ton of carbon emitted is associated with 44/12, or 3.67, tons of carbon dioxide emissions. Estimates of the SCC are typically reported in dollars per ton of carbon, and must be divided by 3.67 to determine their equivalent value per ton of carbon dioxide emissions.

[191] For a discussion of these factors, see Yohe, G.W., R.D. Lasco, Q.K. Ahmad, N.W. Arnell, S.J. Cohen, C. Hope, A.C. Janetos and R.T. Perez, 2007: Perspectives on climate change and sustainability. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, pp. 821-824.

[192] Climate Change 2007 – Impacts, Adaptation and Vulnerability, Contribution of Working Group II to the Fourth Assessment Report of the IPCC, 17. Available at http://www.ipcc-wg2.org (last accessed <Feb. 4, 2008>).

probability function using the SCC estimates of the peer reviewed literature and found estimates ranging from less than zero to over $200 per metric ton of carbon. In an effort to resolve some of the uncertainty in reported estimates of climate damage costs from carbon emissions, Tol (2005) reviewed and summarized one hundred and three estimates of the SCC from 28 published studies. He concluded that when only peer-reviewed studies published in recognized journals are considered, "…climate change impacts may be very uncertain but is unlikely that the marginal damage costs of carbon dioxide emissions exceed $50 per [metric] ton carbon [about $14 per metric ton of CO2]." [193] He also concluded that the costs may be less than $14.

Because of the number of assumptions required by each study, the wide range of uncertainty surrounding these assumptions, and their critical influence on the resulting estimates of climate damage costs, some studies have undoubtedly produced estimates of the SCC that are unrealistically high, while others are likely to have estimated values that are improbably low. Using a value for the SCC that reflects the central tendency of estimates drawn from many studies reduces the chances of relying on a single estimate that subsequently proves to be biased.

It is important to note that estimates of the SCC almost invariably include the value of worldwide damages from potential climate impacts caused by carbon dioxide emissions, and are not confined to damages likely to be suffered within the U.S. In contrast, the other estimates of costs and benefits of increasing fuel economy included in this proposal include only the economic values of impacts that occur within the U.S. For example, the economic value of reducing criteria air pollutant emissions from overseas oil refineries is not counted as a benefit resulting from this rule, because any reduction in damages to health and property caused by overseas emissions are unlikely to be experienced within the U.S.

In contrast, the reduced value of transfer payments from U.S. oil purchasers to foreign oil suppliers that results when lower U.S. oil demand reduces the world price of petroleum (the reduced "monopsony effect") is counted as a benefit of reducing fuel use.[194] If the agency's analysis was conducted from a worldwide rather than a U.S. perspective, however, the benefit from reducing air pollution overseas would be included, while reduced payments from U.S. oil consumers to foreign suppliers would not.

In order to be consistent with NHTSA's use of exclusively domestic costs and benefits in prior CAFE rulemakings, the appropriate value to be placed on changes climate damages caused by carbon emissions should be one that reflects the change in damages to the United States alone. Accordingly, NHTSA notes that the value for the benefits of reducing CO_2 emissions might be restricted to the fraction of those benefits that are likely to be experienced within the United States.

Although no estimates of benefits to the U.S. itself that are likely to result from reducing CO_2 emissions are currently available, NHTSA expects that if such values were developed, the

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

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

agency would employ those rather than global benefit estimates in its analysis. NHTSA also anticipates that if such values were developed, they would be lower than comparable global values, since the U.S. is likely to sustain only a fraction of total global damages resulting from climate change.

In the meantime, the agency has elected to use the IPCC estimate of $43 per metric ton of carbon as an upper bound on the benefits resulting from reducing each metric ton of U.S. emissions.[195] This corresponds to approximately $12 per metric ton of CO_2 when expressed in 2006 dollars. This estimate is based on the 2005 Tol study.[196] The Tol study is cited repeatedly as an authoritative survey in various IPCC reports, which are widely accepted as representing the general consensus in the scientific community on climate change science. Since the IPCC estimate includes the worldwide costs of potential damages from carbon dioxide emissions, NHTSA has elected to employ it as an upper bound on the estimated value of the reduction in U.S. domestic damage costs that is likely to result from lower CO_2 emissions.[197]

The IPCC Working Group II Fourth Assessment Report (2007, p. 822) further suggests that the SCC of carbon is growing at an annual 2.4 percent growth rate, based on estimated increases in damages from future emissions reported in published studies. NHTSA has also elected to apply this growth rate to Tol's original 2005 estimate. Thus by 2011, the agency estimates that the upper bound on the benefits of reducing CO_2 emissions will have reached about $14 per metric ton of CO_2, and will continue increase by 2.4 percent annually thereafter.

In setting a lower bound, the agency agrees with the IPCC Working Group II (2007) report that "significant warming across the globe and the locations of significant observed changes in many systems consistent with warming is very unlikely to be due solely to natural variability of temperatures or natural variability of the systems" (pp. 9). Although this finding suggests that the global value of economic benefits from reducing carbon dioxide emissions is unlikely to be zero, it does not necessarily rule out low or zero values for the benefit to the U.S. itself from reducing emissions.

For most of the analysis it performed to develop this proposal, NHTSA required a single estimate for the value of reducing CO_2 emissions. The agency thus elected to use the midpoint of the range from $0 to $14 (or $7.00) per metric ton of CO_2 as the initial value for the year 2011, and assumed that this value would grow at 2.4 percent annually thereafter. This estimate is employed for the analyses conducted using the Volpe CAFE model to support development of the proposed standards. The agency also conducted sensitivity analyses of the benefits from

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[195] The estimate of $43 per ton of carbon emissions is reported by Tol (p. 2070) as the mean of the "best" estimates reported in peer-reviewed studies (see fn. 4). It thus differs from the mean of all estimates reported in the peer-reviewed studies surveyed by Tol. The $43 per ton value is also attributed to Tol by IPCC Working Group II (2007), p. 822.

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

[197] For purposes of comparison, we note that in the rulemaking to establish CAFE standards for MY 2008-11 light trucks, NRDC recommended a value of $10 to $25 per ton of CO2 emissions reduced by fuel savings and both Environmental Defense and Union of Concerned Scientists recommended a value of $50 per ton of carbon (equivalent to about $14 per ton of CO_2 emissions).

reducing CO_2 emissions using both the upper ($14 per metric ton) and lower ($0 per metric ton) bounds of this range.

NHTSA seeks comment on its tentative conclusions for the value of the SCC, the use of a domestic versus global value for the economic benefit of reducing CO_2 emissions, the rate at which the value of the SCC grows over time, the desirability of and procedures for incorporating benefits from reducing emissions of greenhouse gases other than CO_2, and any other aspects of developing a reliable SCC value for purposes of establishing CAFE standards.

Consumer Benefits from Additional Driving

The increase in travel associated with the rebound effect produces additional benefits to vehicle owners, which reflect the value to drivers and other vehicle occupants of the added (or more desirable) social and economic opportunities that become accessible with additional travel. 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 added travel are at least as large as drivers' added costs for the fuel it consumes (measured at the improved level of fuel economy resulting from stricter CAFE standards).[198] The benefits from additional rebound effect travel also include the consumer surplus received by vehicle buyers who value the opportunities that increased travel makes available to them at more than the fuel cost of the additional driving. Because it depends on the improvement in fuel economy, the value of benefits from increased vehicle use changes by model year and alternative CAFE standard, and is shown in Tables VIII-5 through VIII-9.

Added Costs from Congestion, Crashes, and Noise

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

Increased passenger car and light truck use due to the rebound effect may also increase the costs associated with traffic crashes. Drivers presumably take account of the potential costs they (and the other occupants of their vehicles) face from the possibility of being involved in a crash when they decide to make additional trips. However, they probably do not consider all of the potential costs they impose on occupants of other vehicles and on pedestrians when crashes occur, so any increase in these "external" crash costs must be considered as another cost of additional rebound-effect driving. Like increased delay costs, any increase in these external crash costs caused by

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[198] These benefits are included in the value of fuel savings reported in Tables VIII-5 through VIII-9.

added driving is likely to depend on the traffic conditions under which it takes place, since crashes are more frequent in heavier traffic, but their severity may be reduced by the slower speeds at which heavier traffic typically moves. Thus estimates of the increase in external crash costs from the rebound effect also need to account for when and where the added driving occurs.

Finally, added vehicle use from the rebound effect may also increase traffic noise. Noise generated by vehicles causes inconvenience, irritation, and potentially even discomfort to occupants of other vehicles, to pedestrians and other bystanders, and to residents or occupants of surrounding property. Because 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 vehicle use must be included together with other increased external costs from the rebound effect.

Our analysis uses estimates of the congestion costs, crash costs, and noise costs for pickup trucks and vans developed by the Federal Highway Administration to estimate the increased external costs caused by added light truck use from the rebound effect.[199] These estimates are intended to measure the increases in external costs – that is, the marginal external costs – from added congestion, property damages and injuries in traffic crashes, and noise levels caused by additional usage of light trucks that are borne by persons other than their drivers. FHWA's "Middle" estimates for congestion, crash, and noise costs imposed by passenger cars are 5.22 cents, 2.26 cents and 0.07 cents per vehicle mile when expressed in 2006 dollars.[200] For pickup trucks and vans these costs are 4.66 cents, 2.51 cents, and 0.07 cents per vehicle-mile. These costs are multiplied by the estimated increases in passenger car and light truck use from the rebound effect during each year of the affected model years' lifetimes in the fleet to yield the estimated increases in congestion, crash, and noise externality costs during that year. The resulting estimates are discounted to their present values as of the date each model year is sold and summed to obtain their total values.

The Federal Highway Administration's estimates of these costs agree closely with some other recent estimates. For example, recent published research conducted by Resources for the Future (RFF) estimates marginal congestion and external crash costs for increased light-duty vehicle use in the U.S. to be 3.9 and 3.4 cents per vehicle-mile when converted to 2006 dollars.[201] These estimates incorporate careful adjustments of congestion and crash costs that are intended to reflect the traffic conditions under which additional driving is likely to take place, as well as its likely effects on both the frequency and severity of motor vehicle crashes.

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

[200] Federal Highway Administration, 1997 *Federal Highway Cost Allocation Study*, Tables V-22, V-23, and V-24, http://www.fhwa.dot.gov/policy/hcas/final/index.htm. The higher congestion cost for automobiles than for light trucks reflects the larger fraction of auto than of light truck use that occurs within congested urban areas.

[201] Ian W.H. Parry and Kenneth A. Small, "Does Britain or the U.S. Have the Right Gasoline Tax?" Discussion Paper 02-12, Resources for the Future, March 2002, pp. 19 and Table 1, http://www.rff.org/rff/Documents/RFF-DP-02-12.pdf.

Costs from Increased Air Pollutant Emissions

Finally, as noted previously under Emissions Reductions Resulting from Fuel Savings, additional passenger car and light truck use associated with the rebound effect will increase emissions of air pollutants that occur as motor vehicles are driven. Predominant air pollutants emitted by motor vehicles include hydrocarbon compounds (usually referred to as "volatile organic compounds," or VOC), nitrogen oxides (NOx), fine particulate matter (PM), and sulfur dioxide (SO_2). The increased use of passenger cars and light trucks that occurs through the rebound effect causes higher emissions of these "criteria" pollutants, since Federal standards limit their permissible emissions by motor vehicles on a per-mile basis. The increase in emissions of these pollutants from additional vehicle use is estimated by multiplying the increase in total miles driven by vehicles of each model year and age during a calendar year by age-specific emission rates per vehicle-mile developed using the U.S. Environmental Protection Agency's MOBILE6.2 motor vehicle emissions factor model[202]. The monetized value of changes in criteria pollutant emissions (fine PM, NOx, SO2, VOCs andCO) are derived from EPA estimates of the value of health and welfare-related damages (incurred or avoided). These estimates, expressed as dollars per ton, are based on the benefits associated with recently-adopted regulations that limit emissions of air pollutants from mobile sources, a category that includes passenger cars, light trucks, and other highway vehicles.[203]

The Value of Increased Driving Range

Improving the fuel economy of passenger cars and light-duty trucks may also increase their driving range before they require refueling. By reducing the frequency with which drivers typically refuel their vehicles, and by extending the upper limit of the range they can travel before requiring refueling, improving fuel economy thus provides some additional benefits to their owners. (Alternatively, if manufacturers respond to improved fuel economy by reducing the size of fuel tanks to maintain a constant driving range, the resulting cost saving will presumably be reflected in lower vehicle sales prices.)

No direct estimates of the value of extended vehicle range are readily available, so the agency's analysis calculates the reduction in the annual number of required refueling cycles that results from improved fuel economy, and applies DOT-recommended values of travel time savings to convert the resulting time savings to their economic value.[204] As an illustration of how the value of extended refueling range is estimated, a typical small light truck model has an average fuel tank size of approximately 20 gallons. Assuming that drivers typically refuel when their tanks are 20 percent full (i.e., 4 gallons in reserve), increasing this model's actual on-road fuel economy from 24 to 25 mpg would extend its driving range from 384 miles (= 16 gallons x 24 mpg) to 400 miles (= 16 gallons x 25 mpg). Assuming that it is driven 12,000 miles/year, this reduces the number of times it needs to be refueled each year from 31.3 (= 12,000 miles per year / 384 miles per refueling) to 30.0 (= 12,000 miles per year / 400 miles per refueling), or by 1.3 refuelings per year.

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

[203] EPA, "Mobile Source $ per Ton Estimates," document provided to NHTSA by EPA Office of Transportation and Air Quality staff, June 26, 2007.

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

Weighted by the nationwide mix of urban (about 2/3) and rural (about 1/3) driving and average vehicle occupancy for all driving trips (1.6 persons), the DOT-recommended value of travel time per vehicle-hour is $24.00 (in 2006 dollars).[205] Assuming that locating a station and filling up requires ten minutes, the annual value of time saved as a result of less frequent refueling amounts to $5.20 (calculated as 10/60 x 1.3 x $24.00). This calculation is repeated for each future calendar year that light trucks of each model year affected by the alternative CAFE standards considered in this rule would remain in service. Like fuel savings and other benefits, however, the value of this benefit declines over a model year's lifetime, because a smaller number of vehicles originally produced during that model year remain in service each year, and those remaining in service are driven fewer miles.

The following Table summarizes the values used to calculate the impacts of each scenario.

Table VIII-B

Economic Values for Benefits Computations (2006$)

Rebound Effect (VMT Elasticity)	-0.15
Discount Rate Applied to Future Benefits	7%
Payback Period (years)	5.0
"Gap" between Test and On-Road MPG	20%
Value of Travel Time per Vehicle ($/hour)	$24.00
Economic Costs of Oil Imports ($/gallon)	
"Monopsony" Component	$0.182
Price Shock Component	$0.113
Military Security Component	$ -
Total Economic Costs ($/gallon)	$0.295
Total Economic Costs ($/BBL)	$12.38
External Costs from Additional Automobile Use Due to "Rebound" Effect ($/vehicle-mile)	
Congestion	$0.052
Accidents	$0.023
Noise	$0.001
External Costs from Additional Light Truck Use Due to "Rebound" Effect ($/vehicle-mile)	
Congestion	$0.047
Accidents	$0.025
Noise	$0.001
Emission Damage Costs	
Carbon Monoxide ($/ton)	$ -
Volatile Organic Compounds ($/ton)	$1,700

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[205] The hourly wage rate during 2006 is estimated to be $24.00. 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 $12.67 for urban travel and $17.66 for intercity travel, and must be multiplied by vehicle occupancy (1.6) to obtain the estimate value of time per vehicle hour.

Nitrogen Oxides ($/ton)	$3,900
Particulate Matter ($/ton)	$164,000
Sulfur Dioxide ($/ton)	$16,000
Carbon Dioxide ($/metric ton)	$ 7.00
Annual Increase in CO2 Damage Cost	2.4%

Summary of Benefits

Benefits were calculated separately for passenger cars and light trucks under each alternative CAFE requirement for each model year covered by this proposal. In Tables VIII-5 through VIII-9, the societal impacts for passenger car CAFE standards under the proposed Optimized Net Benefits alternative is shown over the 2011 through 2015 model years. Table VIII-10 summarizes the impacts for passenger cars across all 5 model years. In Tables VIII-11 through VIII-15 the societal impacts for light truck CAFE standards under the Optimized Net Benefits alternative is shown over the 2011 through 2015 model years. Table VIII-16 summarizes the impacts for light trucks across all 5 model years. Table VIII-17 summarizes the impacts across both the passenger car and light truck fleets for the 5 model years combined. These tables include undiscounted values as well as present value calculations at 3 percent and 7 percent. They also show changes in the physical units of measure that produced these values. Negative values in these tables reflect net reductions in fuel consumption or emissions and their resulting economic impacts, which represent benefits from the proposal, while positive values represent increasing emissions, congestion, noise or crash severity and their added costs. The net social benefit from these societal impacts is shown on the Total line in each table.

The proposed standards for passenger cars would save approximately 19 billion gallons of fuel and prevent 178 million metric tons of tailpipe CO_2 emissions over the lifetime of the passenger cars sold during those model years, compared to the fuel savings and emissions reductions that would occur if the standards remained at the adjusted baseline (i.e., the higher of manufacturer's plans or the manufacturer's required level of average fuel economy for MY 2010).

The total value of societal benefits of the proposed passenger car standards would be approximately $31 billion[206] over the lifetime of the 5 model years combined. This estimate of societal benefits includes direct impacts from lower fuel consumption as well as externalities, and also reflects offsetting societal costs resulting from the rebound effect. Direct benefits to consumers, including fuel savings, account for 85% ($29.5 billion) of the roughly $35 billion in gross consumer benefits[207] resulting from increased passenger car CAFE. Petroleum market externalities account for roughly 10% ($3.6 billion). Environmental externalities, i.e., reduction of air pollutants accounts for roughly 5% ($1.8 billion). Over half of this $1.8 billion is the result of greenhouse gas (primarily CO_2) reduction ($1.0 billion). Increased congestion, noise and accidents from increased driving will offset roughly $3.8 billion of the $35 billion in gross consumer benefits, leaving total consumer benefits of $31 billion.

The proposed standards for light trucks would save approximately 36 billion gallons of fuel and prevent 343 million metric tons of tailpipe CO_2 emissions over the lifetime of the light trucks sold during those model years, compared to the fuel savings and emissions reductions that would

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

[207] Gross consumer benefits are benefits measured prior to accounting for the negative impacts of the rebound effect. They include fuel savings, consumer surplus from additional driving, reduced refueling time, reduced criteria pollutants, and reduced greenhouse gas production. Negative impacts from the rebound effect include added congestion, noise, and crash costs due to additional driving.

occur if the standards remained at the adjusted baseline (i.e., the higher of manufacturer's plans or the manufacturer's required level of average fuel economy for MY 2010).

The total value of societal benefits of the proposed light truck standards would be approximately \$57 billion[208] over the lifetime of the 5 model years combined. This estimate of societal benefits includes direct impacts from lower fuel consumption as well as externalities, and also reflects offsetting societal costs resulting from the rebound effect. Direct benefits to consumers, including fuel savings, account for 84% (\$52.7 billion) of the roughly \$63 billion in gross consumer benefits resulting from increased light truck CAFE. Petroleum market externalities account for roughly 10% (\$6.5 billion). Environmental externalities, i.e., reduction of air pollutants accounts for roughly 6% (\$3.5 billion). Over half of this \$3.5 billion is the result of greenhouse gas (primarily CO_2) reduction (\$1.9 billion). Increased congestion, noise and accidents from increased driving will offset roughly \$5.4 billion of the \$63 billion in gross consumer benefits, leaving total consumer benefits of \$57 billion.

Tables VIII-18, 19, and 20 summarize the fuel savings from all alternatives over model years 2011-2015 for passenger cars and light trucks. Each table reports total fuel savings (in millions of gallons) over the lifetime of vehicles manufactured during each model year that are projected to occur under each scenario. As the tables indicate, there is a steady increase in fuel savings for both passenger cars and light trucks with each successive model year under all 7 scenarios. As would be expected, benefit levels parallel the increasing stringency of the various alternatives that were examined. The two Optimized scenarios pushes technology up to the point where is ceases to be cost effective, but the 3% based scenario produces more benefits than the 7% based scenario because it places a higher value on benefits experienced in the future. The TC=TB scenario produces benefits that exceed the Optimized scenario because it allows benefits that accrue from cost-beneficial technologies to offset costs that accrue from technologies that are not cost-beneficial. As might be expected, the High Technology scenario, which assumes the maximum use of all available technologies in all vehicles regardless of cost, produces higher savings than any of the 6 other scenarios in all model years. The 25% Below Optimized, 25% Above Optimized, and 50% Above Optimized scenarios were designed to produce results relative to the Optimized scenario, and their benefits accordingly reflect this.

Tables VIII-21, 22, 23, 24, 25 and 26 summarize the total social benefits from all alternatives over the 2011-2015 model years for passenger cars and light trucks at both 3 percent and 7 percent discount rates. These tables summarize the value of net consumer benefits over the lifetime of the vehicles manufactured during each model year and scenario. There is a steady increase in the social value of fuel savings and other benefits with each model year under all 7 scenarios, which mirrors the trends in fuel savings noted above. Likewise, the value of societal benefits mirrors the trends in stringency across alternative scenarios.

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

Table VIII-5

Lifetime Monetized Societal Impacts, Optimized CAFE, MY 2011, Passenger Cars

Societal Effect	Physical Units	Undiscounted Value (2006$ k)	Present Discounted Value @ 3%	Present Discounted Value @ 7%
Lifetime Fuel Expenditures	-1,563,348(kgal)	-3,082,877	-2,538,092	-2,074,331
Consumer Surplus from Additional Driving	6,154,197(kmiles)	-382,541	-320,292	-261,888
Refueling Time Value	-8,064,500 (hours)	-193,548	-161,963	-132,232
Petroleum Market Externalities	-1,563,348(kgal)	-437,683	-366,257	-299,025
Congestion Costs	6,154,197 (kmiles)	321,249	268,824	219,478
Noise Costs	6,154,197 (kmiles)	4,308	3,605	2,943
Crash Costs	6,154,197 (kmiles)	139,085	116,387	95,023
CO2	-15 (mmT)	-119,479	-98,360	-78,834
CO	281,949(tons)	0	0	0
VOC	-4,589 (tons)	-7,801	5,801	-4,102
NOX	-7,728 (tons)	-30,141	-23,583	-17,773
PM	-191 (tons)	-31,401	-25,396	-20,088
SOX	-2,261(tons)	-36,178	-30,274	-24,717
Total		-3,807,007	-3,181,201	-2,595,546

Table VIII-6

Lifetime Monetized Societal Impacts, Optimized CAFE, MY 2012, Passenger Cars

Societal Effect	Physical Units	Undiscounted Value (2006$ k)	Present Discounted Value @ 3%	Present Discounted Value @ 7%
Lifetime Fuel Expenditures	-2,967,962 (k gal)	-5,819,490	-4,859,768	-3,961,065
Consumer Surplus from Additional Driving	11,771,196(kmiles)	-721,598	-603,190	-492,159
Refueling Time Value	14,848,833 (hours)	-356,372	-298,216	-243,474
Petroleum Market Externalities	-2,967,962 (k gal)	-830,928	-695,329	-567,691
Congestion Costs	11,771,196 (kmiles)	614,456	514,183	419,797
Noise Costs	11,771,196 (kmiles)	8,240	6,895	5,629
Crash Costs	11,771,196 (kmiles)	266,029	222,616	181,751
CO2	-28 (mmT)	-238,466	-196,315	-157,343
CO	86,340(tons)	0	0	0
VOC	1,086 (tons)	1,851	1,300	840
NOX	-6,044 (tons)	-23,570	-20,210	-16,942
PM	-513(tons)	-84,176	-70,096	-56,968
SOX	-4,158 (tons)	-66,522	-55,667	-45,448
Total		-7,250,243	-6,053,796	-4,933,071

Table VIII-7

Lifetime Monetized Societal Impacts,
Optimized CAFE, MY 2013, Passenger Cars

Societal Effect	Physical Units	Undiscounted Value (2006$ k)	Present Discounted Value @ 3%	Present Discounted Value @ 7%
Lifetime Fuel Expenditures	-3,716,507 (k gal)	-7,272,841	-6,064,046	-4,932,346
Consumer Surplus from Additional Driving	14,947,099 (kmiles)	-902,219	-753,173	-613,455
Refueling Time Value	-18,783,958 (hours)	-450,815	-377,246	-307,997
Petroleum Market Externalities	-3,716,507 (k gal)	-1,040,492	-870,693	-710,865
Congestion Costs	14,947,099 (kmiles)	780,239	652,911	533,060
Noise Costs	14,947,099 (kmiles)	10,463	8,756	7,148
Crash Costs	14,947,099 (kmiles)	337,804	282,678	230,788
CO2	-36 (mmT)	-305,686	-251,653	-201,695
CO	104,544 (tons)	0	0	0
VOC	-1,946 (tons)	-3,308	-2,545	-1,882
NOX	-10,551 (tons)	-41,151	-33,835	-27,078
PM	-605 (tons)	-99,250	-81,737	-65,701
SOX	-5,271 (tons)	-84,335	-70,572	-57,618
Total		-9,071,590	-7,561,156	-6,147,651

Table VIII-8

Lifetime Monetized Societal Impacts,
Optimized CAFE, MY 2014, Passenger Cars

Societal Effect	Physical Units	Undiscounted Value (2006$ k)	Present Discounted Value @ 3%	Present Discounted Value @ 7%
Lifetime Fuel Expenditures	-4,771,444(k gal)	-9,340,878	-7,780,728	-6,319,874
Consumer Surplus from Additional Driving	18,970,569 (miles)	-1,145,324	-955,266	-777,109
Refueling Time Value	24,182,292 (hours)	-580,375	-485,663	-396,513
Petroleum Market Externalities	-4,771,444(k gal)	-1,335,837	-1,117,841	-912,645
Congestion Costs	18,970,569 (miles)	990,264	828,662	676,549
Noise Costs	18,970,569 (miles)	13,279	11,112	9,072
Crash Costs	18,970,569 (miles)	428,735	358,769	292,912
CO2	-46 (mmT)	-401,009	-330,127	-264,593
CO	-147,821 (tons)	0	0	0
VOC	-2,690 (tons)	-4,573	-3,520	-2,603
NOX	-13,709 (tons)	-53,464	-43,909	-35,090
PM	-793 (tons)	-130,021	-106,690	-85,396
SOX	-6,764 (tons)	-108,229	-90,567	-73,942
Total		-11,667,432	-9,715,770	-7,889,231

Table VIII-9

Lifetime Monetized Societal Impacts,
Optimized CAFE, MY 2015, Passenger Cars

Societal Effect	Physical Units	Undiscounted Value (2006$ k)	Present Discounted Value @ 3%	Present Discounted Value @ 7%
Lifetime Fuel Expenditures	-5,716,339(k gal)	-11,171,665	-9,298,183	-7,542,913
Consumer Surplus from Additional Driving	22,781,264 (kmiles)	-1,363,084	-1,135,944	-922,974
Refueling Time Value	28,938,083 (hours)	-694,514	-581,176	-474,492
Petroleum Market Externalities	-5,716,339 (k gal)	-1,600,375	-1,339,209	-1,093,378
Congestion Costs	22,781,264 (kmiles)	1,189,182	995,119	812,450
Noise Costs	22,781,264 (kmiles)	15,947	13,345	10,895
Crash Costs	22,781,264 (kmiles)	517,857	430,847	351,751
CO2	-54 (mmT)	-488,493	-402,147	-322,314
CO	-273,604 (tons)	0	0	0
VOC	-4,634 (tons)	-7,878	-6,026	-4,412
NOX	-17,657 (tons)	-68,864	-56,138	-44,462
PM	-958 (tons)	-157,158	-127,963	-101,508
SOX	-8,104 (tons)	-129,669	-108,508	-88,590
Total		-13,961,714	-11,615,995	-9,419,948

Table VIII-10

Lifetime Monetized Societal Impacts, Optimized CAFE, MY 2011- 2015, Passenger Cars

Societal Effect	Physical Units	Undiscounted Value (2006$ k)	Present Discounted Value @ 3%	Present Discounted Value @ 7%
Lifetime Fuel Expenditures	-18,735,610 (kgal)	-36,637,752	-28,459,291	-24,830,539
Consumer Surplus from Additional Driving	74,624,325 (kmiles)	-4,514,765	-3,507,694	-3,067,584
Refueling Time Value	-94,817,655 (hours)	-2,275,624	-1,774,730	-1,554,709
Petroleum Market Externalities	-18,735,610 (kgal)	-5,245,315	-4,090,602	-3,583,605
Congestion Costs	74,624,325 (kmiles)	3,895,390	3,038,066	2,661,335
Noise Costs	74,624,325 (kmiles)	52,237	40,740	35,688
Crash Costs	74,624,325 (kmiles)	1,686,510	1,315,331	1,152,225
CO2	-178 (mmT)	-1,553,133	-1,190,956	-1,024,777
CO	-721,578 (tons)	0	0	0
VOC	-12,770 (tons)	-21,709	-15,625	-12,160
NOX	-55,689 (tons)	-217,189	-165,746	-141,345
PM	-3,061 (tons)	-502,006	-385,311	-329,661
SOX	-26,558 (tons)	-424,934	-331,395	-290,316
Total		-45,758,291	-35,527,213	-30,985,447

Table VIII-11

Lifetime Monetized Societal Impacts, Optimized CAFE, MY 2011, Light Trucks

Societal Effect	Physical Units	Undiscounted Value (2006$ k)	Present Discounted Value @ 3%	Present Discounted Value @ 7%
Lifetime Fuel Expenditures	-2,403,611 (kgal)	-4,811,383	-3,883,226	-3,087,364
Consumer Surplus from Additional Driving	7,666,300 (kmiles)	-595,411	-481,267	-383,161
Refueling Time Value	-9,383,882 (hours)	-225,213	-182,196	-144,998
Petroleum Market Externalities	-2,403,611 (kgal)	-672,927	-544,395	-433,248
Congestion Costs	7,666,300 (kmiles)	357,250	289,013	230,007
Noise Costs	7,666,300 (kmiles)	5,366	4,341	3,455
Crash Costs	7,666,300 (kmiles)	192,424	155,670	123,888
CO2	-23 (mmT)	-199,178	-156,241	-120,625
CO	84,710 (tons)	0	0	0
VOC	1,859 (tons)	3,161	2,062	1,256
NOX	-3,552 (tons)	-13,852	-12,277	-10,642
PM	-500 (tons)	-81,980	-66,292	-52,737
SOX	-3,382 (tons)	-54,105	-43,771	-34,834
Total		-6,095,848	-4,918,579	-3,909,004

Table VIII-12

Lifetime Monetized Societal Impacts, Optimized CAFE, MY 2012, Light Trucks

Societal Effect	Physical Units	Undiscounted Value (2006$ k)	Present Discounted Value @ 3%	Present Discounted Value @ 7%
Lifetime Fuel Expenditures	-5,478,272 (kgal)	-10,868,471	-8,754,164	-6,941,594
Consumer Surplus from Additional Driving	17,399,527 (kmiles)	-1,327,696	-1,071,130	-850,722
Refueling Time Value	-20,525,226 (hours)	-492,605	-398,516	-317,152
Petroleum Market Externalities	-5,478,272 (kgal)	-1,533,724	-1,240,776	-987,452
Congestion Costs	17,399,527 (kmiles)	810,818	655,948	522,026
Noise Costs	17,399,527 (kmiles)	12,180	9,853	7,842
Crash Costs	17,399,527 (kmiles)	436,728	353,311	281,177
CO2	-53 (mmT)	-461,762	-362,219	-279,649
CO	761,706 (tons)	0	0	0
VOC	18,561 (tons)	31,554	21,119	13,250
NOX	17,083 (tons)	66,622	37,737	16,756
PM	-1,523 (tons)	-249,839	-201,709	-160,269
SOX	-8,040 (tons)	-128,642	-104,069	-82,820
Total		-13,704,838	-11,054,616	-8,778,608

Table VIII-13

Lifetime Monetized Societal Impacts, Optimized CAFE, MY 2013, Light Trucks

Societal Effect	Physical Units	Undiscounted Value (2006$ k)	Present Discounted Value @ 3%	Present Discounted Value @ 7%
Lifetime Fuel Expenditures	-8,508,804 (kgal)	-16,796,650	-13,508,492	-10,688,849
Consumer Surplus from Additional Driving	27,188,329 (kmiles)	-2,054,826	-1,655,395	-1,312,269
Refueling Time Value	-32,253,023 (hours)	-774,073	-626,221	-498,368
Petroleum Market Externalities	-8,508,804 (kgal)	-2,382,167	-1,927,162	-1,533,702
Congestion Costs	27,188,329 (kmiles)	1,266,976	1,024,978	815,712
Noise Costs	27,188,329 (kmiles)	19,032	15,397	12,253
Crash Costs	27,188,329 (kmiles)	682,427	552,080	439,364
CO2	-82 (mmt)	-730,569	-573,079	-442,442
CO	734,617 (tons)	0	0	0
VOC	17,081 (tons)	29,037	19,409	12,103
NOX	9,106 (tons)	35,513	13,286	-2,256
PM	-2,232 (tons)	-366,080	-295,685	-235,000
SOX	-12,319 (tons)	-197,096	-159,448	-126,893
Total		-21,268,476	-17,120,333	-13,560,347

Table VIII-14

Lifetime Monetized Societal Impacts,
Optimized CAFE, MY 2014, Light Trucks

Societal Effect	Physical Units	Undiscounted Value (2006$ k)	Present Discounted Value @ 3%	Present Discounted Value @ 7%
Lifetime Fuel Expenditures	-9,391,857 (kgal)	-18,376,166	-14,768,243	-11,671,696
Consumer Surplus from Additional Driving	30,130,353 (kmiles)	-2,265,105	-1,823,071	-1,443,287
Refueling Time Value	-35,503,043 (hours)	-852,073	-689,323	-548,587
Petroleum Market Externalities	-9,391,857 (kgal)	-2,629,391	-2,127,165	-1,692,871
Congestion Costs	30,130,353 (kmiles)	1,404,074	1,135,890	903,980
Noise Costs	30,130,353 (kmiles)	21,091	17,063	13,579
Crash Costs	30,130,353 (kmiles)	756,272	611,820	486,908
CO2	-89 (mmT)	-812,842	-637,617	-492,268
CO	-5,658 (tons)	0	0	0
VOC	-1,090 (tons)	-1,853	-2,068	-2,182
NOX	-9,088 (tons)	-35,445	-36,431	-35,546
PM	-2,786 tons)	-456,882	-367,050	-290,218
SOX	-13,876 (tons)	-222,024	-179,614	-142,941
Total		-23,470,345	-18,865,810	-14,915,129

Table VIII-15

Lifetime Monetized Societal Impacts, Optimized CAFE, MY 2015, Light Trucks

Societal Effect	Physical Units	Undiscounted Value (2006$ k)	Present Discounted Value @ 3%	Present Discounted Value @ 7%
Lifetime Fuel Expenditures	-10,195,498 (kgal)	-19,973,909	-16,040,212	-12,660,941
Consumer Surplus from Additional Driving	32,977,172 (kmiles)	-2,454,647	-1,974,101	-1,560,979
Refueling Time Value	-38,972,327 (hours)	-935,336	-756,682	-602,194
Petroleum Market Externalities	-10,195,498 (kgal)	-2,854,383	-2,309,182	-1,837,726
Congestion Costs	32,977,172 (kmiles)	1,536,736	1,243,213	989,391
Noise Costs	32,977,172 (kmiles)	23,084	18,675	14,862
Crash Costs	32,977,172 (kmiles)	827,727	669,627	532,912
CO2	-96 (mmT)	-902,032	-707,580	-546,283
CO	-99,460 (tons)	0	0	0
VOC	-3,380 (tons)	-5,745	-4,895	-4,158
NOX	-13,408 (tons)	-52,290	-48,866	-44,507
PM	-3,048 (tons)	-499,947	-401,659	-317,517
SOX	-15,050 (tons)	-240,797	-194,802	-155,028
Total		-25,531,539	-20,506,465	-16,192,169

Table VIII-16

Lifetime Monetized Societal Impacts, Optimized CAFE, MY 2011-2015, Light Trucks

Societal Effect	Physical Units	Undiscounted Value (2006$ k)	Present Discounted Value @ 3%	Present Discounted Value @ 7%
Lifetime Fuel Expenditures	-35,978,042 (kgal)	-70,826,579	-56,954,337	-45,050,444
Consumer Surplus from Additional Driving	115,361,681 (kmiles)	-8,697,686	-7,004,965	-5,550,419
Refueling Time Value	-136,637,500 (hours)	-3,279,300	-2,652,939	-2,111,299
Petroleum Market Externalities	-35,978,042 (kgal)	-10,072,593	-8,148,681	-6,485,000
Congestion Costs	115,361,681 (kmiles)	5,375,854	4,349,041	3,461,116
Noise Costs	115,361,681 (kmiles)	80,753	65,329	51,991
Crash Costs	115,361,681 (kmiles)	2,895,578	2,342,509	1,864,249
CO2	-343 (mmT)	-3,106,382	-2,436,737	-1,881,267
CO	1,475,915 (tons)	0	0	0
VOC	33,031 (tons)	56,154	35,627	20,269
NOX	141 (tons)	548	-46,551	-76,195
PM	-10,090 (tons)	-1,654,728	-1,332,395	-1,055,741
SOX	-52,667 (tons)	-842,664	-681,704	-542,517
Total		-90,071,046	-72,465,802	-57,355,257

Table VIII-17

Lifetime Monetized Societal Impacts, Optimized CAFE, MY 2011-2015, Passenger Cars and Light Trucks

Societal Effect	Physical Units	Undiscounted Value (2006$ k)	Present Discounted Value @ 3%	Present Discounted Value @ 7%
Lifetime Fuel Expenditures	-54,713,652 (kgal)	-107,464,331	-85,413,628	-69,880,983
Consumer Surplus from Additional Driving	189,986,006 (kmiles)	-13,212,451	-10,512,659	-8,618,003
Refueling Time Value	-231,455,155 (hours)	-5,554,924	-4,427,668	-3,666,008
Petroleum Market Externalities	-54,713,652 (kgal)	-15,317,908	-12,239,283	-10,068,605
Congestion Costs	189,986,006 (kmiles)	9,271,244	7,387,107	6,122,451
Noise Costs	189,986,006 (kmiles)	132,990	106,069	87,679
Crash Costs	189,986,006 (kmiles)	4,582,088	3,657,841	3,016,475
CO2	-521 (mmT)	-4,659,516	-3,627,693	-2,906,044
CO	754,337 (tons)	0	0	0
VOC	20,261 (tons)	34,444	20,001	8,109
NOX	-55,549 (tons)	-216,641	-212,298	-217,540
PM	-13,151 (tons)	-2,156,735	-1,717,706	-1,385,402
SOX	-79,225 (tons)	-1,267,599	-1,013,099	-832,832
Total		-135,829,336	-107,993,015	-88,340,704

Table VIII-18

Savings in Millions of Gallons of Fuel
Undiscounted, over the Lifetime of the Model Year Fleet
Passenger Cars

	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015	All 5 MYs
25% Below Optimized	708	1261	1946	3135	4151	11201
Optimized Net Impact -7%	1563	2968	3717	4771	5716	18735
25% Above Optimized	2313	4480	5221	6601	7476	26091
50% Above Optimized	2641	5523	6422	7913	9121	31620
Optimized Net Impact -3%	3463	6197	6905	8587	9784	34936
TC=TB	3599	6860	7676	9320	10461	37916
Technology Exhaustion	3677	7143	8261	10233	11562	40876

Table VIII-19
Savings in Millions of Gallons of Fuel
Undiscounted, over the Lifetime of the Model Year Fleet
Light Trucks

	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015	All 5 MYs
25% Below Optimized	2157	4933	7902	7799	7808	30599
Optimized Net Impact -7%	2404	5478	8509	9392	10195	35978
25% Above Optimized	2585	6339	9070	10592	12534	41120
50% Above Optimized	2909	6780	9697	11458	13584	44428
Optimized Net Impact -3%	2414	5488	8978	9959	11127	37966
TC = TB	3228	7471	10640	12778	14602	48719
Technology Exhaustion	3263	7506	12659	14448	16147	54023

Table VIII-20
Savings in Millions of Gallons of Fuel
Undiscounted, over the Lifetime of the Model Year Fleet
Passenger Cars and Light Trucks

	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015	All 5 MYs
25% Below Optimized	2865	6194	9848	10934	11959	41800
Optimized Net Impact -7%	3967	8446	12226	14163	15911	54713
25% Above Optimized	4898	10819	14291	17193	20010	67211
50% Above Optimized	5550	12303	16119	19371	22705	76048
Optimized Net Impact -3%	5877	11685	15883	18546	20911	72902
TC = TB	6827	14331	18316	22098	25063	86635
Technology Exhaustion	6940	14649	20920	24681	27709	94899

Table VIII-21
Present Value @3% Discount Rate of Lifetime Social Benefits
(Millions of 2006 Dollars), Passenger Cars

	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015	All 5 MYs
25% Below Optimized	1418	2581	3977	6399	8387	22762
Optimized Net Impact-7%	3181	6054	7561	9716	11616	38128
25% Above Optimized	4604	8939	10403	13109	14907	51962
50% Above Optimized	5241	10842	12571	15503	17893	62050
Optimized Net Impact -3%	6798	12188	13519	16833	19216	68554
TC = TB	7075	13366	14881	18059	20364	73745
Technology Exhaustion	7156	13865	15967	19654	22312	78954

Table VIII-22
Present Value @3% Discount Rate of Lifetime Social Benefits (Millions of 2006 Dollars), Light Trucks

	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015	All 5 MYs
25% Below Optimized	4414	9959	15910	15715	15745	61743
Optimized Net Impact -7%	4919	11055	17120	18866	20506	72466
25% Above Optimized	5286	12599	17972	20984	24662	81503
50% Above Optimized	5848	13249	18955	22375	26475	86902
Optimized Net Impact -3%	4939	11075	17976	19902	22246	76138
TC = TB	6343	14452	20631	24704	28352	94482
Technology Exhaustion	6420	14528	24517	27951	31387	104803

Table VIII-23
Present Value @3% Discount Rate of Lifetime Social Benefits (Millions of 2006 Dollars), Passenger Cars and Light Trucks

	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015	All 5 MYs
25% Below Optimized	5832	12540	19887	22114	24132	84505
Optimized Net Impact -7%	8100	17109	24681	28582	32122	110594
25% Above Optimized	9890	21538	28375	34093	39569	133465
50% Above Optimized	11089	24091	31526	37878	44368	148952
Optimized Net Impact -3%	11737	23263	31495	36735	41462	144692
TC = TB	13418	27818	35512	42763	48716	168227
Technology Exhaustion	13576	28393	40484	47605	53699	183757

Table VIII-24
Present Value @7% Discount Rate of Lifetime Social Benefits (Millions of 2006 Dollars), Passenger Cars

	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015	All 5 MYs
25% Below Optimized	1156	2104	3235	5197	6799	18491
Optimized Net Impact -7%	2596	4933	6148	7889	9420	30986
25% Above Optimized	3755	7280	8454	10638	12083	42210
50% Above Optimized	4274	8825	10213	12576	14495	50383
Optimized Net Impact -3%	5543	9922	10983	13654	15569	55671
TC=TB	5769	10878	12087	14644	16492	59870
Technology Exhaustion	5834	11282	12968	15930	18061	64075

Table VIII-25
Present Value @7% Discount Rate of Lifetime Social Benefits (Millions of 2006 Dollars), Light Trucks

	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015	All 5 MYs
25% Below Optimized	3508	7910	12603	12432	12441	48894
Optimized Net Impact - 7%	3909	8779	13560	14915	16192	57355
25% Above Optimized	4201	9990	14236	16587	19457	64471
50% Above Optimized	4642	10507	15011	17687	20892	68739
Optimized Net Impact -3%	3926	8794	14251	15752	17589	60312
TC = TB	5027	11453	16330	19515	22367	74692
Technology Exhaustion	5088	11513	19395	22074	24759	82829

Table VIII-26
Present Value @7% Discount Rate of Lifetime Social Benefits
(Millions of 2006 Dollars), Passenger Cars and Light Trucks

	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015	All 5 MYs
25% Below Optimized	4664	10014	15838	17629	19240	67385
Optimized Net Impact -7%	6505	13712	19708	22804	25612	88341
25% Above Optimized	7956	17270	22690	27225	31540	106681
50% Above Optimized	8916	19332	25224	30263	35387	119122
Optimized Net Impact -3%	9469	18716	25234	29406	33158	115983
TC = TB	10796	22331	28417	34159	38859	134562
Technology Exhaustion	10922	22795	32363	38004	42820	146904

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IX. NET BENEFITS AND SENSITIVITY ANALYSES

This chapter compares the costs of technologies needed to make improvements in fuel economy to meet the alternatives with the potential benefits, expressed in total costs (millions of dollars) for each model year. The costs do not include fines, since these are transfer payments. Thus, the total costs shown in this section do not match the total costs shown in Chapter VII. The following tables combine the estimated costs and benefits from a societal perspective. These are incremental costs and benefits compared to an adjusted baseline of manufacturers' production plans. Tables utilizing a 3 percent and 7 percent discount rate for benefits are presented. Sensitivity analyses are also performed on some of the assumptions made in this analysis. Finally, a payback period is calculated, from the consumer's perspective.

Table IX-1 provides the total incremental costs (in millions of dollars) from a societal perspective. Table IX-2a and Table IX-2b provide the total benefits at a 3 percent and 7 percent discount rate from a societal perspective for all vehicles produced during each model year to which the standard is applicable. Table IX-3a and Table IX-3b show the total net benefits in millions of dollars at a 3 percent and 7 percent discount rate for the projected fleet of sales for each model year.

Table IX-1
Incremental Total Cost (excludes fines)
(Millions of 2006 Dollars)

	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015	Total 5 years
Passenger Cars						
25% Below Optimized	835	818	1,253	2,153	3,209	8,268
Optimized (7%)	1,884	2,373	2,879	3,798	4,862	15,796
25% Above Optimized	3,387	5,653	6,445	8,240	9,084	32,808
50% Above Optimized	4,010	7,885	8,986	11,207	12,981	45,070
Optimized (3%)	5,467	8,791	9,821	12,447	14,484	51,011
TC = TB	5,913	10,796	12,303	15,403	17,398	61,812
Technology Exhaustion	6,079	12,595	14,701	18,759	21,110	73,245
Light Trucks						
25% Below Optimized	1,349	4,296	6,329	6,212	6,326	24,512
Optimized (7%)	1,649	4,986	7,394	8,160	8,761	30,949
25% Above Optimized	2,072	7,034	9,815	11,903	14,781	45,606
50% Above Optimized	2,922	8,098	11,586	14,386	17,969	54,961
Optimized (3%)	1,662	4,974	8,190	9,058	10,253	34,136
TC = TB	3,788	10,525	15,196	18,762	21,364	69,635
Technology Exhaustion	3,933	10,670	18,275	21,051	23,479	77,408
Passenger Cars and Light Trucks Combined						
25% Below Optimized	2,184	5,114	7,582	8,365	9,534	32,780
Optimized (7%)	3,534	7,358	10,273	11,957	13,623	46,745
25% Above Optimized	5,459	12,687	16,261	20,143	23,865	78,414
50% Above Optimized	6,932	15,983	20,572	25,593	30,950	100,030
Optimized (3%)	7,128	13,765	18,011	21,505	24,737	85,147
TC = TB	9,702	21,321	27,499	34,164	38,761	131,447
Technology Exhaustion	10,013	23,266	32,976	39,810	44,589	150,653

Total costs follow a predictable pattern with costs rising to reflect the more expensive technologies that manufacturers must apply in order to achieve the CAFE levels that are required under the more aggressive alternatives, with the exception of the Optimized (3%) for light trucks. For the combined fleet, total compliance costs for the Total Cost = Total Benefit alternative is roughly 2.8 times those for the Optimized (7%) alternative over the 5 model years. Relative to the proposed Optimized (7%) alternative, Technology exhaustion produces costs that are 3.2 times the Optimized cost levels.

Table IX-2a
Present Value of Lifetime Societal Benefits by Alternative
(Millions of 2006 Dollars)
(Discounted 3%)

	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015	Total 5 years
Passenger Cars						
25% Below Optimized	1,418	2,581	3,977	6,399	8,387	22,762
Optimized (7%)	3,181	6,054	7,561	9,716	11,616	38,128
25% Above Optimized	4,604	8,939	10,403	13,109	14,907	51,962
50% Above Optimized	5,241	10,842	12,571	15,503	17,893	62,050
Optimized (3%)	6,798	12,188	13,519	16,833	19,216	68,554
TC = TB	7,075	13,366	14,881	18,059	20,364	73,745
Technology Exhaustion	7,156	13,865	15,967	19,654	22,312	78,954
Light Trucks						
25% Below Optimized	4,414	9,959	15,910	15,715	15,745	61,743
Optimized (7%)	4,919	11,055	17,120	18,866	20,506	72,466
25% Above Optimized	5,286	12,599	17,972	20,984	24,662	81,503
50% Above Optimized	5,848	13,249	18,955	22,375	26,475	86,902
Optimized (3%)	4,939	11,075	17,976	19,902	22,246	76,138
TC = TB	6,343	14,452	20,631	24,704	28,352	94,482
Technology Exhaustion	6,420	14,528	24,517	27,951	31,387	104,803
Passenger Cars and Light Trucks Combined						
25% Below Optimized	5,832	12,540	19,887	22,114	24,132	84,505
Optimized (7%)	8,100	17,109	24,681	28,582	32,122	110,594
25% Above Optimized	9,890	21,538	28,375	34,093	39,569	133,465
50% Above Optimized	11,089	24,091	31,526	37,878	44,368	148,952
Optimized (3%)	11,737	23,263	31,495	36,735	41,462	144,692
TC = TB	13,418	27,818	35,512	42,763	48,716	168,227
Technology Exhaustion	13,576	28,393	40,484	47,605	53,699	183,757

From Table IX-2a, lifetime societal benefits follow a similar predictable pattern, with higher benefits associated with the more expensive technologies that are enabled under the more aggressive alternatives. For the combined fleet, the TC=TB alternative produces gross benefits roughly 1.5 times as high as the Optimized (7%) alternative, and the Technology exhaustion alternative produces gross benefits that are 1.7 times the Optimized (7%) alternative.

Similar results occur for benefits discounted at the 7% rate (Table IX-2b). However, while the pattern for benefits is directionally similar to the pattern for costs, the more aggressive technology scenarios do not increase benefits by as high a ratio as they do for costs. For example, the TC=TB alternative increases total benefits by $46 billion over the Optimized (7%) alternative, but it also increases total costs by $85 billion, a net loss to society of $39 billion. This is a function of the more aggressive alternatives relatively unrestrained functions. While the Optimized (7%) alternative adds technology until the marginal cost to society begins to exceed the marginal benefit, the TC=TB scenario and the Technology exhaustion scenario allow for continued investment in technology despite its negative net return. Thus, while both costs and benefits continue to rise with more aggressive technologies, the costs rapidly begin to exceed the benefits that society derives from the added investment.

Table IX-2b
Present Value of Lifetime Societal Benefits by Alternative
(Millions of 2006 Dollars)
(Discounted 7**%**)

	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015	Total 5 years
Passenger Car						
25% Below Optimized	1,156	2,104	3,235	5,197	6,799	18,491
Optimized (7%)	2,596	4,933	6,148	7,889	9,420	30,986
25% Above Optimized	3,755	7,280	8,454	10,638	12,083	42,210
50% Above Optimized	4,274	8,825	10,213	12,576	14,495	50,383
Optimized (3%)	5,543	9,922	10,983	13,654	15,569	55,671
TC = TB	5,769	10,878	12,087	14,644	16,492	59,870
Technology Exhaustion	5,834	11,282	12,968	15,930	18,061	64,075
Light Trucks						
25% Below Optimized	3,508	7,910	12,603	12,432	12,441	48,894
Optimized (7%)	3,909	8,779	13,560	14,915	16,192	57,355
25% Above Optimized	4,201	9,990	14,236	16,587	19,457	64,471
50% Above Optimized	4,642	10,507	15,011	17,687	20,892	68,739
Optimized (3%)	3,926	8,794	14,251	15,752	17,589	60,312
TC = TB	5,027	11,453	16,330	19,515	22,367	74,692
Technology Exhaustion	5,088	11,513	19,395	22,074	24,759	82,829
Passenger Cars and Light Trucks Combined						
25% Below Optimized	4,664	10,014	15,838	17,629	19,240	67,385
Optimized (7%)	6,505	13,712	19,708	22,804	25,612	88,341
25% Above Optimized	7,956	17,270	22,690	27,225	31,540	106,681
50% Above Optimized	8,916	19,332	25,224	30,263	35,387	119,122
Optimized (3%)	9,469	18,716	25,234	29,406	33,158	115,983
TC = TB	10,796	22,331	28,417	34,159	38,859	134,562
Technology Exhaustion	10,922	22,795	32,363	38,004	42,820	146,904

Table IX-3a
Net Total Benefits
Over the Vehicle's Lifetime – Present Value
(Millions of 2006 Dollars)*
(Discounted 3%)

Passenger Cars	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015	Total 5 years
25% Below Optimized	583	1,763	2,724	4,246	5,178	14,494
Optimized (7%)	1,297	3,681	4,682	5,918	6,754	22,332
25% Above Optimized	1,217	3,286	3,958	4,869	5,823	19,154
50% Above Optimized	1,231	2,957	3,585	4,296	4,912	16,980
Optimized (3%)	1,331	3,397	3,698	4,386	4,732	17,543
TC = TB	1,162	2,570	2,578	2,656	2,966	11,933
Technology Exhaustion	1,077	1,270	1,266	895	1,202	5,709
Light Trucks						
25% Below Optimized	3,065	5,663	9,581	9,503	9,419	37,231
Optimized (7%)	3,270	6,069	9,726	10,706	11,745	41,517
25% Above Optimized	3,214	5,565	8,157	9,081	9,881	35,897
50% Above Optimized	2,926	5,151	7,369	7,989	8,506	31,941
Optimized (3%)	3,277	6,101	9,786	10,844	11,993	42,002
TC = TB	2,555	3,927	5,435	5,942	6,988	24,847
Technology Exhaustion	2,487	3,858	6,242	6,900	7,908	27,395
Passenger Cars and Light Trucks Combined						
25% Below Optimized	3,648	7,426	12,305	13,749	14,598	51,725
Optimized (7%)	4,566	9,751	14,408	16,625	18,499	63,849
25% Above Optimized	4,431	8,851	12,114	13,950	15,704	55,051
50% Above Optimized	4,157	8,108	10,954	12,285	13,418	48,922
Optimized (3%)	4,609	9,498	13,484	15,230	16,725	59,545
TC = TB	3,716	6,497	8,013	8,599	9,955	36,780
Technology Exhaustion	3,563	5,127	7,508	7,795	9,110	33,104

The impact of the relatively unrestricted technology application that is enabled by the more aggressive scenarios is apparent from Tables IX-3a and IX-3b, which show net total lifetime societal benefits under each alternative. Across all 5 model years the Optimized (7%) or the Optimized (3%) alternative produces the highest net total benefits to society, as would be expected.   Under a 3% discount rate, net benefits produced by the Optimized (7%) alternative exceed those produced by the TC = TB alternative by an extra $27 billion, and exceed those produced under the Technology Exhaustion alternative by $30 billion. Under the 7% discount rate, the Technology exhaustion alternative produces a net loss to society of over $3.7 billion.

Table IX-3b
Net Total Benefits
Over the Vehicle's Lifetime – Present Value
(Millions of 2006 Dollars)
(Discounted 7%)

Passenger Cars	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015	Total 5 years
25% Below Optimized	321	1,286	1,982	3,044	3,590	10,223
Optimized (7%)	712	2,560	3,269	4,091	4,558	15,190
25% Above Optimized	368	1,627	2,009	2,398	2,999	9,402
50% Above Optimized	264	940	1,227	1,369	1,514	5,313
Optimized (3%)	76	1,131	1,162	1,207	1,085	4,660
TC = TB	-144	82	-216	-759	-906	-1,942
Technology Exhaustion	-245	-1,313	-1,733	-2,829	-3,049	-9,170
Light Trucks						
25% Below Optimized	2,159	3,614	6,274	6,220	6,115	24,382
Optimized (7%)	2,260	3,793	6,166	6,755	7,431	26,406
25% Above Optimized	2,129	2,956	4,421	4,684	4,676	18,865
50% Above Optimized	1,720	2,409	3,425	3,301	2,923	13,778
Optimized (3%)	2,264	3,820	6,061	6,694	7,336	26,176
TC = TB	1,239	928	1,134	753	1,003	5,057
Technology Exhaustion	1,155	843	1,120	1,023	1,280	5,421
Passenger Cars and Light Trucks Combined						
25% Below Optimized	2,480	4,900	8,256	9,264	9,706	34,605
Optimized (7%)	2,971	6,354	9,435	10,847	11,989	41,596
25% Above Optimized	2,497	4,583	6,429	7,082	7,675	28,267
50% Above Optimized	1,984	3,349	4,652	4,670	4,437	19,092
Optimized (3%)	2,341	4,951	7,223	7,901	8,421	30,836
TC = TB	1,094	1,010	918	-5	98	3,115
Technology Exhaustion	909	-471	-613	-1,806	-1,769	-3,749

Sensitivity Analyses

The agency has performed several sensitivity analyses to examine important assumptions. The analyses include:

1) The value of CO_2. We examined a range from \$0 per metric ton to \$14 per metric ton, with the main analysis using a value of \$7.50 per metric ton. These values can be translated into a value for carbon by multiplying by a factor of 3.66, or can be translated into cents per gallon by multiplying by 0.0089[209], as shown below:

   \$7.50 per ton CO_2 = \$7.50*3.667 = \$27.50 per ton C = \$7.50*0.0089 = \$0.06675 per gallon
   \$14.00 per ton CO_2 = \$14.00*3.667 = \$51.34 per ton C = \$14.00*0.0089 = \$0.1246 per gallon

2) The value of externalities. The main analysis uses \$0.295 per gallon for externalities. The sensitivity analysis examines \$0.120 and \$0.504 per gallon.

3) The price of gasoline. The main analysis uses the AEO 2008 reference case estimate for the price of gasoline. The preliminary AEO 2008 estimate does not contain a high price or low price of gasoline case. We assumed for this analysis an estimate of the AEO 2008 high price and low price for gasoline (based on applying the percentage increase between the high price estimate and the reference case estimate in the AEO 2007 forecast to the AEO 2008 reference case estimate).

4) The rebound effect. The main analysis uses a rebound effect of 15 percent. The sensitivity analysis examines rebound effects of 10 percent and 20 percent.

Sensitivity analyses were performed on just the optimized (7%) alternative. Presented are information on the average mpg expected by model year, the price per vehicle increase for MY 2015, total benefits for MY 2015 vehicles, the total cost increase for MY 2015, the total fuel saved (all 5 model years combined) and the total CO_2 emissions reduction (all 5 model years combined).

The results of the sensitivity analyses indicate that the value of CO_2, the value of externalities, and the value of the rebound effect have almost no impact on the level of the standards. Assuming a higher price of gasoline has the largest impact of the sensitivity analyses examined (raising the MY 2015 passenger car standard level by 6.7 mpg and the light truck level by 0.8 mpg). It appears that the light truck levels are not as sensitive as the passenger car levels to changes in the estimated benefits. This can occur because the technologies that have not been used under the Optimized alternative, and are still available for light trucks, are not that close to being cost effective and it takes a larger increase in benefits to bring them over the cost-benefit threshold.

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[209] The molecular weight of Carbon (C) is 12, the molecular weight of Oxygen (O) is 16, thus the molecular weight of CO_2 is 44. One ton of C = 44/12 tons CO_2 = 3.67 tons CO_2. 1 gallon of gas weighs 2,819 grams, of that 2,433 grams are carbon. \$1.00 CO_2 = \$3.67 C and
\$3.67/ton * ton/1000kg * kg/1000g * 2433g/gallon = (3.67 * 2433) / 1000 * 1000 = \$0.0089/gallon

Note that there are some slight inconsistencies in the relationships one would expect when comparing the required mpg levels for corresponding model years in the various sensitivity analyses to those under the proposed CAFE standards. For example, the level of the standard should increase when CO_2 is assigned a higher value, because this increases the benefit of each gallon of fuel saved, but the optimized standards for some model years are actually *lower* with the high CO_2 value than under the proposal. Problems such as this arise when making slight changes in parameter values used by the CAFE model, since the model derives a relationship between net benefits and the stringency level of standards for each model year, and minor changes in parameter values can affect the exact shapes and positions of those curves. In any case, the seemingly anomalous results are mostly small (0.1 mpg or less), and are sometimes the result of rounding. When larger variations are made to the model's parameters or other inputs, such as substituting EIA's High gasoline price forecast for the Reference Case forecast, the sensitivity analysis invariable produces the anticipated result.

Table IX-5a
Passenger Car Sensitivity Analyses
(mpg)

Optimized	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
Proposal	31.2	32.8	34.0	34.8	35.7
Low CO_2	31.2	32.7	33.8	34.7	35.3
High CO_2	31.2	32.7	33.8	34.6	35.7
Low Externalities	31.2	32.8	33.9	34.7	35.4
High Externalities	31.1	32.7	34.1	34.9	36.0
Low Fuel Price	31.1	32.8	33.8	34.7	35.9
High Fuel Price	37.4	38.9	40.4	41.3	42.4
10% Rebound	31.1	32.7	33.9	34.6	36.0
20% Rebound	31.2	32.8	33.8	34.8	35.7

Optimized	MY 2015 Per Vehicle Cost ($)	MY 2015 Total Benefits ($ Mill.)	MY 2015 Total Cost ($ Mill.)	Total Fuel Saved (Bill. Gal.)	Total CO_2 Emissions Reduced (mmt)
Proposal	649	9,420	4,862	18.736	178
Low CO_2	571	8,583	4,263	18.129	173
High CO_2	633	9,655	4,731	18.351	174
Low Externalities	596	8,340	4,458	18.307	175
High Externalities	715	10,660	5,367	19.276	182
Low Fuel Price	675	8,273	5,014	18.446	171
High Fuel Price	2,081	24,622	15,477	36.686	319
10% Rebound	714	10,343	5,346	19.730	186
20% Rebound	644	8,833	4,811	17.738	169

Table IX-5b
Light Truck Sensitivity Analyses
(mpg)

Optimized	MY 2011	MY 2012	MY 2013	MY 2014	MY 2015
Proposal	25.0	26.4	27.8	28.2	28.6
Low CO_2	25.0	26.4	27.7	28.2	28.6
High CO_2	25.0	26.4	27.7	28.1	28.6
Low Externalities	25.1	25.4	27.2	27.9	28.2
High Externalities	25.0	26.4	27.8	28.2	28.8
Low Fuel Price	25.1	25.2	26.9	27.6	28.2
High Fuel Price	25.1	26.7	28.1	28.6	29.4
10% Rebound	25.0	26.4	27.7	28.1	28.6
20% Rebound	25.0	26.4	27.8	28.2	28.7

Optimized	MY 2015 Per Vehicle Cost ($)	MY 2015 Total Benefits ($ Mill.)	MY 2015 Total Cost ($ Mill.)	Total Fuel Saved (Bill. Gal.)	Total CO_2 Emissions Reduced (mmt)
Proposal	979	16,192	8,761	35.978	343
Low CO_2	966	15,543	8,646	35.752	340
High CO_2	943	16,587	8,434	35.564	339
Low Externalities	775	13,874	6,927	31.927	304
High Externalities	1,025	18,001	9,172	36.331	346
Low Fuel Price	789	12,887	7,054	30.054	285
High Fuel Price	1,393	27,647	12,468	40.115	376
10% Rebound	943	16,839	8,434	37.262	355
20% Rebound	997	15,603	8,924	34.403	327

Payback Period

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

The length of this payback period depends on the initial increase in a vehicle's purchase price, the improvement in its fuel economy, the number of miles it is driven each year, and the retail price of fuel. We calculated payback periods using the fuel economy improvement and average price increase estimated to result from the standard, the future retail gasoline prices, and estimates of the number of miles vehicles are driven each year as they age. These calculations are taken from a consumer's perspective, not a societal perspective. Thus, only gasoline savings are included on the benefits side of the equation. The price of gasoline includes fuel taxes and future savings are not discounted to present value, since consumers generally only consider and respond to what they pay at the pump. The payback periods was estimated for only MY 2015 vehicles and an average of all manufacturers for the different alternatives. The payback periods for MY 2015 are shown in Table IX-10.

Table IX-10
Payback Period for MY 2015 Average Vehicles
(in years)

	Passenger Cars	Light Trucks
25% Below Optimized	4.3	3.9
Optimized (7%)	4.7	4.2
25% Above Optimized	6.7	6.0
50% Above Optimized	8.3	7.0
Optimized (3%)	8.8	4.5
TC = TB	10.4	8.3
Technology Exhaustion	Never	8.3

X. PROBABILISTIC UNCERTAINTY ANALYSIS

OMB Circular A-4 requires formal probabilistic uncertainty analysis of complex rules where there are large, multiple uncertainties whose analysis raises technical challenges or where effects cascade and where the impacts of the rule exceed $1 billion. CAFE meets all of these criteria. This chapter identifies and quantifies the major uncertainties in the preliminary regulatory impact analysis and estimates the probability distribution of the benefits, costs, and net benefits of the compliance options selected for the proposed rule for MY 2011-2015 passenger car and light truck CAFE standards. Throughout the course of the main analysis, input values were selected from a variety of often conflicting sources. Best estimates were selected based on the preponderance of data and analyses available, but there is inevitably a level of uncertainty in these selections. Some of these inputs contributed less to the overall variations of the outcomes, and, thus, are less significant. Some inputs depend on others or are closely related (e.g. oil import externalities), and thus can be combined. With the vast number of uncertainties imbedded in this regulatory analysis, this uncertainty analysis identifies only the major independent uncertainty factors having appreciable variability and impact on the end results and quantifies them by their probability distributions. These newly defined values are then randomly selected and fed back into the model to determine the net benefits using the Monte Carlo statistical simulation technique.[210] The simulation technique induces the probabilistic outcomes accompanied with degrees of probability or plausibility. This facilitates a more informed decision-making process.

The analysis is based on the actual processes used to derive net benefits as described in the previous chapters. Each variable (e.g., cost of technology) in the mathematical model represents an uncertainty factor that would potentially alter the modeling outcomes if its value was changed. We assume that these variables are independent of each other. The confidence intervals around the costs and benefits of technologies reflect independent levels of uncertainty regarding costs and benefits, rather than linked probabilities dependent on higher or lower quality versions of a specific technology. By contrast, there is reason to believe that monopsony costs may be dependent on fuel prices. However, monopsony costs are only one of several oil import externalities, and the range of monopsony costs is quite narrow. The potential for significant error due to an assumption of independence for monopsony costs is thus quite low. Given this, the agency has elected to treat monopsony costs as an independent variable.

The uncertainties of these variables are described by appropriate probability distribution functions based on available data. If data are not sufficient or not available, professional judgments are used to estimate the probability distributions of these uncertainty factors. A complete description of the formulas and methods used in the CAFE model is available in the public docket.[211]

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[210] See, for example, Morgan, MG, Henrion, M, and Small M, "Uncertainty: A Guide to Dealing with Uncertainty in Quantitative Risk and Policy Analysis", Cambridge University Press, 1990.

[211] CAFE Compliance and Effects Modeling System Documentation, Volpe Center, U.S. Dept. of Transportation, July 2005, pp. 27-46 and C-22 to C-35. Docket No. NHTSA 21974-2.

After defining and quantifying the major uncertainty factors, the next step is to simulate the model to obtain probabilistic results rather than single-value estimates. In the uncertainty analysis, CAFE levels were kept constant; in other words, we did not change the CAFE standards for each run based on net benefits. The simulation process was run repeatedly for 20,000 trials under each discount rate scenario. Each complete run is a trial. For each trial, the simulation first randomly selects a value for each of the uncertainty factors based on their probability distributions. The selected values are then fit into the models to forecast results. In addition to the simulation results, the program also estimates the degree of certainty (or confidence, credibility). The degree of certainty provides the decision-maker with an additional piece of important information with which to evaluate the forecast results.

Simulation Models and Uncertainty Factors

A Monte Carlo simulation was conducted using the CAFE modeling system that was developed to estimate the impacts of higher CAFE requirements described in previous chapters. The focus of the simulation model was variation around the chosen uncertainty parameters and their resulting impact on the key output parameters, fuel savings, and net benefits. Net benefits measure the difference between (1) the total dollar value that would be saved in fuel and other benefits and (2) the total costs of the rule.

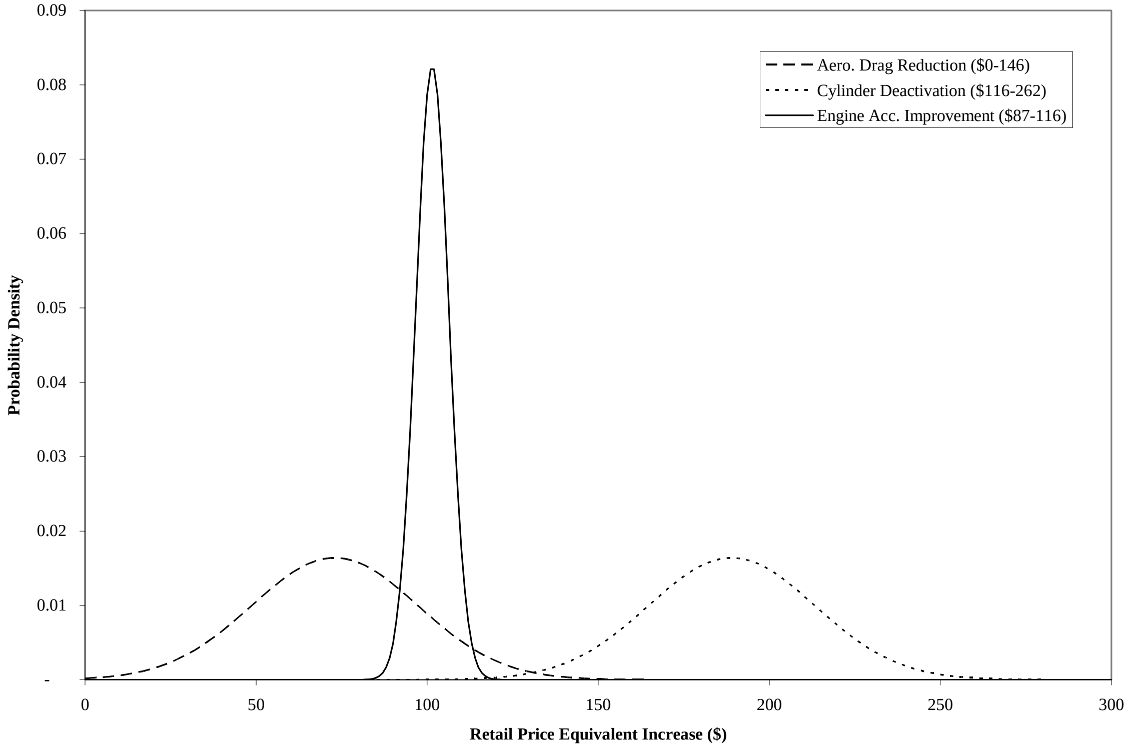
The agency reviewed the inputs and relationships that drive the CAFE model to determine the factors that are the major sources of uncertainty. Five factors were identified as contributing the most uncertainty to the estimated impacts of higher CAFE standards:
(1) Technology costs;
(2) Technology effectiveness;
(3) Fuel prices;
(4) The value of oil consumption externalities; and
(5) The rebound effect.

Technology Costs

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

Forty-one different technologies were examined as possible methods to comply with higher CAFE standards. These technologies were summarized in Chapter V earlier in this analysis. Chapter V also summarizes the estimated range of costs for these technologies. The expected values (mid-range values) were used in the main analysis. For the uncertainty analysis, the full range of NAS cost estimates is used. The uncertainty model assumes a normal distribution for these costs, with each end of the range being three standard deviations from the mean (or expected) value. Figure X-1 graphically demonstrates the distributions of a hypothetical sample of three of the technologies.

Figure X-1
Normal Distributions for 3 Different Technologies



Technology Effectiveness

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

As noted above, forty-one different technologies were examined as possible methods to comply with higher CAFE standards. These technologies were summarized in Chapter V earlier in this analysis. Chapter V also summarizes the estimated range of effectiveness for these technologies. The expected values (mid-range values) were used in the main analysis. For the uncertainty analysis, the full range of effectiveness estimates is used. The uncertainties model assumes a normal distribution for these values, with each end of the range being three standard deviations from the mean (or expected) value.

Fuel Prices

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

The analysis attempts to measure impacts that occur as much as 40 years in the future and estimating gasoline prices this far in advance is an uncertain process. In the main analysis, the agency utilized predicted fuel prices from the Energy Information Administration's (EIA) publication Annual Energy Outlook 2008 (AEO) Revised Early Release. The main analysis is based on the AEO Reference Case scenario, which represents EIA's best estimate of future fuel prices. For the uncertainty analysis, the Agency examined two other AEO scenarios, the Low Oil Price scenario (LOP) and the High Oil Price scenario (HOP). The AEO 2008 Early Release did not contain LOP and HOP estimates. The agency therefore estimated these levels by adjusting the 2008 Reference case proportionately to these cases in the AEO 2007 report. The LOP scenario was chosen to allow for the possibility that the EIA's Reference Case predictions could overestimate the price of gasoline in the future. However, recent escalation in the price of gasoline has resulted in prices that have at times exceeded those estimated by EIA for their reference case. It is unclear whether this just reflects a temporary spike in price levels or whether it is an indication of permanently higher price levels. To reflect the possibility of significantly higher prices, the Agency selected the HOP case, which among the AEO 2008 scenarios comes closest to matching the highest prices seen during the recent gasoline price surge, and which gives the highest gasoline price forecasts among all AEO 2008 scenarios

Each of these scenarios was applied as a discrete input (i.e., draws were not made from among the three scenarios separately for each future year). Rather, for each draw, one of the three scenarios was chosen and applied across the full vehicle life for each model year. The probability of selection for each of the three scenarios was modeled using discrete weights of 50 percent for the Reference Case, and 25 percent for both the LOP and HOP cases. Table X-1 lists the AEO gasoline price forecasts under each scenario. These same prices are demonstrated graphically (in 2006 economics) in Figure X-2. Note that these prices include Federal, State, and local fuel taxes. For the uncertainty analysis, taxes were removed because they are viewed as transfer payments (see discussion in Chapter VIII). Estimated retail prices are shown here because they are a better reference point for most readers.

Table X-1

AEO 2008 Gasoline Price Scenarios

	Low	Forecast	High
2011	$2.302	$2.553	$3.056
2012	$2.151	$2.477	$3.068
2013	$2.069	$2.405	$3.082
2014	$2.076	$2.389	$3.189
2015	$1.986	$2.316	$3.194
2016	$1.931	$2.255	$3.139
2017	$1.892	$2.267	$3.162
2018	$1.940	$2.293	$3.237
2019	$1.991	$2.362	$3.320
2020	$2.047	$2.420	$3.430
2021	$2.027	$2.386	$3.410
2022	$2.021	$2.406	$3.418
2023	$2.057	$2.414	$3.467
2024	$2.039	$2.409	$3.452
2025	$2.040	$2.425	$3.486
2026	$2.057	$2.438	$3.577
2027	$2.031	$2.451	$3.609
2028	$2.029	$2.474	$3.641
2029	$2.040	$2.498	$3.712
2030	$2.052	$2.514	$3.736
2031	$2.052	$2.514	$3.736
2032	$2.052	$2.514	$3.736
2033	$2.052	$2.514	$3.736
2034	$2.052	$2.514	$3.736
2035	$2.052	$2.514	$3.736
2036	$2.052	$2.514	$3.736
2037	$2.052	$2.514	$3.736
2038	$2.052	$2.514	$3.736
2039	$2.052	$2.514	$3.736
2040	$2.052	$2.514	$3.736
2041	$2.052	$2.514	$3.736
2042	$2.052	$2.514	$3.736
2043	$2.052	$2.514	$3.736
2044	$2.052	$2.514	$3.736
2045	$2.052	$2.514	$3.736
2046	$2.052	$2.514	$3.736
2047	$2.052	$2.514	$3.736

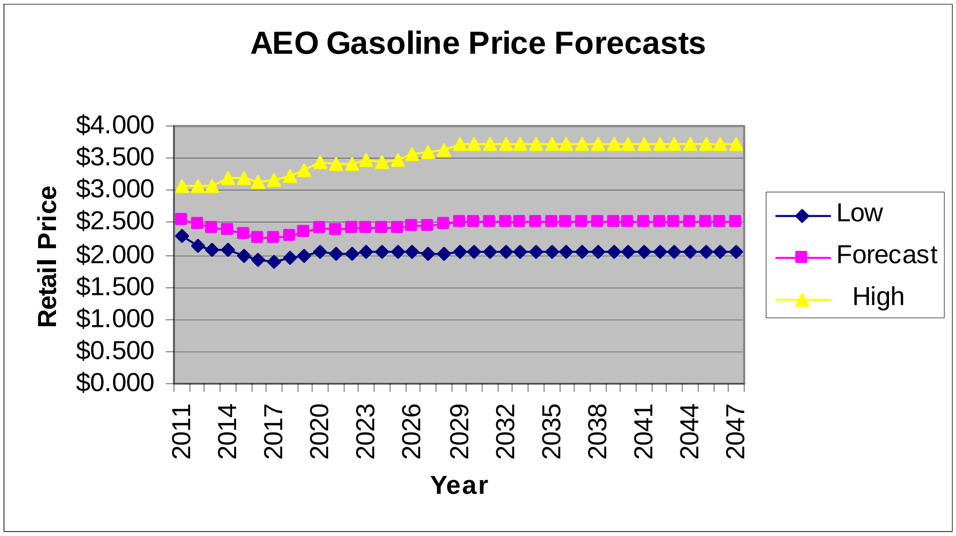


Figure X-2

Oil Consumption Externalities

Reduced fuel consumption can benefit society by lowering the world market price for oil, reducing the threat of petroleum supply disruptions, and reducing the cost of maintaining military security in oil producing regions and operating the strategic petroleum reserve. These benefits are called “externalities” because they are not reflected directly in the market price of fuel. A full description of these externalities is included in Chapter VIII under “Other Economic Benefits from Reducing Petroleum Use.” These factors increase the net social benefits from reduced fuel consumption. Although they represent a relatively small portion of overall social benefits, there is a significant level of uncertainty as to their values. For this reason, they were examined in the uncertainty analysis.

Table X-3 lists the range of values that were examined for oil consumption externalities. The expected values were used in the main analysis. Both the value of reducing U.S. demand on the world market price for oil and the value of reduced threat of supply disruptions were derived from a study by Leiby (2008) (see Chapter VIII). For reasons noted in Chapter VIII, military security is not specifically valued in this analysis. A normal distribution was assumed for the range of values for oil consumption externalities with the low and high values assumed to be two standard deviations from the mean, based on the Leiby estimates.

Table X-3
Uncertainty Ranges for Oil Consumption Externalities ($/gallon)

	Low	Expected	High
For reducing U.S. demand on world market price	$0.028	$0.182	$0.336
For reducing the threat of supply disruptions	$0.035	$0.113	$0.191

The Rebound Effect

By reducing the amount of gasoline used and, thus, the cost of operating a vehicle, higher CAFE standards are expected to result in a slight increase in annual miles driven per vehicle. This "rebound effect" impacts net societal benefits because the increase in miles driven offsets a portion of the gasoline savings that results from more fuel-efficient vehicles. Although consumers derive some value from this extra driving, it also leads to increases in crash, congestion, noise, and pollution costs associated with driving. Most recent estimates of the magnitude of the rebound effect for light duty vehicles fall in the range of 10-20 percent (i.e., increasing vehicle use will offset 10-20 percent of the fuel savings resulting from an improvement in fuel economy). A more complete discussion of the rebound effect is included in Chapter VIII. The agency employed a rebound effect of 15 percent in the main analysis. For the uncertainty analysis, a range of 10 to 20 percent is used and employed in a skewed Beta distribution which produced a mean of approximately 14 percent. The skewed distribution reflects the agency's belief that the more credible studies that differ from the 15 percent value chosen for the main analysis fall below this value and differ by more substantial margins than the upper range of credible values. Table X-3 Summarizes the economic parameters used in the uncertainty analysis.

Table X-3

Monte-Carlo Specific Parameters

Alternative Discount Rates (%)	0.03
Rebound Randomization Parameters	
Rebound Alpha Shape	6.0
Rebound Beta Shape	2.7
Rebound Scale	-0.20
Rebound Base	-0.05
Monopsony Randomization Parameters	
Monopsony Mean	$0.182
Monopsony Standard Deviation	$0.077
Price Shock Randomization Parameters	
Price Shock Mean	$0.113
Price Shock Standard Deviation	$0.039
Military Security Randomization Parameters	
Military Security Mean	$0.000
Military Security Standard Deviation	$0.000
Total Economic Costs of Petroleum Randomization Parameters (Specified in $/gallon)	
Total Economic Costs Alpha Shape	4
Total Economic Costs Beta Shape	2.4118
Total Economic Costs Scale	0.46
Total Economic Costs Base	0.05
Carbon Dioxide Randomization Parameters	
CO-2 Mean	$7.00
CO-2 Standard Deviation	$3.25
Default Cost and FC Variations	
Cost Variation %	0.37
FC Variation %	0.31

Modeling Results – Trial Draws

Because of the complexity of the CAFE model, the computer time required to perform the uncertainty analysis was significant. The uncertainty analysis conducted a total of 40,000 trials (20,000 for each discount rate) Figures X- 3 through X-14 graphically illustrate the draw results for a sample of the 85 variables (41 technology effectiveness rates, 41 technology costs, the fuel price scenario, oil import externalities, the rebound effect, and CO2.) that were examined. Tables X-3 through X-7 list the draw results for each economic input, technology cost, and technology effectiveness.

Figure X-3
Monte Carlo Draw Profile, Passenger Car Costs

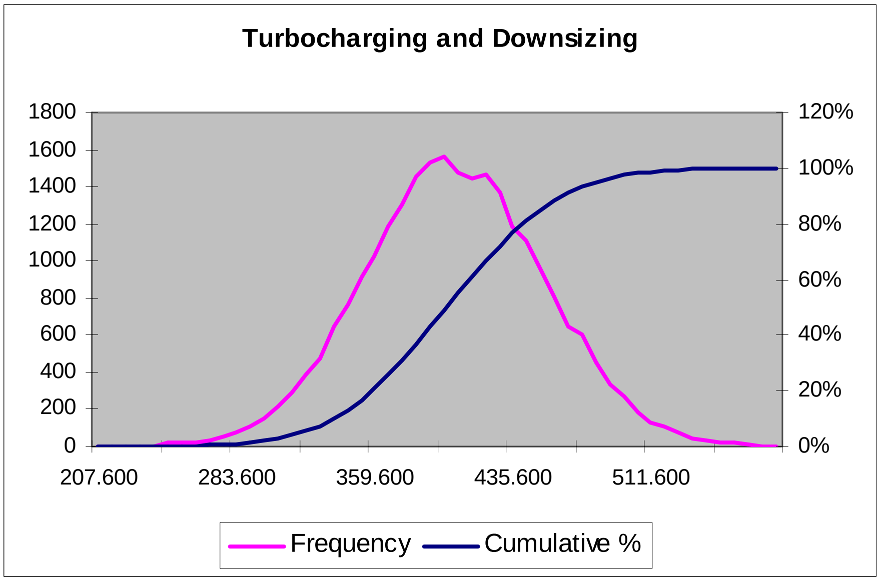


Figure X-4
Monte Carlo Draw Profile, Passenger Car Effectiveness

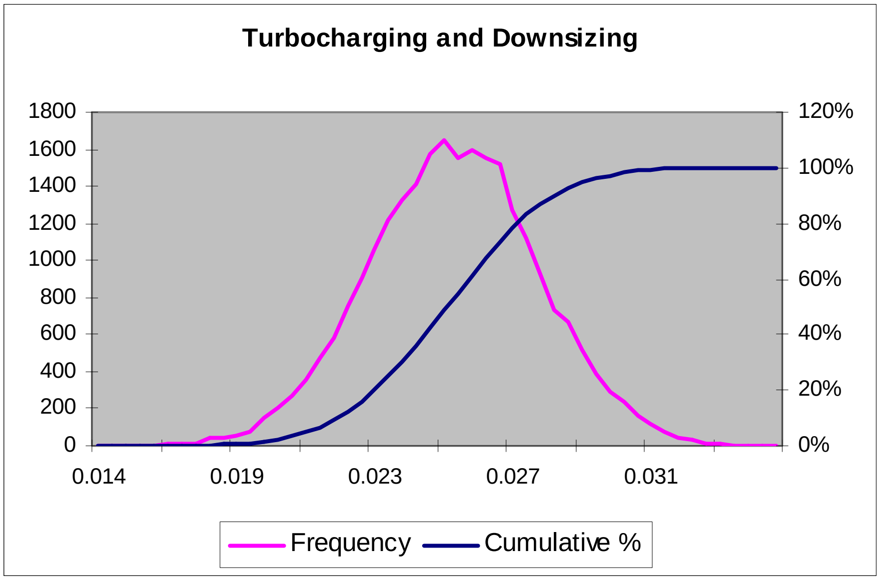


Figure X-5
Monte Carlo Draw Profile, Passenger Cars, Costs

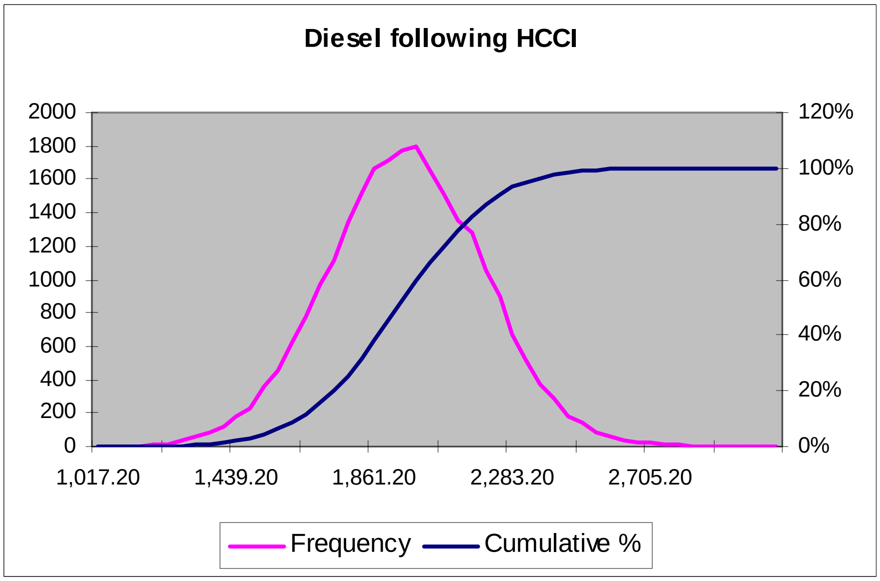


Figure X-6
Monte Carlo Draw Profile, Passenger Cars, Effectiveness

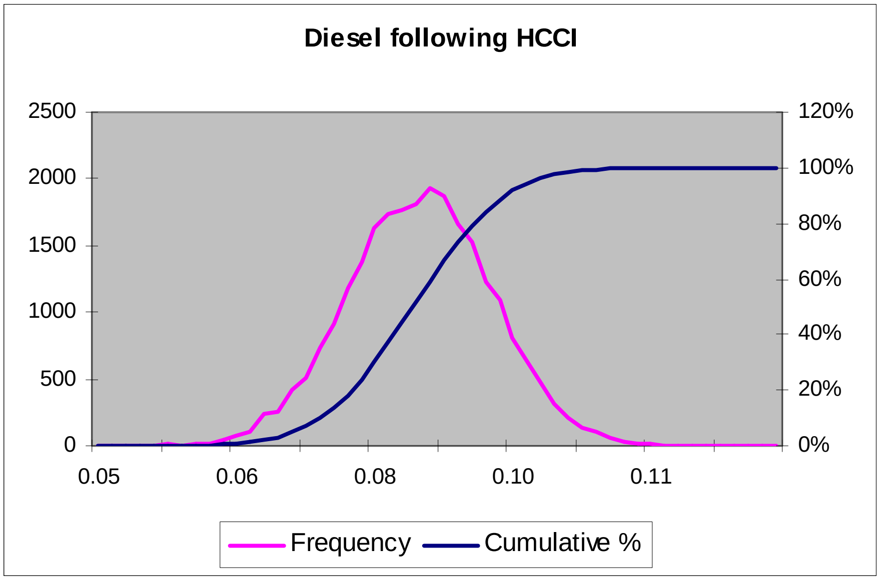


Figure X-7
Monte Carlo Draw Profile, Passenger Cars, Costs

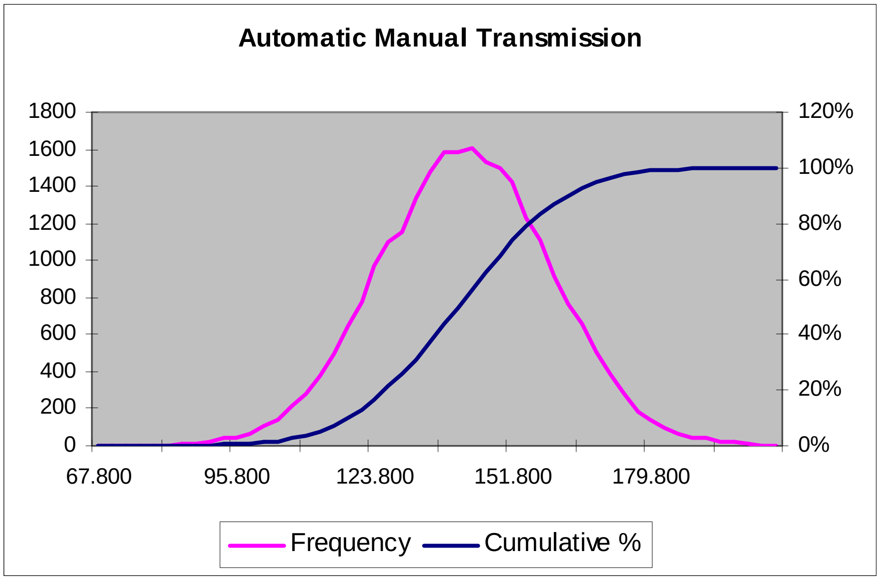


Figure X-8
Monte Carlo Draw Profile, Passenger Cars, Effectiveness

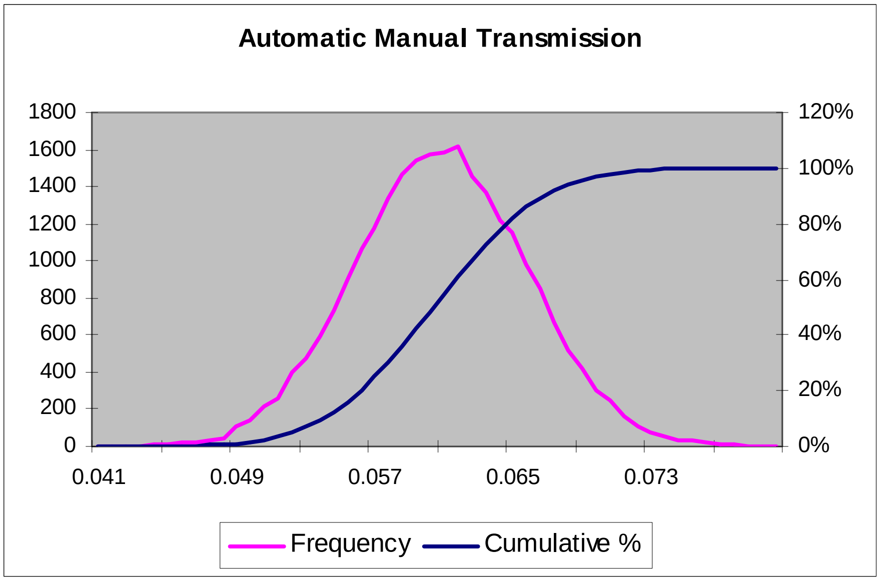


Figure X-9
Monte Carlo Draw Profile
Pretax Fuel Price Path

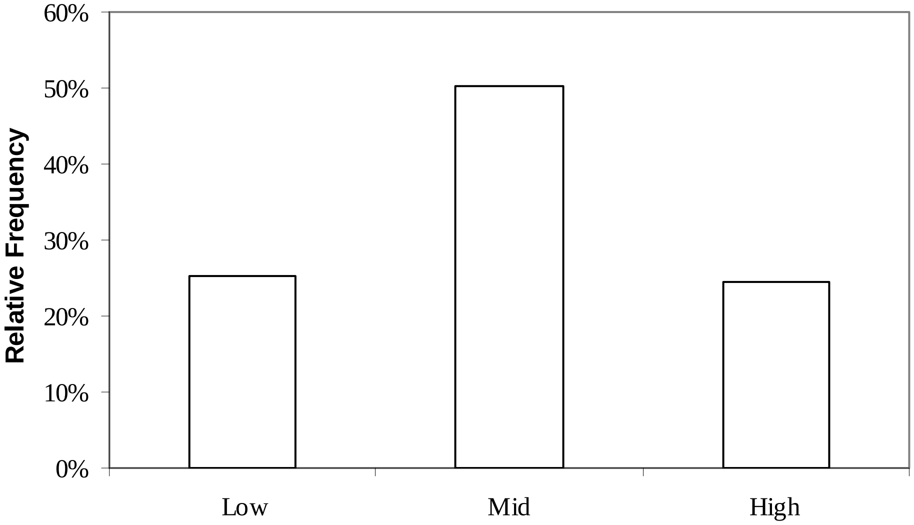


Figure X-10
Monte Carlo Draw Profile

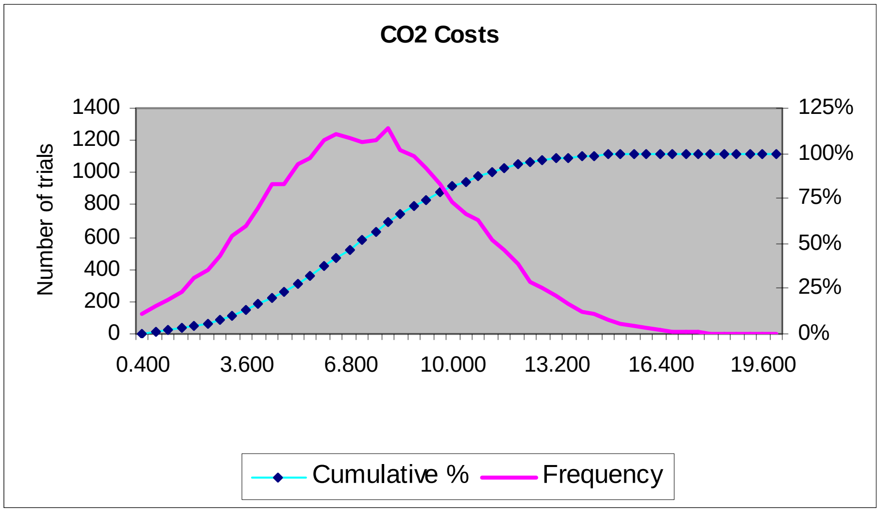


Figure X-11
Monte Carlo Draw Profile

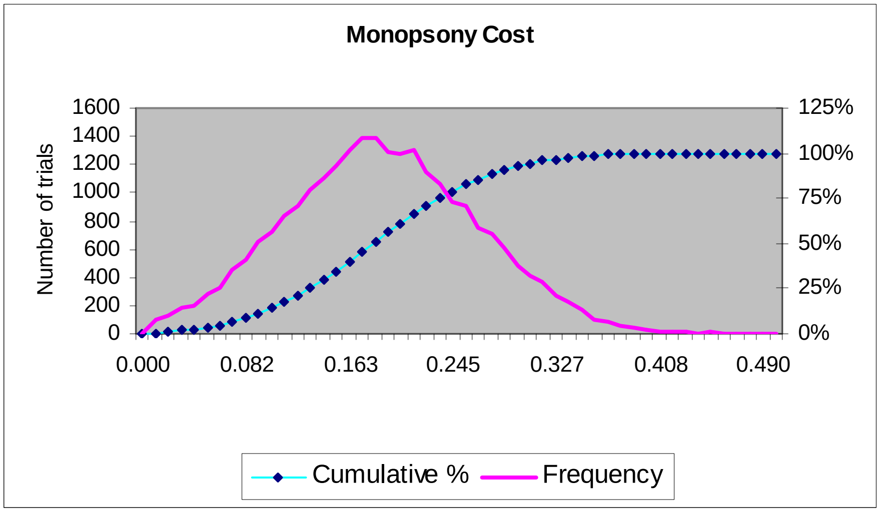


Figure X-12
Monte Carlo Draw Profile

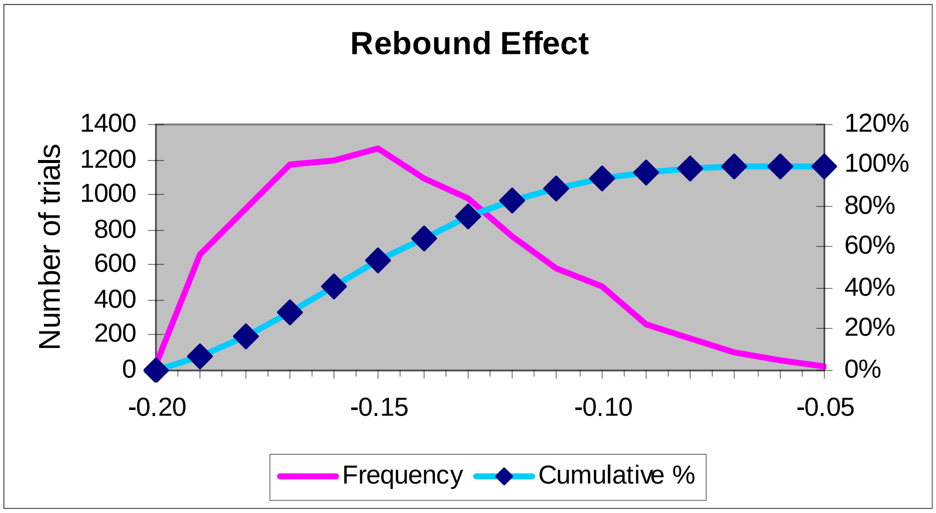


Figure X-13
Monte Carlo Draw Profile

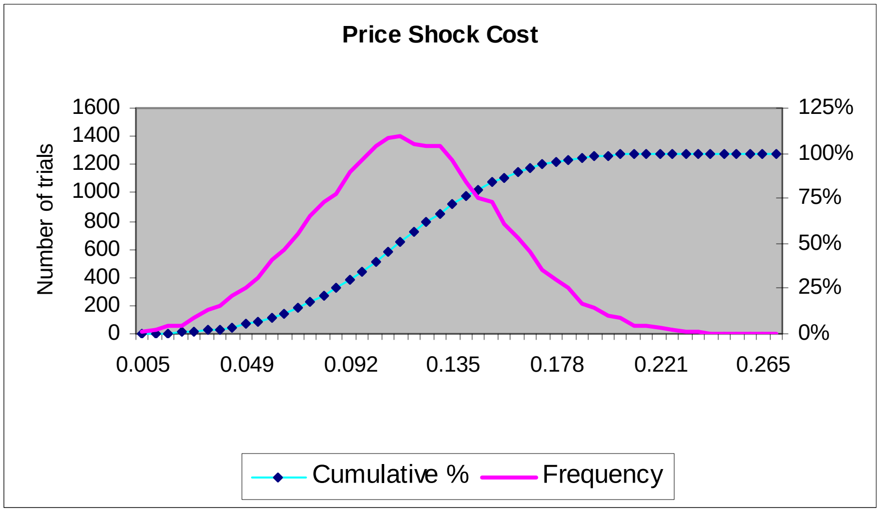


Figure X-14
Monte Carlo Draw Profile

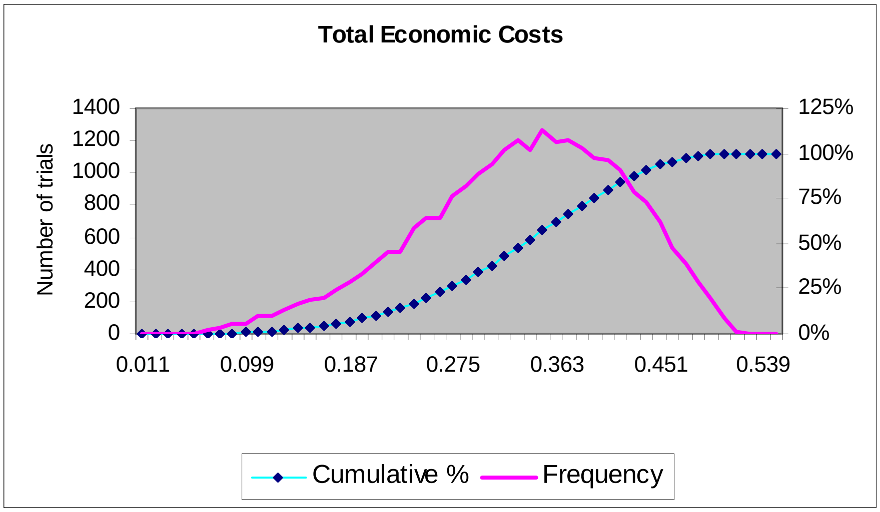


Table X-3
Monte Carlo Draw Results, Economic Inputs

Economic Inputs	**Minimum**	**Maximum**	**Mean**	**StdDev**
Rebound Effect	-0.200	-0.050	-0.139	0.031
Monopsony Cost	2.08E-05	0.4758454	0.184348	0.075127
Price Cost Shock	0.000587	0.2694044	0.112852	0.038933
Total Economic Costs	0.051902	0.508969	0.328306	0.087728
CO2 Costs	0.003939	19.552248	7.150228	3.110129

Table X-4
Monte Carlo Draw Results, Passenger Car Technology Costs

Passenger Car Technology Costs	**Minimum**	**Maximum**	**Mean**	**StdDev**
Low Friction Lubricants	$1.49	$4.74	$3.00	$0.37
Engine Friction Reduction	$0.33	$119.10	$52.78	$17.42
Variable Valve Timing (ICP)	$46.16	$142.36	$89.60	$11.00
Variable Valve Timing (CCP)	$0.00	$0.00	$0.00	$0.00
Variable Valve Timing (DCP)	$29.90	$93.84	$60.68	$7.50
Cylinder Deactivation	$53.49	$165.05	$103.36	$12.82
Variable Valve Lift & Timing (CVVL)	$180.04	$553.92	$361.94	$44.52
Variable Valve Lift & Timing (DVVL)	$103.16	$327.22	$208.04	$25.65
Cylinder Deactivation on OHV	$54.85	$152.41	$103.52	$12.78
Variable Valve Timing (CCP) on OHV	$29.20	$94.35	$59.33	$7.33
Multivalve Overhead Cam with CVVL	$469.56	$1,444.80	$936.29	$114.36
Variable Valve Lift & Timing (DVVL) on OHV	$103.30	$307.42	$208.46	$25.57
Camless Valve Actuation	$0.00	$0.00	$0.00	$0.00
Stoichiometric GDI	$123.72	$536.56	$318.20	$48.03
Diesel following GDI-S (SIDI)	$1,235.43	$3,339.62	$2,219.62	$275.52
Lean Burn GDI	$0.00	$0.00	$0.00	$0.00
Turbocharging and Downsizing	$204.72	$577.86	$399.36	$49.36
Diesel following Turbo D/S	$946.96	$2,877.83	$1,822.07	$224.84
HCCI	$145.97	$440.72	$289.76	$35.85
Diesel following HCCI	$991.05	$3,075.29	$1,932.76	$238.19
5 Speed Automatic Transmission	$59.29	$180.41	$121.75	$15.09
Aggressive Shift Logic	$18.76	$55.53	$38.05	$4.68
Early Torque Converter Lockup	$15.13	$47.27	$30.01	$3.68
6 Speed Automatic Transmission	$0.00	$0.00	$0.00	$0.00
Continuously Variable Transmission	$65.89	$187.47	$120.00	$14.91
6 Speed Manual	$54.50	$168.33	$106.43	$13.08
Improved Accessories	$116.76	$174.09	$145.25	$6.90
Electronic Power Steering	$103.77	$214.40	$157.73	$13.06
42-Volt Electrical System	$184.50	$267.97	$226.75	$10.75
Low Rolling Resistance Tires	$3.25	$8.69	$6.00	$0.74
Low Drag Brakes	$0.00	$0.00	$0.00	$0.00
Secondary Axle Disconnect - Unibody	$633.60	$721.41	$675.69	$11.88
Secondary Axle Disconnect - Ladder Frame	$0.00	$0.00	$0.00	$0.00
Aero Drag Reduction	$0.19	$84.64	$37.59	$12.40
Material Substitution (1%)	$0.00	$0.00	$0.00	$0.00
Material Substitution (2%)	$0.00	$0.00	$0.00	$0.00
Material Substitution (5%)	$0.00	$0.00	$0.00	$0.00
ISG with Idle-Off	$299.07	$858.05	$581.96	$71.76
IMA/ISAD/BSG Hybrid (includes engine downsizing	$967.35	$3,068.39	$1,958.43	$242.67
2-Mode Hybrid	$391.09	$1,163.87	$764.67	$94.39
Power Split Hybrid	$309.05	$960.34	$627.41	$76.93

Table X-5
Monte Carlo Draw Results, Passenger Car Fuel Economy Improvement Rates

Passenger Car Fuel Economy Improvement Rates	Minimum	Maximum	Mean	StdDev
Low Friction Lubricants	0.002908	0.0073035	0.004997	0.000518
Engine Friction Reduction	0.004595	0.0329195	0.01996	0.003341
Variable Valve Timing (ICP)	0.009356	0.0206904	0.014895	0.001545
Variable Valve Timing (CCP)	0.011859	0.0281932	0.020186	0.002083
Variable Valve Timing (DCP)	0.011895	0.0280668	0.02018	0.002085
Cylinder Deactivation	0.013563	0.0348619	0.022915	0.00237
Variable Valve Lift & Timing (CVVL)	0.023194	0.0522346	0.037476	0.003869
Variable Valve Lift & Timing (DVVL)	0.013216	0.0318864	0.022365	0.002324
Cylinder Deactivation on OHV	0.018306	0.044046	0.030546	0.003144
Variable Valve Timing (CCP) on OHV	0.017041	0.0407676	0.027473	0.00283
Multivalve Overhead Cam with CVVL	0.017591	0.0444581	0.030094	0.003111
Variable Valve Lift & Timing (DVVL) on OHV	0.008878	0.0223505	0.014976	0.001546
Camless Valve Actuation	0	0	0	0
Stoichiometric GDI	0.007243	0.0217997	0.014994	0.001682
Diesel following GDI-S (SIDI)	0.094756	0.2441063	0.160479	0.01659
Lean Burn GDI	0.023047	0.0549808	0.037155	0.003851
Turbocharging and Downsizing	0.014385	0.0345359	0.024998	0.002575
Diesel following Turbo D/S	0.078206	0.1893723	0.135461	0.013972
HCCI	0.044389	0.1117523	0.075102	0.007783
Diesel following HCCI	0.049223	0.1261183	0.085368	0.008877
5 Speed Automatic Transmission	0.015092	0.0344635	0.024962	0.002575
Aggressive Shift Logic	0.007926	0.0215958	0.015003	0.001683
Early Torque Converter Lockup	0.002939	0.0074048	0.004999	0.000518
6 Speed Automatic Transmission	0.000918	0.0281055	0.01499	0.003332
Continuously Variable Transmission	0.020615	0.0505527	0.034988	0.003622
6 Speed Manual	0.002992	0.0069901	0.005	0.000518
Improved Accessories	0.007504	0.0212326	0.015009	0.001664
Electronic Power Steering	0.015584	0.0168713	0.016271	0.000147
42-Volt Electrical System	0.008567	0.0217223	0.014992	0.001662
Low Rolling Resistance Tires	0.008928	0.0218487	0.014998	0.001664
Low Drag Brakes	0	0	0	0
Secondary Axle Disconnect - Unibody	0.005908	0.0144799	0.009997	0.001032
Secondary Axle Disconnect - Ladder Frame	0	0	0	0
Aero Drag Reduction	0.017873	0.041923	0.029955	0.003111
Material Substitution (1%)	0.005713	0.0071391	0.006498	0.000168
Material Substitution (2%)	0.00586	0.0071669	0.0065	0.000167
Material Substitution (5%)	0.016592	0.0214113	0.019248	0.000582
ISG with Idle-Off	0.044364	0.1094447	0.075005	0.0078
IMA/ISAD/BSG Hybrid (includes engine downsizing)	0.03486	0.083258	0.059502	0.006136
2-Mode Hybrid	0.010524	0.0267755	0.017813	0.001832
Power Split Hybrid	0.03312	0.0822965	0.057607	0.00598

Table X-6
Monte Carlo Draw Results, Light Truck Technology Costs

Light Truck Technology Costs	Minimum	Maximum	Mean	StdDev
Low Friction Lubricants	$1.49	$4.74	$3.00	$0.37
Engine Friction Reduction	$0.42	$155.39	$68.86	$22.73
Variable Valve Timing (ICP)	$61.18	$188.69	$118.76	$14.58
Variable Valve Timing (CCP)	$0.00	$0.00	$0.00	$0.00
Variable Valve Timing (DCP)	$44.25	$138.87	$89.81	$11.10
Cylinder Deactivation	$108.70	$335.40	$210.04	$26.04
Variable Valve Lift & Timing (CVVL)	$237.53	$730.81	$477.52	$58.74
Variable Valve Lift & Timing (DVVL)	$132.02	$418.79	$266.26	$32.82
Cylinder Deactivation on OHV	$111.47	$309.70	$210.37	$25.96
Variable Valve Timing (CCP) on OHV	$29.20	$94.35	$59.33	$7.33
Multivalve Overhead Cam with CVVL	$648.92	$1,996.67	$1,293.93	$158.04
Variable Valve Lift & Timing (DVVL) on OHV	$132.21	$393.45	$266.80	$32.73
Camless Valve Actuation	$0.00	$0.00	$0.00	$0.00
Stoichiometric GDI	$142.88	$619.65	$367.48	$55.47
Diesel following GDI-S (SIDI)	$1,470.51	$3,975.08	$2,641.97	$327.94
Lean Burn GDI	$0.00	$0.00	$0.00	$0.00
Turbocharging and Downsizing	$157.93	$445.79	$308.09	$38.08
Diesel following Turbo D/S	$1,214.16	$3,689.84	$2,336.19	$288.28
HCCI	$209.73	$633.21	$416.31	$51.51
Diesel following HCCI	$1,143.01	$3,546.83	$2,229.12	$274.71
5 Speed Automatic Transmission	$59.29	$180.41	$121.75	$15.09
Aggressive Shift Logic	$18.76	$55.53	$38.05	$4.68
Early Torque Converter Lockup	$15.13	$47.27	$30.01	$3.68
6 Speed Automatic Transmission	$0.00	$0.00	$0.00	$0.00
Continuously Variable Transmission	$8.78	$24.99	$16.00	$1.99
6 Speed Manual	$54.50	$168.33	$106.43	$13.08
Improved Accessories	$116.76	$174.09	$145.25	$6.90
Electronic Power Steering	$103.77	$214.40	$157.73	$13.06
42-Volt Electrical System	$184.50	$267.97	$226.75	$10.75
Low Rolling Resistance Tires	$2.36	$6.31	$4.36	$0.54
Low Drag Brakes	$38.97	$122.58	$77.27	$9.63
Secondary Axle Disconnect - Unibody	$580.10	$660.49	$618.63	$10.87
Secondary Axle Disconnect - Ladder Frame	$55.77	$159.17	$100.75	$12.41
Aero Drag Reduction	$0.19	$84.64	$37.59	$12.40
Material Substitution (1%)	$0.26	$0.73	$0.50	$0.06
Material Substitution (2%)	$0.37	$0.98	$0.67	$0.08
Material Substitution (5%)	$0.46	$1.23	$0.83	$0.10
ISG with Idle-Off	$308.54	$885.22	$600.39	$74.03
IMA/ISAD/BSG Hybrid (includes engine downsizing	$0.00	$0.00	$0.00	$0.00
2-Mode Hybrid	$2,121.66	$6,314.06	$4,148.37	$512.05
Power Split Hybrid	$0.00	$0.00	$0.00	$0.00

Table X-7
Monte Carlo Draw Results, Light Truck Fuel Economy Improvement Rates

Light Truck Technology Improvement Rates	**Minimum**	**Maximum**	**Mean**	**StdDev**
Low Friction Lubricants	0.002908	0.007303	0.004997	0.000518
Engine Friction Reduction	0.004595	0.03292	0.01996	0.003341
Variable Valve Timing (ICP)	0.007989	0.017667	0.012718	0.001319
Variable Valve Timing (CCP)	0.008747	0.020794	0.014888	0.001536
Variable Valve Timing (DCP)	0.007505	0.01771	0.012733	0.001315
Cylinder Deactivation	0.02665	0.068502	0.045026	0.004656
Variable Valve Lift & Timing (CVVL)	0.012312	0.027728	0.019894	0.002054
Variable Valve Lift & Timing (DVVL)	0.00584	0.014089	0.009882	0.001027
Cylinder Deactivation on OHV	0.03597	0.086549	0.060021	0.006178
Variable Valve Timing (CCP) on OHV	0.00783	0.018731	0.012623	0.001301
Multivalve Overhead Cam with CVVL	0.011624	0.029378	0.019886	0.002056
Variable Valve Lift & Timing (DVVL) on OHV	0.005849	0.014726	0.009867	0.001019
Camless Valve Actuation	0	0	0	0
Stoichiometric GDI	0.007243	0.0218	0.014994	0.001682
Diesel following GDI-S (SIDI)	0.106364	0.274009	0.180138	0.018622
Lean Burn GDI	0	0	0	0
Turbocharging and Downsizing	0.014385	0.034536	0.024998	0.002575
Diesel following Turbo D/S	0.089555	0.216855	0.155119	0.015999
HCCI	0.044389	0.111752	0.075102	0.007783
Diesel following HCCI	0.06055	0.155142	0.105014	0.01092
5 Speed Automatic Transmission	0.015092	0.034464	0.024962	0.002575
Aggressive Shift Logic	0.007926	0.021596	0.015003	0.001683
Early Torque Converter Lockup	0.002939	0.007405	0.004999	0.000518
6 Speed Automatic Transmission	0.000918	0.028105	0.01499	0.003332
Continuously Variable Transmission	0.010549	0.025869	0.017904	0.001853
6 Speed Manual	0.002992	0.00699	0.005	0.000518
Improved Accessories	0.007504	0.021233	0.015009	0.001664
Electronic Power Steering	0.019155	0.020736	0.019999	0.000181
42-Volt Electrical System	0.008567	0.021722	0.014992	0.001662
Low Rolling Resistance Tires	0.006489	0.015879	0.010901	0.00121
Low Drag Brakes	0.002886	0.00734	0.004883	0.000504
Secondary Axle Disconnect - Unibody	0.004294	0.010524	0.007266	0.00075
Secondary Axle Disconnect - Ladder Frame	0.004331	0.010856	0.007326	0.000759
Aero Drag Reduction	0.014964	0.0351	0.02508	0.002605
Material Substitution (1%)	0.005713	0.007139	0.006498	0.000168
Material Substitution (2%)	0.00586	0.007167	0.0065	0.000167
Material Substitution (5%)	0.016592	0.021411	0.019248	0.000582
ISG with Idle-Off	0.044364	0.109445	0.075005	0.0078
IMA/ISAD/BSG Hybrid (includes engine downsizing)	0	0	0	0
2-Mode Hybrid	0.035708	0.090851	0.06044	0.006215
Power Split Hybrid	0.027148	0.067457	0.047219	0.004901

Modeling Results – Output

Tables X-8 and X-9 summarize the modeling results for fuel saved, total costs, societal benefits, and net benefits for passenger cars and trucks respectively under a 7% discount rate. They also indicate the probability that net benefits exceed zero. Tables X-10 and X-11 summarize these same results under a 3% discount rate. These results are also illustrated in Figures X-15 through X-18 for passenger cars under Optimized CAFE at 7 percent for MY 2015. Although not shown here, the general shape of the resulting output distributions are similar for the light trucks, the 3 percent discount rate, and for other model years as well. The humped shape that occurs for both social benefits and net benefits reflects the three different gasoline price scenarios. About half of all draws were selected from the AEO Reference Case, while about one quarter were drawn from the Low Oil Price scenario and one quarter were drawn from the High Oil Price scenario. This produces three separate humps which reflect the increasing impact on benefits from the three progressively higher oil price scenarios. The Low Oil scenario is close enough to the Forecast scenario that the 2 humps visually begin to merge. However, the difference between the High Oil Price scenario and the Forecast is typically more than double the difference between the Forecast and the Low Oil price scenario, which results in a separate distribution further up the x axis. The following discussions summarize the range of results presented in these tables for the combined passenger car and light truck across both the 7 percent (typically the lower range) and 3 percent (typically upper range) discount rates[212].

<u>Fuel Savings</u>: The analysis indicates that MY 2011 vehicles (both passenger cars and light trucks) will experience between 3,370 million and 4,735 million gallons of fuel savings over their useful lifespan. MY 2012 vehicles will experience between 7,476 million and 9,639 million gallons of fuel savings over their useful lifespan. MY 2013 vehicles will experience between 10,863 million and 13,763 million gallons of fuel savings over their useful lifespan. MY 2014 vehicles will experience between 12,568 and 15,664 million gallons of fuel savings over their useful lifespan. MY 2015 vehicles will experience between 14,188 and 17,659 million gallons of fuel savings over their useful lifespan. Over the combined lifespan of the five model years, between 48.5 billion and 61.4 billion gallons of fuel will be saved.

<u>Total Costs</u>: The analysis indicates that owners of MY 2011 passenger cars and light trucks will pay between $2,447 million and $5,256 million in higher vehicle prices to purchase vehicles with improved fuel efficiency. MY 2012 owners will pay between $5,817 million and $10,427 million more. MY 2013 owners will pay between $7,942 million and $15,288 million more. MY 2014 owners will pay between $9,338 million and $17,189 million more. MY 2015 owners will pay between $10,940 million and $19,842 million more. Owners of all five model years vehicles combined will pay between $36.5 billion and $67.9 billion in higher vehicle prices to purchase vehicles with improved fuel efficiency.

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[212] In a few cases the upper range results were obtained from the 7% rate and the lower range results were obtained from the 3% rate. While this may seem counterintuitive, it results from the random selection process that is inherent in the Monte Carlo technique.

<u>Societal Benefits:</u> The analysis indicates that changes to MY 2011 passenger cars and light trucks to meet the proposed CAFE standards will produce overall societal benefits valued between $4,375 million and $13,041 million. MY 2012 vehicles will produce benefits valued between $9,363 million and $28,214 million. MY 2013 vehicles will produce benefits valued between $13,370 million and $41,027 million. MY 2014 vehicles will produce benefits valued between $15,586 million and $47,087 million. MY 2015 vehicles will produce benefits valued between $17,486 million and $53,708 million. Over the combined lifespan of the five model years, societal benefits valued between $60.1 billion and $183.1 billion will be produced.

<u>Net Benefits</u>: The uncertainty analysis indicates that the net impact of the higher CAFE requirements for MY 2011 passenger cars and light trucks will be a net benefit of between $937 million and $9,678 million. There is at least a 99.3 percent certainty that changes made to MY 2011 vehicles to achieve the higher CAFE standards will produce a net benefit. The net impact of the higher CAFE requirements for MY 2012 will be a net benefit of between $283 million and a net benefit of $21,139 million. There is at least a 99.6 percent certainty that changes made to MY 2012 vehicles to achieve the CAFE standards will produce a net benefit. The net impact of the higher CAFE requirements for MY 2013 will be a net benefit of between $494 million and a net benefit of $31,311 million. There is at least a 99.6 percent certainty that changes made to MY 2013 vehicles to achieve the higher CAFE standards will produce a net benefit. The net impact of the higher CAFE requirements for MY 2014 will be a net benefit of between $711 million and $35,746 million. There is 100 percent certainty that changes made to MY 2014 vehicles to achieve the CAFE standards will produce a net benefit. The net impact of the higher CAFE requirements for MY 2015 will be a net benefit of between $654 million and $40,703 million. There is 100 percent certainty that changes made to MY 2015 vehicles to achieve the CAFE standards will produce a net benefit. Over all five model years, the higher CAFE standards will produce net benefits ranging from $3.1 billion to $138.6 billion. There is <u>at least</u> a 99.3 percent certainty that higher CAFE standards will produce a net societal benefit in <u>each</u> of the model years covered by this final rule. In most years, this probability is 100%.

Table X-8
Uncertainty Analysis Results, Passenger Cars
(7% Discount Rate)

MY 2011	Mean	Low	High
Fuel Saved (mill. gall.)	1487	1285	1813
Total Cost ($mill.)	1760	1291	2302
Societal Benefits ($mill.)	2605	1723	4201
Net Benefits ($mill.)	845	435	2574
% Certainty Net Ben. > 0	99.3%		
MY 2012			
Fuel Saved (mill. gall.)	2870	2618	3403
Total Cost ($mill.)	2271	1676	3237
Societal Benefits ($mill.)	5023	3296	8127
Net Benefits ($mill.)	2753	404	6009
% Certainty Net Ben. > 0	100%		
MY 2013			
Fuel Saved (mill. gall.)	3585	3237	4283
Total Cost ($mill.)	2769	2021	3970
Societal Benefits ($mill.)	6280	4071	10388
Net Benefits ($mill.)	3511	493	7666
% Certainty Net Ben. > 0	100%		
MY 2014			
Fuel Saved (mill. gall.)	4613	4200	5372
Total Cost ($mill.)	3707	2793	5109
Societal Benefits ($mill.)	8113	5262	12996
Net Benefits ($mill.)	4407	589	9669
% Certainty Net Ben. > 0	100%		
MY 2015			
Fuel Saved (mill. gall.)	5513	5025	6389
Total Cost ($mill.)	4713	3773	6339
Societal Benefits ($mill.)	9703	6296	15668
Net Benefits ($mill.)	4989	445	11413
% Certainty Net Ben. > 0	100%		

Table X-9
Uncertainty Analysis Results, Light Trucks
(7% Discount Rate)

MY 2011	Mean	Low	High
Fuel Saved (mill. gall.)	2312	2085	2922
Total Cost ($mill.)	1696	1156	2954
Societal Benefits ($mill.)	3968	2652	6131
Net Benefits ($mill.)	2272	502	4491
% Certainty Net Ben. > 0	100.0		
MY 2012			
Fuel Saved (mill. gall.)	5373	4858	6236
Total Cost ($mill.)	5213	4141	7190
Societal Benefits ($mill.)	9128	6067	14300
Net Benefits ($mill.)	3915	-121	9273
% Certainty Net Ben. > 0	99.6%		
MY 2013			
Fuel Saved (mill. gall.)	8270	7626	9453
Total Cost ($mill.)	7501	5921	11318
Societal Benefits ($mill.)	14053	9299	21967
Net Benefits ($mill.)	6552	-29	15031
% Certainty Net Ben. > 0	99.6		
MY 2014			
Fuel Saved (mill. gall.)	9071	8381	10258
Total Cost ($mill.)	8216	6545	12080
Societal Benefits ($mill.)	15489	10324	24311
Net Benefits ($mill.)	7273	122	16549
% Certainty Net Ben. > 0	100.0%		
MY 2015			
Fuel Saved (mill. gall.)	9942	9163	11270
Total Cost ($mill.)	8996	7167	13435
Societal Benefits ($mill.)	17013	11190	26862
Net Benefits ($mill.)	8018	209	18321
% Certainty Net Ben. > 0	100%		

Table X-10
Uncertainty Analysis Results, Passenger Cars
(3% Discount Rate)

MY 2011	Mean	Low	High
Fuel Saved (mill. gall.)	1503	1285	1798
Total Cost ($mill.)	1782	1309	2295
Societal Benefits ($mill.)	3235	2142	5087
Net Benefits ($mill.)	1454	-29	3544
% Certainty Net Ben. > 0	100%		
MY 2012			
Fuel Saved (mill. gall.)	2889	2621	3392
Total Cost ($mill.)	2299	1695	3286
Societal Benefits ($mill.)	6215	4050	10036
Net Benefits ($mill.)	3916	1180	7953
% Certainty Net Ben. > 0	100%		
MY 2013			
Fuel Saved (mill. gall.)	3611	3245	4284
Total Cost ($mill.)	2807	2086	3990
Societal Benefits ($mill.)	7789	5002	12868
Net Benefits ($mill.)	4982	1468	10164
% Certainty Net Ben. > 0	100%		
MY 2014			
Fuel Saved (mill. gall.)	4639	4220	5374
Total Cost ($mill.)	3754	2877	5050
Societal Benefits ($mill.)	10053	6475	16285
Net Benefits ($mill.)	6299	1847	12783
% Certainty Net Ben. > 0	100%		
MY 2015			
Fuel Saved (mill. gall.)	5538	5047	6389
Total Cost ($mill.)	4764	3730	6298
Societal Benefits ($mill.)	12025	7770	19419
Net Benefits ($mill.)	7262	1956	15167
% Certainty Net Ben. > 0	100%		

Table X-11

Uncertainty Analysis Results, Light Trucks
(3% Discount Rate)

MY 2011	Mean	Low	High
Fuel Saved (mill. gall.)	2324	2090	2836
Total Cost ($mill.)	1721	1190	2922
Societal Benefits ($mill.)	5031	3359	7954
Net Benefits ($mill.)	3311	1324	6134
% Certainty Net Ben. > 0	100%		
MY 2012			
Fuel Saved (mill. gall.)	5371	4855	6234
Total Cost ($mill.)	5212	4200	7046
Societal Benefits ($mill.)	11522	7622	18178
Net Benefits ($mill.)	6310	1853	13186
% Certainty Net Ben. > 0	100%		
MY 2013			
Fuel Saved (mill. gall.)	8278	7640	9479
Total Cost ($mill.)	7517	6049	11122
Societal Benefits ($mill.)	17791	11729	28159
Net Benefits ($mill.)	10274	2736	21147
% Certainty Net Ben. > 0	100%		
MY 2014			
Fuel Saved (mill. gall.)	9074	8348	1029
Total Cost ($mill.)	8227	6567	11945
Societal Benefits ($mill.)	19618	12966	30802
Net Benefits ($mill.)	11391	3169	22963
% Certainty Net Ben. > 0	100%		
MY 2015			
Fuel Saved (mill. gall.)	9942	9175	11264
Total Cost ($mill.)	9008	7297	13544
Societal Benefits ($mill.)	21567	14121	34289
Net Benefits ($mill.)	12559	3551	25536
% Certainty Net Ben. > 0	100%		

Figure X-13

Model Output Profile

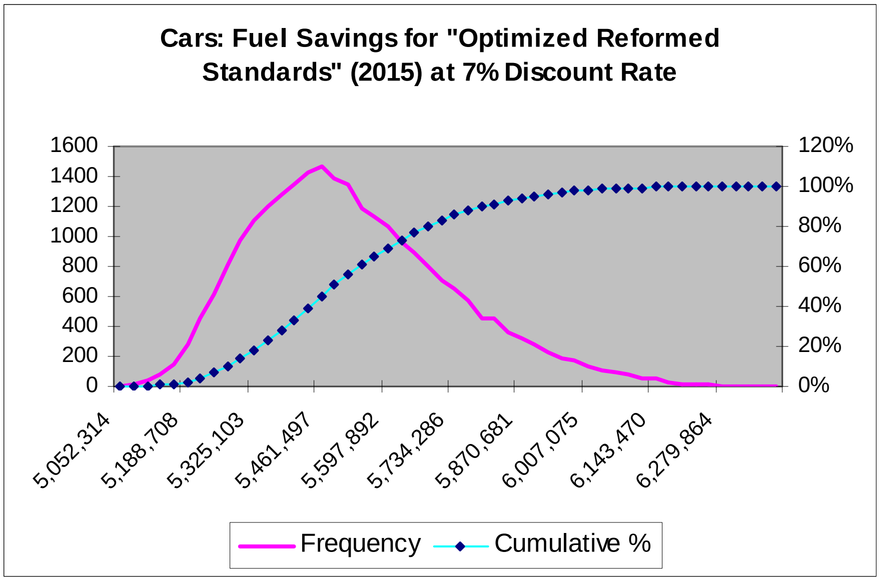

Figure X-14

Model Output Profile

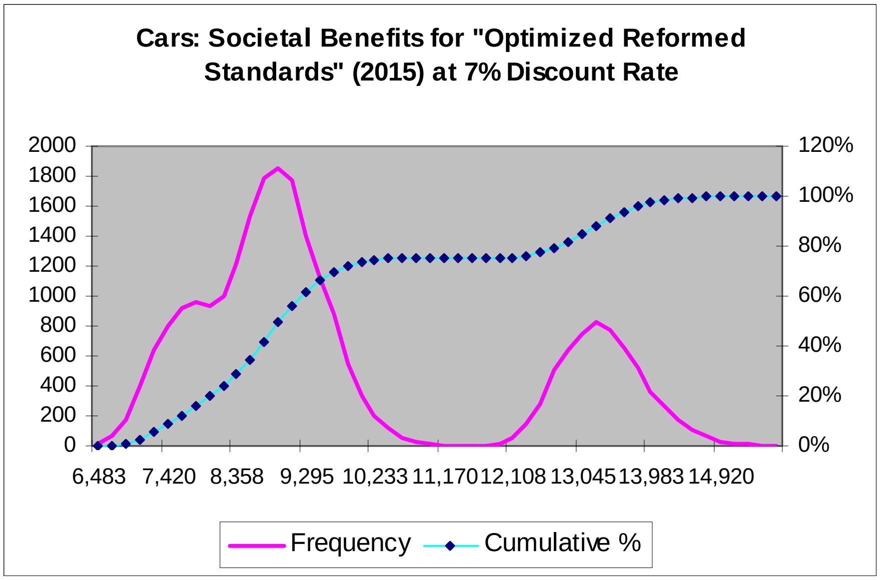

Figure X-15

Model Output Profile

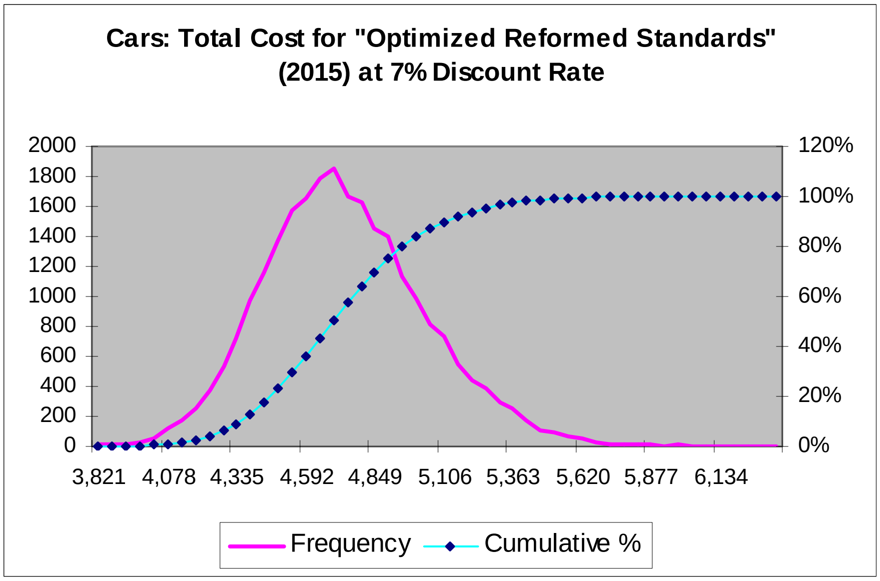

Figure X-16

Model Output Profile