Chapter 3 Affected Environment and Environmental Consequences

3.1 INTRODUCTION

Council on Environmental Quality (CEQ) regulations for implementing the procedural provisions of the National Environmental Policy Act (NEPA) suggest a standard format for an environmental impact statement (EIS) that includes a section on affected environment and a section on environmental consequences. In this Final EIS (FEIS), the National Highway Traffic Safety Administration (NHTSA) addresses affected environment and potential environmental consequences of the proposed action and alternatives in sections under the heading for each resource area – energy (Section 3.2), air quality (Section 3.3), climate (Section 3.4), and various other potentially affected resource areas (Section 3.5). This structure enables the reader to readily learn about existing environmental conditions and potential environmental consequences related to each resource area.

The table below lists topics in a typical NEPA analysis and the section(s) in this chapter that address each topic.

Typical NEPA Topics	FEIS Sections
Water	3.4 Climate; 3.5.1 Water Resources
Ecosystems	3.4 Climate; 3.5.1 Water Resources; 3.5.2 Biological Resources
Threatened and endangered species	3.5.2.1.4 Endangered Species
Publicly owned parklands, recreational areas, wildlife and waterfowl refuges, historic sites, Section 4(f)-related issues	3.4 Climate; 3.5.1 Water Resources; 3.5.2 Biological Resources; 3.5.3 Land Use and Development; 3.5.6 Land Uses Protected under Section 4(f); 3.5.7 Historic and Cultural Resources
Properties and sites of historic and cultural significance	3.4 Climate; 3.5.3 Land Use and Development; 3.5.6 Land Uses Protected under Section 4(f); 3.5.7 Historic and Cultural Resources
Considerations relating to pedestrians and bicyclists	3.4 Climate; 3.5.3 Land Use and Development
Social impacts	3.2 Energy; 3.4 Climate; 3.5.3 Land Use and Development; 3.5.9 Environmental Justice
Noise	3.4 Climate; 3.5.3 Land Use and Development; 3.5.8 Noise
Air	3.2 Energy; 3.3 Air Quality; 3.4 Climate
Energy supply and natural resource development	3.2 Energy; 3.3 Air Quality; 3.4 Climate; 3.5.1 Water Resources; 3.5.2 Biological Resources; 3.5.3 Land Use and Development
Floodplain management evaluation	3.4 Climate; 3.5.1 Water Resources
Wetlands and coastal zones	3.4 Climate; 3.5.1 Water Resources; 3.5.2 Biological Resources
Construction impacts	3.2 Energy; 3.3 Air Quality; 3.4 Climate; 3.5.1 Water Resources; 3.5.2 Biological Resources; 3.5.3 Land Use and Development
Land use and urban growth	3.2 Energy; 3.3 Air Quality; 3.4 Climate; 3.5.1 Water Resources; 3.5.2 Biological Resources; 3.5.3 Land Use and Development
Human environment involving community disruption and relocation	3.2 Energy; 3.3 Air Quality; 3.4 Climate; 3.5.3 Land Use and Development; 3.5.4 Safety and Other Human Health Impacts; 3.5.5 Hazardous Materials and Regulated Wastes; 3.5.9 Environmental Justice

3.1.1 Direct and Indirect Impacts

CEQ regulations state that an EIS "shall succinctly describe" the environment to be affected by the alternatives under consideration and to provide data and analyses "commensurate with the importance of the impact[s]." 40 Code of Federal Regulations (CFR) §§ 1502.15, 1502.16. This chapter provides the analysis to determine and compare the significance of the direct and indirect effects of the proposed action and alternatives. Under NEPA, direct effects "are caused by the action and occur at the same time and place." 40 CFR §1508.8. CEQ regulations define indirect effects as those that "are caused by the action and are later in time or farther removed in distance but are still reasonably foreseeable. Indirect effects may include … effects on air and water and other natural systems, including ecosystems." 40 CFR §1508.8. Sections 3.2, 3.3, and 3.4 provide a quantitative analysis of the direct and indirect effects of the proposed action on energy, air, and climate, respectively. Impacts to other resource areas typically addressed in an EIS and the areas required by U.S. Department of Transportation (DOT) Order 5610, such as biological resources, water resources, noise, land use, and environmental justice, are described qualitatively in Section 3.5, because there were not enough data available in the literature for a quantitative analysis and because many of these effects are not localized. In this FEIS, such qualitative analysis is sufficient for NEPA purposes (DOT 1979).

3.1.2 Areas Not Affected

DOT's NEPA procedures[1] describe various areas that should be considered in an EIS. Many of these areas are covered in the sections below. NHTSA has considered the impact of the proposed action alternatives to all areas outlined by the procedures and has determined the following would not be directly or indirectly affected by the proposed action: human environment, including disruption and relocation, and considerations relating to pedestrians and bicyclists; floodplain management; and construction impacts. However, some of these areas could be affected by the cumulative impacts of the proposed action in combination with other foreseeable actions (*see* Chapter 4).

3.1.3 Approach to Scientific Uncertainty and Incomplete Information

3.1.3.1 CEQ Regulations

CEQ regulations recognize that many federal agencies encounter limited information and substantial uncertainties when analyzing the potential environmental impacts of their actions under NEPA. Accordingly, the regulations provide agencies with a means of formally acknowledging incomplete or unavailable information in NEPA documents. Where "information relevant to reasonably foreseeable significant adverse impacts cannot be obtained because the overall costs of obtaining it are exorbitant or the means to obtain it are not known," the regulations (40 CFR § 1502.22(b)) require an agency to include in its NEPA document:

1. A statement that such information is incomplete or unavailable

2. A statement of the relevance of the incomplete or unavailable information to evaluating reasonably foreseeable significant adverse impacts on the human environment

[1] *See* 42 United States Code (U.S.C.) § 4332 (requiring federal agencies to "identify and develop methods and procedures … which will insure that presently unquantified environmental amenities and values may be given appropriate consideration"); 40 CFR § 1502.23 (requiring an EIS to discuss the relationship between a cost-benefit analysis and any analyses of unquantified environmental impacts, values, and amenities); CEQ 1984 (recognizing that agencies are sometimes "limited to qualitative evaluations of effects because cause-and-effect relationships are poorly understood" or cannot be quantified).

3. A summary of existing credible scientific evidence relevant to evaluating the reasonably foreseeable significant adverse impacts on the human environment

4. The agency's evaluation of such impacts based on theoretical approaches or research methods generally accepted in the scientific community

Relying on these provisions is appropriate when an agency is performing a NEPA analysis that involves potential environmental impacts due to carbon dioxide (CO_2) emissions. *See*, for example, *Mayo Found. v. Surface Transp. Bd.*, 472 F.3d 545, 555 (8th Cir. 2006). CEQ regulations also authorize agencies to incorporate material into a NEPA document by reference to "cut down on bulk without impeding agency and public review of the action" (40 CFR § 1502.21).

Throughout this FEIS, NHTSA uses these two mechanisms – acknowledging incomplete or unavailable information and incorporation by reference – to address areas for which NHTSA cannot develop a credible estimate of the potential environmental impacts of the proposed action or alternatives. In particular, NHTSA recognizes that information about the potential environmental impacts of changes in emissions of CO_2 and other greenhouse gases (GHGs) and associated changes in temperature, including those expected to result from the proposed rule, is incomplete. NHTSA often relies on the Intergovernmental Panel on Climate Change (IPCC) 2007 Fourth Assessment Report as a recent "summary of existing credible scientific evidence which is relevant to evaluating the reasonably foreseeable significant adverse impacts on the human environment" (40 CFR § 1502.22(b)(3)).

3.1.3.2 Uncertainty with the IPCC Framework

The IPCC reports communicate uncertainty and confidence bounds using descriptive words in italics, such as *likely* and *very likely*, to represent levels of confidence in conclusions. This convention is briefly explained in the IPCC Fourth Assessment Synthesis Report and the IPCC Fourth Assessment Report Summary for Policymakers (IPCC 2007d, IPCC 2007c). A more detailed discussion of the IPCC treatment of uncertainty can be found in the IPCC Guidance Notes for Lead Authors of the IPCC Fourth Assessment Report on Addressing Uncertainties (IPCC 2005).

This FEIS uses the IPCC uncertainty language (always noted in italics) throughout Chapters 3 and 4 when discussing qualitative environmental impacts to certain resources. The reader should refer to the referenced IPCC documents above to gain a full understanding of the meaning of those uncertainty terms, because they might be used differently than similar language describing uncertainty in the FEIS, as required by the CEQ regulations described in Section 3.1.3.1.

3.1.4 Common Methodologies

The Corporate Average Fuel Economy (CAFE) Compliance and Effects Modeling System (referred to herein as the Volpe model) is a peer-reviewed modeling system developed by the DOT Volpe National Transportation Systems Center (Volpe Center). The Volpe model serves two fundamental purposes: (1) to identify technologies each manufacturer could apply to comply with a specified set of CAFE standards and (2) to calculate the costs and effects of manufacturers' application of technologies – including changes in fuel use and, therefore, CO_2 emissions. The Volpe model provides data that were used to analyze energy, air, and climate impacts.

The Volpe model begins with an initial state of the domestic vehicle market, which in this case is the market for passenger cars and light trucks to be sold during the period covered by the proposed rule. The vehicle market is defined on a model-by-model, engine-by-engine, and transmission-by-transmission

basis, such that each defined vehicle model refers to a separately defined engine and a separately defined transmission.

For the model years covered by the current proposal, the light vehicle (passenger car and light truck) market forecast includes more than 3,000 vehicle models, more than 400 specific engines, and nearly 400 specific transmissions. This level of detail in the representation of the vehicle market is vital to an accurate analysis of manufacturer-specific costs and the analysis of reformed CAFE standards, and is much greater than the level of detail used by many other models and analyses relevant to light vehicle fuel economy.[2]

The Volpe model also uses several additional categories of data and estimates provided in various external input files for all vehicle categories (small, mid-size, and large sport utility vehicles [SUVs]; small and large pickups; minivans; sub-compact, compact, midsize, and large cars) including:

- Fuel-saving technology characteristics
  - Commercialization year
  - Effectiveness and cost
  - "Learning effect" cost coefficients
  - "Technology path" inclusion/exclusion
  - "Phase-in caps" on penetration rates
  - "Synergy" options
- Vehicular emissions rates, carbon monoxide (CO), volatile organic compounds (VOCs), nitrogen oxides (NO_x), particulate matter (PM), and sulfur dioxide (SO_2) for vehicular travel (that is, vehicle miles traveled [VMT])
- Economic and other data and estimates
  - Vehicle survival (percent of vehicles of a given vintage that remain in service)
  - Mileage accumulation (annual travel by vehicles of a given vintage)
  - Price/fuel taxation rates for seven fuels (such as gasoline and diesel)
  - Pump prices (including taxes) for vehicle fuel savings/retail price
  - Rebound effect coefficient (the elasticity of VMT in relation to per-mile cost of fuel)
  - Discount rate; "payback period" (the number of years purchasers consider when taking into account fuel savings)
  - Fuel economy "gap" (for example, laboratory versus actual)
  - Per-vehicle value of travel time (in dollars per hour)
  - The economic costs (in dollars per gallon) of petroleum consumption
  - Various external costs (all in dollars per mile) associated with changes in vehicle use

[2] Because CAFE standards apply to the average performance of each manufacturer's fleet of cars and light trucks, the impact of potential standards on individual manufacturers cannot be credibly estimated without analysis of manufacturers' planned fleets. Furthermore, because required CAFE levels under an attribute-based CAFE standard depend on manufacturers' fleet composition, the stringency of an attribute-based standard cannot be predicted without performing analysis at this level of detail.

  - Damage costs (all on a dollar-per-ton basis) for each of the above-mentioned criteria pollutants
  - The civil-penalties rate for noncompliance

- Properties of different fuels
  - Upstream CO_2 and criteria pollutant emissions rates (that is, U.S. emissions resulting from the production and distribution of each fuel)
  - Density (pounds per gallon); energy density (British thermal unit [BTU] per gallon)
  - Carbon content
  - Shares of fuel savings leading to reduced domestic refining
  - Relative shares of different gasoline blends

- Sensitivity analysis coefficients; high and low fuel price forecasts

- CAFE scenarios
  - Baseline (no action or business-as-usual)
  - Alternative scenarios defining coverage, structure, and stringency of CAFE standards

With all of the above input data and estimates, the modeling system develops an estimate of a set of technologies each manufacturer could apply in response to each specified CAFE scenario alternative.

The modeling system begins with the "initial state" (baseline) of each manufacturer's future vehicles and accumulates the estimated costs of progressive additions of fuel-saving technologies. Within a set of specified constraints, the system adds technologies following a cost-minimizing approach. At each step, the system evaluates the effective cost of applying available technologies to individual vehicle models, engines, or transmissions, and selects the application of technology that produces the lowest effective cost. The effective cost estimated to be considered by the manufacturer is calculated by adding the total incurred technology costs (in retail price equivalent [RPE]), subtracting the reduction in civil penalties owed for noncompliance with the CAFE standard, subtracting the estimated value of the reduction in fuel costs, and dividing the result by the number of affected vehicles.

In representing manufacturer decisions in response to a given CAFE standard, the modeling system accounts for the fact that, historically, some manufacturers have not been willing to pay penalties and some have. Thus, the system applies technologies until any of the following conditions are met: the manufacturer no longer owes civil penalties for failing to meet the applicable standard, the manufacturer has exhausted technologies expected to be available in that model year, or the manufacturer is estimated to be willing to pay civil penalties, and doing so is estimated to be less expensive than continuing to add technologies.

The system then progresses to the next model year (if included in the vehicle market and scenario input files), "carrying over" technologies where vehicle models are projected to be succeeded by other vehicle models. The Volpe model does not attempt to account for CAFE credits or intentional over-compliance (that is, achieving an average fuel economy higher than that required by law), or the "pull ahead" application of technologies.[3]

[3] Manufacturers might "pull ahead" the implementation of some technologies in response to CAFE standards that they know will be steadily increasing over time. For example, if a manufacturer plans to redesign many vehicles in

The Volpe model completes this compliance simulation for all manufacturers and all model years and produces various outputs from the effects of changes in fuel economy. The outputs include:

- Total cost (TC) of all applied technologies
- Year-by-year mileage accumulation – including the rebound effect
- Year-by-year fuel consumption
- CO_2 and criteria pollutants – domestic full fuel-cycle emissions,[4] monetary damages
- Total discounted/undiscounted national societal costs of year-to-year fuel consumption
- Additional travel – consumer surplus[5]
- Economic externalities – congestion, accidents, noise
- Value of time saved
- Total discounted/undiscounted societal benefits – including net social benefits and benefit-cost ratio (EIA 2008a)

The specific outputs associated with each alternative examined in this FEIS reflect the estimated values for key inputs into the Volpe model. The outputs of the Volpe model provide data used to analyze energy, air, and climate impacts, so these environmental impacts also reflect the inputs into the Volpe model. NHTSA acknowledges that appropriate model input values are subject to uncertainty and debate. In this FEIS, NHTSA addresses uncertainty by explicitly presenting analytical results for Reference Case model inputs, high case (High Scenario) model inputs, and several other scenarios with model inputs (such as fuel prices) and outputs (such as required miles per gallon) that fall between those in the Reference Case and High Scenarios. Table 2.5-19 in this FEIS shows how variations in key Volpe model input values affect Volpe model outputs (vehicle miles, miles per gallon [mpg], fuel consumption, and carbon emissions) across the range of input scenarios for the Optimized Alternative. For discussions of model inputs chosen for the various scenarios, refer to Chapter 10 of this FEIS.

Sections 3.3.3.2 through 3.3.4.9 describe the analysis of alternatives for the Reference Case model inputs (Sections 3.3.3.2 through 3.3.3.8) and then describe the impacts for the same alternatives under the High Scenario and two other scenarios – Mid-1 and Mid-2 – that have Volpe model inputs and outputs that fall between those of the Reference Case and High Scenario (Sections 3.3.4.2 through 3.3.4.9). This analytical structure is designed to fully inform the public and decisionmakers about the potential environmental impacts of any combination of economic inputs into the Volpe model, across the range of feasible alternatives.

model year (MY) 2011 and not in MY 2013, but the standard for MY 2013 is considerably higher than that for MY 2011, the manufacturer might find it less expensive during MY 2011 through MY 2013 (taken together) to apply more technology in MY 2011 than is necessary for compliance with the MY 2011 standard.

[4] Domestic full fuel-cycle emissions include the emissions associated with production, transportation, and refining operations, and the CO_2 emissions from fuel combustion.

[5] Consumer surplus measures the net benefits that drivers receive from additional travel and refers to the amount by which the benefits from additional travel exceed its costs (for fuel and other operating expenses).

3.2 ENERGY

Over the past decade and a half, energy intensity in the United States (energy use per dollar of gross domestic product [GDP]) has declined at about 2 percent per year (EIA 2008a). Despite the growth in population and the economy, energy intensity has fallen due to a combination of increased efficiency and a structural shift in the economy to less energy-intensive industries. Nevertheless, transportation fuel consumption has grown steadily and is the major component of the use of petroleum.

3.2.1 Affected Environment

Table 3.2-1 shows U.S. and global energy consumption by sector from the Energy Information Administration (EIA), which collects and provides the official energy statistics for the United States and whose data are the primary source for analysis and modeling of energy systems by government and private entities. Actual-consumption data show a steady increase in the United States in most of the sectors, particularly the transportation sector. By 2004, transportation was the second highest consumer of energy after industrial and comprised 27.8 and 17.3 percent of the U.S. and global (less U.S.) energy use, respectively.

Table 3.2-1

Energy Consumption By Sector

Sector (Quadrillion Btu)	Actual a/				Forecast b/				
	1990	1995	2000	2004	2010	2015	2020	2025	2030
United States									
Residential	17.0	18.6	20.5	21.2	22.2	22.6	23.4	24.2	25.0
Commercial	13.3	14.7	17.2	17.7	18.7	20.3	22.0	23.5	25.0
Industrial	31.9	34.0	34.8	33.6	33.3	33.9	34.3	34.9	35.0
Transportation	22.4	23.8	26.6	27.9	29.0	30.4	31.2	31.9	33.0
Total	84.7	91.2	99.0	100.4	103.3	107.3	110.8	114.5	118.0
Transportation (%)	26.5	26.2	26.8	27.8	28.1	28.4	28.2	27.9	28.0
World									
Residential	- -	- -	- -	47.7	53.9	59.0	62.7	65.8	69.0
Commercial	- -	- -	- -	24.5	28.3	31.7	34.6	37.5	40.7
Industrial	- -	- -	- -	163.6	183.1	201.4	220.5	238.1	257.1
Transportation	- -	- -	- -	87.7	97.5	106.3	115.4	125.3	136.5
Total	347.4	365.0	398.1	446.7	511.1	559.4	607.0	653.7	701.6
Transportation (%)	- -	- -	- -	19.6	19.1	19.0	19.0	19.2	19.5
International (World less United States)									
Residential	- -	- -	- -	26.5	31.7	36.4	39.3	41.6	44.0
Commercial	- -	- -	- -	6.8	9.6	11.4	12.6	14.0	15.7
Industrial	- -	- -	- -	130.0	149.8	167.5	186.2	203.2	222.1
Transportation	- -	- -	- -	59.8	68.5	75.9	84.2	93.4	103.5
Total	262.8	273.9	299.2	346.3	407.8	452.1	496.2	539.2	583.6
Transportation (%)	- -	- -	- -	17.3	16.8	16.8	17.0	17.3	17.7

a/ **Actual United States data**: Annual Energy Review (AER) 2006, http://www.eia.doe.gov/aer/pdf/pages/sec2_4.pdf
Actual World data: International Energy Review (IER) 2005, http://www.eia.doe.gov/pub/international/iealf/tablee1.xls

b/ **Forecasted United States data**: Annual Energy Outlook (AEO) 2008, http://www.eia.doe.gov/oiaf/aeo/excel/aeotab_2.xls
Forecasted World data: International Energy Outlook (IEO) 2007, http://www.eia.doe.gov/oiaf/ieo/excel/ieonuctab_1.xls

EIA projections show a steady increase in both U.S. and global transportation energy consumption (EIA 2008a). Despite efforts to increase the use of non-fossil fuels in transportation, fuel use remains largely petroleum based. In 2007, finished motor gasoline and on-road diesel constituted 66 percent of all finished petroleum products consumed in the United States. If other transportation fuels (aviation fuels, marine and locomotive diesel, and bunkers) are included, transportation fuels constitute approximately 79 percent of the finished petroleum products used.

Most U.S. gasoline and diesel is produced domestically (EIA 2008b). In 2007, 4 percent of finished motor gasoline and 6 percent of on-road diesel were imported. However, increasing volumes of crude oil are imported for processing in U.S. refineries because indigenous production is declining steadily. By 2006, petroleum imports equaled 60 percent of total liquids supplied, and by 2007 crude oil imports had surpassed 10 million barrels per day (EIA 2008b), a high proportion of it coming from volatile and unstable regions.

A fall in the demand for transportation fuels likely would affect the import of crude oil more than motor gasoline. Over the last decade there has been a shift in product imports, with volumes of finished gasoline stabilizing and declining slightly. However, volumes of motor gasoline blending components have been rapidly increasing, so that by 2007, the imports of blending components were twice that of finished gasoline.

According to the EIA, net imports, in part due to the changes in CAFE standards and in part due to biofuels, will fall to 51 percent in 2022 and then rise again to 54 percent in 2030. The impact on the industry and the environment in which it works will be felt largely by overseas producers. The actual impact on overseas producers and whether there is a decline in production, and a concomitant decline in emissions, would depend on the demand patterns in the developing nations.

The projections used in this FEIS do not include any large-scale, national efforts to reduce energy consumption or dramatically reduce fossil-fuel use as a result of national security or climate change-issues. NHTSA notes this only to remind readers that the FEIS projections are based on past trends and, in light of the current national focus on energy and climate-change concerns, do not project future regulations or initiatives that could arise but are not, at present, foreseeable. Any large-scale initiative such as this would obviously change the assumptions used in this analysis.

3.2.2 Methodology

The Volpe model, as described in Section 3.1.4, begins with an initial state of the domestic vehicle market, which in this case is the market for passenger cars and light trucks to be sold during the period covered by the proposed rule. It uses several categories of data and estimates for all vehicle categories to develop an estimate of a set of technologies each manufacturer could apply in response to the standard. The Volpe model produces various outputs, one of which is year-by-year fuel consumption, which NHTSA used in the analysis below. NHTSA estimated fuel consumption to 2060, at which point nearly all of the operating fleet of passenger cars and light trucks would be MY 2011-2015 or newer, thus achieving the maximum fuel savings under this rule.

3.2.3 Environmental Consequences

Table 3.2-2 lists the impact on fuel consumption for passenger cars from 2020 through 2060 (a period in which an increasing proportion of the fleet would be MY 2011-2015 cars), which shows the increasing impact of the CAFE alternatives over time. The table lists the total fuel consumption for passenger cars, both gasoline and diesel, under the No Action Alternative (Alternative 1) and the six action alternatives with the Reference Case inputs, as described in Table 2.2-1. By 2060, when the entire

Table 3.2-2

Reference Case Passenger Car Annual Fuel Consumption and Fuel Savings (billion gallons)

	Alternative CAFE Standards for Model Years 2011-2015						
	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7
Calendar Year	No Action	25% Below Optimized	Optimized	25% Above Optimized	50% Above Optimized	Total Cost Equal Total Benefit	Technology Exhaustion
Fuel Consumption							
2020	67.8	66.4	66.4	66.3	66.2	66.1	59.4
2030	78.9	76.3	76.2	76.1	75.9	75.7	64.3
2040	91.2	88.2	88.0	87.9	87.7	87.4	74.0
2050	105.7	102.1	102.0	101.8	101.6	101.2	85.7
2060	121.9	117.8	117.6	117.4	117.1	116.7	98.8
Fuel Savings Compared to No Action							
2020	--	1.4	1.4	1.5	1.6	1.7	8.4
2030	--	2.6	2.7	2.8	3.0	3.2	14.5
2040	--	3.1	3.2	3.3	3.6	3.8	17.2
2050	--	3.6	3.7	3.9	4.1	4.4	20.0
2060	--	4.1	4.3	4.4	4.7	5.1	23.0

fleet is likely to be composed of MY 2011 or later cars, fuel consumption reaches 121.9 billion gallons under the No Action Alternative. Consumption falls under all the action alternatives, from 117.6 billion gallons under the Optimized Alternative (Alternative 3) to 98.8 billion gallons under the Technology Exhaustion Alternative (Alternative 7). As a point of comparison, in 2007 the United States consumed 9.3 million barrels of fuel per day. Consumption under the Technology Exhaustion Alternative amounts to 6.4 million barrels of fuel per day.

Table 3.2-3 lists results for light trucks/SUVs for the same period and for the same alternatives. As in the previous table, fuel consumption is the total for both diesel and gasoline. Fuel consumption

Table 3.2-3

Reference Case Light Truck Annual Fuel Consumption and Fuel Savings (billion gallons)

	Alternative CAFE Standards for Model Years 2011-2015						
	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7
Calendar Year	No Action	25% Below Optimized	Optimized	25% Above Optimized	50% Above Optimized	Total Cost Equal Total Benefit	Technology Exhaustion
Fuel Consumption							
2020	84.0	83.0	82.8	82.4	82.2	81.7	75.5
2030	93.5	91.4	91.0	90.4	89.9	89.2	77.5
2040	107.3	104.6	104.1	103.4	102.7	101.9	87.1
2050	124.0	120.8	120.2	119.4	118.5	117.5	100.2
2060	143.0	139.3	138.7	137.7	136.7	135.6	115.5
Fuel Savings Compared to No Action							
2020	--	1.0	1.2	1.6	1.8	2.2	8.5
2030	--	2.1	2.5	3.0	3.6	4.3	16.0
2040	--	2.7	3.2	3.9	4.6	5.4	20.2
2050	--	3.2	3.7	4.6	5.4	6.4	23.8
2060	--	3.7	4.3	5.3	6.3	7.4	27.5

under the No Action Alternative is 143.0 billion gallons in 2060. Consumption falls under the action alternatives from 138.7 under the Optimized Alternative to 115.5 billion gallons under the Technology Exhaustion Alternative, which represent a savings of 27.5 billion gallons from the No Action Alternative.

3.2.4 Input Scenarios

In response to public comments, and to test how different economic assumptions could affect estimates of fuel consumption, NHTSA ran a scenario using the High Scenario assumptions and compared the results below to the Reference Case. Table 3.2-4 lists the impact on fuel consumption under the High Scenario in the Volpe model for passenger cars from 2020 through 2060. The High Scenario uses the economic inputs described in Table 2.2-1. Table 3.2-4 lists total fuel consumption for passenger cars, both gasoline and diesel, under the No Action Alternative and the six action alternatives. With the assumption of higher fuel prices, lower consumption is expected across the alternatives. By 2060, when the entire fleet is likely to be composed of MY 2011 or later cars, fuel consumption reaches 106.2 billion gallons under the No Action Alternative. Consumption totals 96.6 billion gallons under the Optimized Alternative, as opposed to 117.6 billion gallons under the Optimized Alternative in the Reference Case. Consumption under the Technology Exhaustion Alternative is 86.1 billion gallons, equivalent to 5.6 million barrels per day.

Table 3.2-4

High Scenario Passenger Car Annual Fuel Consumption and Fuel Savings (billion gallons)

	Alternative CAFE Standards for Model Years 2011-2015						
	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7
Calendar Year	No Action	25% Below Optimized	Optimized	25% Above Optimized	50% Above Optimized	Total Cost Equal Total Benefit	Technology Exhaustion
Fuel Consumption							
2020	62.1	59.3	58.8	58.3	57.9	57.3	54.5
2030	71.1	65.7	64.9	64.0	63.5	62.6	58.0
2040	81.4	75.0	74.1	73.1	72.4	71.4	66.0
2050	93.2	85.9	84.8	83.7	82.9	81.8	75.6
2060	106.2	97.8	96.6	95.3	94.4	93.1	86.1
Fuel Savings Compared to No Action							
2020	--	2.8	3.3	3.9	4.3	4.8	7.7
2030	--	5.4	6.2	7.1	7.6	8.5	13.1
2040	--	6.4	7.4	8.4	9.0	10.0	15.4
2050	--	7.3	8.4	9.6	10.3	11.5	17.6
2060	--	8.4	9.6	10.9	11.7	13.1	20.1

Table 3.2-5 shows the High Scenario results for light trucks/SUVs for the same period and the same alternatives. As in previous tables, fuel consumption is the total for diesel and gasoline. Fuel consumption under the No Action Alternative is 124.6 billion gallons in 2060. Consumption under the Optimized Alternative is 113.6 billion gallons, compared to 138.7 billion gallons under the Optimized Alternative in the Reference Case. Consumption under the Technology Exhaustion Alternative is 100.6 billion gallons.

To further assess how different economic assumptions could affect estimates of fuel consumption, NHTSA ran two additional scenarios in the Volpe model: the Mid-1 Scenario and the Mid-2 Scenario. As the names of the scenarios suggest, results from the two additional scenarios fall between those of the Reference Case and the High Scenario. These scenarios use the economic inputs listed in Table 2.2-1. *See* Appendix B for a summary of Mid-1 and Mid-2 Scenario results.

Table 3.2-5

High Scenario Light Truck Annual Fuel Consumption and Fuel Savings (billion gallons)

	Alternative CAFE Standards for Model Years 2011-2015						
	Alt. 1	**Alt. 2**	**Alt. 3**	**Alt. 4**	**Alt. 5**	**Alt. 6**	**Alt. 7**
Calendar Year	**No Action**	**25% Below Optimized**	**Optimized**	**25% Above Optimized**	**50% Above Optimized**	**Total Cost Equal Total Benefit**	**Technology Exhaustion**
Fuel Consumption							
2020	77.0	74.1	73.6	73.1	72.6	72.3	69.2
2030	84.3	78.7	77.7	76.8	76.0	75.6	69.8
2040	95.8	88.7	87.5	86.4	85.3	84.9	77.8
2050	109.4	101.1	99.8	98.4	97.2	96.7	88.4
2060	124.6	115.2	113.6	112.1	110.7	110.0	100.6
Fuel Savings Compared to No Action							
2020	--	2.8	3.4	3.9	4.3	4.6	7.8
2030	--	5.6	6.6	7.5	8.3	8.7	14.4
2040	--	7.1	8.2	9.4	10.4	10.9	18.0
2050	--	8.2	9.6	11.0	12.2	12.7	21.0
2060	--	9.4	11.0	12.5	13.9	14.5	24.0

3.3 AIR QUALITY

3.3.1 Affected Environment

3.3.1.1 Relevant Pollutants and Standards

The new CAFE standards would affect air pollution and air quality, which in turn, has potential effects on public health and welfare. The primary federal legislation that addresses air quality is the Clean Air Act (CAA). Under the authority of the CAA and its amendments, the U.S. Environmental Protection Agency (EPA) has established National Ambient Air Quality Standards (NAAQS) for six criteria pollutants (relatively commonplace pollutants that can accumulate in the atmosphere as a result of normal levels of human activity). The air quality analysis assesses the impacts of the alternatives in relation to criteria pollutants and some hazardous air pollutants from mobile sources (also known as mobile source air toxics [MSATs]).

The criteria pollutants are CO, nitrogen dioxide (NO_2) (one of several oxides of nitrogen, ozone, SO_2, suspended PM of 10 microns diameter or less (PM_{10}) and 2.5 microns diameter or less ($PM_{2.5}$), and lead. Ozone is not emitted directly from vehicles, but is evaluated based on emissions of the ozone precursor pollutants NO_x and VOCs.

The U.S. transportation sector is a major source of emissions of certain criteria pollutants or their chemical precursors. Total emissions from on-road mobile sources (cars and trucks) have declined dramatically since 1970 as a result of pollution controls on vehicles and regulation of the chemical content of fuels, despite continuing increases in the amount of vehicle travel. From 1970 to 2006, the most recent year for which data are available, emissions from on-road mobile sources declined 67 percent for CO, 48 percent for NO_x, 62 percent for PM_{10}, 31 percent for SO_2, and 77 percent for VOCs. Emissions of $PM_{2.5}$ from onroad mobile sources declined 62 percent from 1990, the earliest year of available data, to 2006 (EPA 2006c).

On-road mobile sources are responsible for 54 percent of total U.S. emissions of CO, 5 percent of $PM_{2.5}$ emissions, and 1 percent of PM_{10} emissions (EPA 2006c). Almost all of the PM in vehicle exhaust is $PM_{2.5}$; therefore, this analysis focuses on $PM_{2.5}$ rather than PM_{10}. On-road mobile sources also contribute 22 percent of total nationwide emissions of VOCs and 36 percent of NO_x, which are chemical precursors of ozone. On-road mobile sources contribute only 1 percent of SO_2, but SO_2 and other oxides of sulfur (SO_x) are important because they contribute to the formation of $PM_{2.5}$ in the atmosphere. With the elimination of lead in gasoline, lead is no longer emitted in more than negligible quantities from motor vehicles, and is no longer a pollutant of significance for transportation projects. Lead is not assessed further in this analysis.

Table 3.3-1 lists the primary and secondary NAAQS for each criteria pollutant. Primary standards are set at levels intended to protect against adverse effects on human health; secondary standards are intended to protect against adverse effects on public welfare, such as damage to agricultural crops or vegetation, and damage to buildings or other property. Because each criteria pollutant has different potential effects on human health and public welfare, the NAAQS specify different permissible levels for each pollutant. NAAQS for some pollutants include standards for both short- and long-term average levels. Short-term standards, which typically specify higher levels of a pollutant, are intended to protect against acute health effects from short-term exposure to higher levels of a pollutant; long-term standards are established to protect against chronic health effects resulting from long-term exposure to lower levels of a pollutant.

Table 3.3-1

National Ambient Air Quality Standards

Pollutant	Primary Standards		Secondary Standards	
	Level a/	Averaging Time	Level a/	Averaging Time
Carbon monoxide	9 ppm (10 mg/m^3)	8 hours b/	None	
	35 ppm (40 mg/m^3)	1 hour b/		
Lead	1.5 µg/m^3	Quarterly Average	Same as Primary	
Nitrogen dioxide	0.053 ppm (100 µg/m^3)	Annual (Arithmetic Mean)	Same as Primary	
Particulate matter (PM_{10})	150 µg/m^3	24 hours c/	Same as Primary	
Particulate matter ($PM_{2.5}$)	15.0 µg/m^3	Annual d/ (Arithmetic Mean)	Same as Primary	
	35 µg/m^3	24 hours e/	Same as Primary	
Ozone	0.075 ppm (2008 std.)	8 hours f/	Same as Primary	
	0.08 ppm (1997 std.)	8 hours g/ h/	Same as Primary	
	0.12 ppm	1 hour i/ j/ (Applies only in limited areas)	Same as Primary	
Sulfur dioxide	0.03 ppm	Annual (Arithmetic Mean)	0.5 ppm (1300 µg/m^3)	3 hours b/
	0.14 ppm	24 hours b/		

a/ Units of measure for the standards are parts per million (ppm) by volume, milligrams per cubic meter of air (mg/m^3), and micrograms per cubic meter of air (µg/m^3).
b/ Not to be exceeded more than once per year.
c/ Not to be exceeded more than once per year on average over 3 years.
d/ To attain this standard, the 3-year average of the weighted annual mean $PM_{2.5}$ concentrations from single or multiple community-oriented monitors must not exceed 15.0 µg/m^3.
e/ To attain this standard, the 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area must not exceed 35 µg/m^3 (effective December 17, 2006).
f/ To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.075 ppm (effective May 27, 2008).
g/ To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.08 ppm.
h/ The 1997 standard—and the implementation rules for that standard—will remain in place for implementation purposes as EPA undertakes rulemaking to address the transition from the 1997 ozone standard to the 2008 ozone standard.
i/ The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is less than 1.
j/ As of June 15, 2005, EPA revoked the 1-hour ozone standard in all areas except the 8-hour ozone nonattainment Early Action Compact (EAC) Areas.

Source: 40 CFR 50, as presented in EPA 2008c.

Under the CAA, EPA is required to review NAAQS every 5 years and to change the levels of the standards if warranted by new scientific information. NAAQS formerly included an annual standard, but EPA revoked the annual PM_{10} standard in 2005 based on an absence of evidence of health effects associated with annual PM_{10} levels. In September 2006, EPA tightened the 24-hour $PM_{2.5}$ standard from

65 micrograms per cubic meter ($\mu g/m^3$) to 35 $\mu g/m^3$. In March 2008, EPA tightened the 8-hour ozone standard from 0.08 parts per million (ppm) to 0.075 ppm. EPA currently is considering further changes to the $PM_{2.5}$ standards.

The air quality of a geographic region is usually assessed by comparing the levels of criteria air pollutants found in the atmosphere to the levels established by NAAQS. Concentrations of criteria pollutants within the air mass of a region are measured in parts of a pollutant per million parts of air or in micrograms of a pollutant per cubic meter of air present in repeated air samples taken at designated monitoring locations. These ambient concentrations of each criteria pollutant are compared to the permissible levels specified by NAAQS to assess whether the region's air quality could be unhealthful.

When the measured concentrations of a criteria pollutant within a geographic region are below those permitted by NAAQS, EPA designates the region as an attainment area for that pollutant; regions where concentrations of criteria pollutants exceed federal standards are called nonattainment areas. Former nonattainment areas that have attained NAAQS are designated as maintenance areas. Each nonattainment area is required to develop and implement a State Implementation Plan (SIP), which documents how the region will reach attainment levels within periods specified in the CAA. In maintenance areas, the SIP documents how the state intends to maintain compliance with NAAQS. When EPA changes a NAAQS, states must revise their SIPs to address how they will attain the new standard.

Toxic air pollutants emitted from vehicles are known as mobile source air toxics (MSATs). The MSATs included in this analysis are acetaldehyde, acrolein, benzene, 1,3-butadiene, diesel particulate matter (DPM), and formaldehyde. EPA and the Federal Highway Administration (FHWA) have identified these air toxics as the MSATs of concern for impacts of highway vehicles (EPA 2007c, FHWA 2006). DPM is a component of exhaust from diesel-fueled vehicles and falls almost entirely within the $PM_{2.5}$ particle-size class.

Section 3.4 addresses the major GHGs – CO_2, methane (CH_4), and nitrous oxides (N_2O); these GHGs are not included in this air quality analysis, except that N_2O, as one of the oxides of nitrogen (NO_x), is included in the evaluation of NO_x.

3.3.1.2 Health Effects of Criteria Pollutants

The health effects of the six federal criteria pollutants are briefly summarized below. (This section is adapted from EPA 2008e.) Though we did not conduct a formal analysis of health impacts, the alternatives considered in this FEIS will contribute to reductions in criteria pollutants that will improve public health and welfare.

- Ozone is a photochemical oxidant and the major component of smog. Ozone is not emitted directly into the air but is formed through complex chemical reactions between precursor emissions of VOCs and NO_x in the presence of the ultraviolet component of sunlight. Ground-level ozone causes health problems because it irritates the mucous membranes, damages lung tissue, reduces lung function, and sensitizes the lungs to other irritants. Exposure to ozone for several hours at relatively low concentrations has been found to substantially reduce lung function and induce respiratory inflammation in normal, healthy people during exercise. There is also evidence that short-term ozone exposure directly or indirectly contributes to non-accidental and cardiopulmonary-related mortality.

- PM includes dust, dirt, soot, smoke, and liquid droplets directly emitted into the air, and particles formed in the atmosphere by condensation or the transformation of emitted gases such as SO_2 and VOCs. PM is emitted by both gasoline-fueled and diesel-fueled vehicles.

Particles composed of elemental carbon (carbon black or black carbon) are included in the definition of PM. Heavy-duty diesel vehicles (large trucks and buses) are a major source of PM emissions. In general, the smaller the PM, the deeper it can penetrate into the respiratory system, and the more damage it can cause. Depending on the size and composition, PM can damage lung tissue, aggravate existing respiratory and cardiovascular diseases, alter the body's defense systems against foreign materials, damage lung tissue, and cause cancer and premature death. As noted above, EPA regulates PM according to two particle size classifications: PM_{10} and $PM_{2.5}$.

- CO is a colorless, odorless, and poisonous gas produced by incomplete burning of carbon in fuels. Motor vehicles are the largest source of CO emissions nationally. When CO enters the bloodstream, it acts as an asphyxiant by reducing the delivery of oxygen to the body's organs and tissues. It can impair the brain's ability to function properly. Health threats are most serious for those who suffer from cardiovascular disease, particularly those with angina or peripheral vascular disease.

- Lead is a toxic heavy metal used in industry, such as in battery manufacturing, and formerly in widespread use as an additive in paints. Lead exposure can occur through multiple pathways, including inhalation of air and ingestion of lead in food, water, soil, or dust. Excessive lead exposure can cause seizures, mental retardation, behavioral disorders, severe and permanent brain damage, and death. Even low doses of lead can lead to central nervous system damage. Because of the prohibition of lead as an additive in liquid fuels, transportation sources are no longer a major source of lead pollution.

- SO_2, one of various oxides of sulfur (SO), is a gas formed from combustion of fuels containing sulfur. Most SO_2 emissions are produced by stationary sources such as power plants. SO_2 is also formed when gasoline is extracted from crude oil in petroleum refineries, and in other industrial processes. High concentrations of SO_2 cause severe respiratory distress (difficulty breathing), irritate the upper respiratory tract, and can aggravate existing respiratory and cardiovascular disease. SO_2 also is a primary contributor to acid deposition, or acid rain, which causes acidification of lakes and streams and can damage trees, crops, historic buildings, and statues.

- NO_2 is a reddish-brown, highly reactive gas, one of the oxides of nitrogen formed by high-temperature combustion (as in vehicle engines) of nitrogen and oxygen. Most NO_x created in the combustion reaction consists of nitric oxide (NO), and the NO oxidizes to NO_2 in the atmosphere. NO_2 can irritate the lungs and mucous membranes, cause bronchitis and pneumonia, and lower resistance to respiratory infections. Nitrogen oxides are an important precursor both to ozone and acid rain, and can affect both terrestrial and aquatic ecosystems.

3.3.1.3 Health Effects of Mobile Source Air Toxics

The health effects of the MSATs of concern are briefly summarized below (adapted from EPA 2007c.)

- Acetaldehyde is a probable human carcinogen based on increased incidence of nasal tumors in rats and throat tumors in hamsters after inhalation exposure. Acetaldehyde is also a potent respiratory irritant.

- Acrolein, an aldehyde, is a respiratory irritant. Its potential carcinogenic effects are uncertain.

- Benzene, an aromatic hydrocarbon, is a known human carcinogen (causing leukemia) by all routes of exposure. Benzene also affects the immune system.

- 1,3-butadiene, a hydrocarbon, is characterized as carcinogenic to humans by inhalation. It also damages the reproductive system.

- Diesel particulate matter is a component, along with diesel exhaust organic gases, of diesel exhaust. EPA has not established a particle size classification for regulating DPM. The DPM particles are very fine, with most particles smaller than 1 micron, and their small size allows inhaled DPM to reach the lungs. Particles typically have a carbon core coated by condensed organic compounds, which include mutagens and carcinogens. DPM also includes elemental carbon (carbon black or black carbon) particles emitted from diesel engines. Diesel exhaust is likely to be carcinogenic to humans by inhalation from environmental exposure.

- Formaldehyde is a probable human carcinogen, based on evidence in humans and in rats, mice, hamsters, and monkeys. Formaldehyde also is a respiratory and eye irritant.

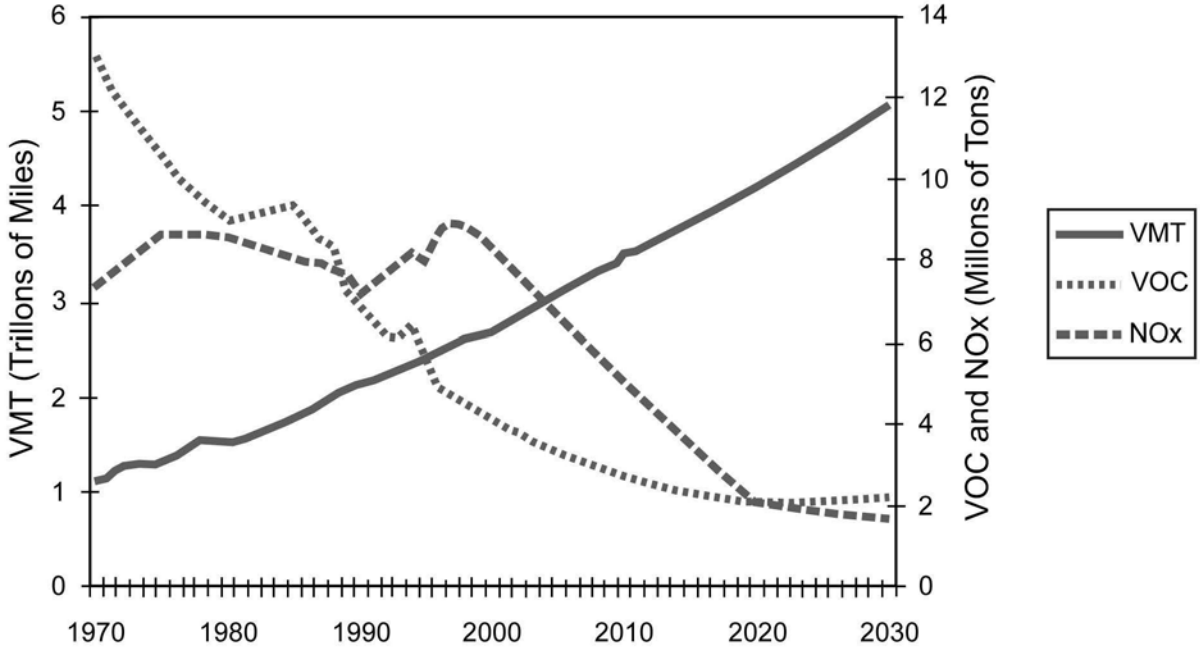
3.3.1.4 Clean Air Act and Conformity Regulations

3.3.1.4.1 Vehicle Emissions Standards

Under the CAA, EPA has established emissions standards for vehicles. EPA has tightened the emissions standards over time as more effective emission control technologies have become available. These reductions in the levels of the standards are responsible for the declines in total emissions from motor vehicles, as discussed above. The emissions standards that will apply to MY 2011-2015 passenger cars and light trucks were established by the EPA Tier 2 Vehicle & Gasoline Sulfur Program, which went into effect in 2004 (EPA 1999b). Under the Tier 2 standards, emissions from passenger cars and light trucks will continue to decline. In 2004, the Nation's refiners and importers of gasoline began to manufacture gasoline with sulfur levels capped at 300 ppm, approximately a 15-percent reduction from the previous industry average of 347 ppm. By 2006, refiners met a 30-ppm average sulfur level with a cap of 80 ppm. These fuels enable post-2006 model year vehicles to use emissions controls that reduce tailpipe emissions of NO_x by 77 percent for passenger cars and by as much as 95 percent for pickup trucks, vans, and SUVs compared to 2003 levels. Figure 3.3-1 shows that cleaner vehicles and fuels will result in continued reductions in emissions from passenger cars and light trucks, despite increases in travel. Figure 3.3-1 illustrates current trends in travel and emissions from passenger cars and light trucks under the current CAFE standards. Figure 3.3-1 does not show the effects of the alternatives, which are discussed in 3.3.3.

From 1970 to 1999, aggregate emissions traditionally associated with vehicles substantially decreased (with the exception of NO_x) even as vehicle miles traveled have increased by approximately 149 percent. NO_x emissions increased between 1970 and 1999 by 16 percent, due mainly to emissions from light-duty trucks and heavy-duty vehicles. However, as future trends show, vehicle travel is having a smaller and smaller impact on emissions as a result of stricter EPA standards for vehicle emissions and the chemical composition of fuels, even with additional growth in VMT (Smith 2002). This general trend will continue, to a greater or lesser degree, with implementation of any of the alternative CAFE standards.

Figure 3.3-1. Vehicle Miles Traveled (VMT) vs. Vehicle Emissions



EPA is addressing air toxics through its MSAT rules (EPA 2007c). These rules limit the benzene content of gasoline beginning in 2011. They also limit exhaust emissions of hydrocarbons (many VOCs and MSATs are hydrocarbons) from passenger cars and light trucks when they are operated at cold temperatures. The cold-temperature standard will be phased in from 2010 to 2015. The MSAT rules also adopt nationally the California evaporative emissions standards. EPA projects that these controls will substantially reduce emissions of acetaldehyde, acrolein, benzene, 1,3-butadiene, and formaldehyde.

3.3.1.4.2 Conformity Regulations

Section 176(c) of the CAA prohibits federal agencies from taking actions in nonattainment or maintenance areas that do not "conform" to the SIP. The purpose of this conformity requirement is to ensure that general activities do not interfere with meeting the emissions targets in the SIPs, do not cause or contribute to new violations of NAAQS, and do not impede the ability to attain or maintain NAAQS. The EPA has issued two sets of regulations to implement CAA Section 176(c):

- The Transportation Conformity Rules (40 CFR 51, Subpart T), which apply to transportation plans, programs, and projects funded under title 23 U.S.C. or the Federal Transit Act. Highway and transit infrastructure projects funded by FHWA or the Federal Transit Administration (FTA) usually are subject to transportation conformity.
- The General Conformity Rules (40 CFR 51, Subpart W) apply to all other federal actions not covered under transportation conformity. The General Conformity Rules established emissions thresholds, or *de minimis* levels, for use in evaluating the conformity of a project. If the net emissions increases due to the project are less than these thresholds, then the project is presumed to conform and no further conformity evaluation is required. If the emissions increases exceed any of these thresholds, then a conformity determination is required. The conformity determination can entail air quality modeling studies, consultation with EPA and

state air quality agencies, and commitments to revise the SIP or to implement measures to mitigate air quality impacts.

The CAFE standards and associated program activities are not funded under title 23 U.S.C. or the Federal Transit Act. Further, CAFE standards are established by NHTSA and are not an action undertaken by FHWA or FTA. Accordingly, the CAFE standards and associated rulemakings are not subject to transportation conformity.

The General Conformity Rules contain several exemptions applicable to federal actions, which the conformity regulations define as: "any activity engaged in by a department, agency, or instrumentality of the Federal Government, or any activity that a department, agency or instrumentality of the Federal Government supports in any way, provides financial assistance for, licenses, permits, or approves, other than activities [subject to transportation conformity]." 40 CFR 51.852. "Rulemaking and policy development and issuance" are exempted at 40 CFR 51.853(c)(2)(iii). Because NHTSA's CAFE standards involve a rulemaking process, NHTSA's action is exempt from general conformity. Also, emissions for which a federal agency does not have a "continuing program responsibility" are not considered "indirect emissions" subject to general conformity under 40 CFR 51.852. "Emissions that a Federal agency has a continuing program responsibility for means emissions that are specifically caused by an agency carrying out its authorities, and does not include emissions that occur due to subsequent activities, unless such activities are required by the Federal agency" (40 CFR 51.852). Emissions that occur as a result of the CAFE standards are not caused by NHTSA carrying out its statutory authorities and clearly occur due to subsequent activities, including vehicle manufacturers' production of passenger-car and light-truck fleets and consumer purchases and driving behavior. Thus, changes in any emissions that result from NHTSA's new CAFE standards are not those for which the agency has a "continuing program responsibility" and therefore a general conformity determination is not required. Nonetheless, NHTSA is evaluating the potential impacts of air emissions for the purposes of NEPA.

3.3.2 Methodology

3.3.2.1 Overview

NHTSA analyzed air quality impacts by calculating the emissions from passenger cars and light trucks that would occur under each alternative, and assessing the changes in emissions in relation to the No Action Alternative (Alternative 1). Many of the factors that affect air quality at any given location, such as meteorology and atmospheric processes, cannot be accounted for when evaluating human health and environmental impacts; such analysis cannot be performed without a full-scale photochemical air quality modeling analysis. NHTSA did not perform full-scale photochemical air quality modeling for this analysis; therefore, the FEIS does not characterize the ambient air quality impacts associated with each alternative. Full-scale photochemical air quality modeling is necessary to accurately project levels of $PM_{2.5}$, ozone, and air toxics. A national-scale air quality modeling analysis would analyze the combined impacts of each alternative on $PM_{2.5}$, ozone, and MSATs. The atmospheric chemistry related to ambient concentrations of $PM_{2.5}$, ozone, and air toxics is very complex, and making predictions based solely on emissions changes is extremely difficult. The analysis of the alternatives is predicated on the common-sense proposition that assessing emissions is a valid approach to assessing air quality impacts because emissions, ambient concentrations, and health effects are connected. Lower emissions should result in lower ambient concentrations of pollutants on an overall average basis, which should lead to decreased health effects of those pollutants.

The No Action Alternative consists of the existing CAFE standards with no changes in the future. The basic method used to estimate emissions entails multiplying activity levels of passenger cars and light trucks expressed as VMT, by emissions factors in grams of pollutant emitted per VMT. National

emissions estimates were provided by the Volpe model. The Volpe model entails the EPA's MOBILE6.2 emissions factor model (EPA 2004d). MOBILE6.2 is EPA's required model for calculating emissions factors for onroad vehicles. In calculating emissions factors, MOBILE6.2 accounts for EPA's emission control requirements for passenger cars and light trucks, including exhaust (tailpipe) emissions, evaporative emissions, and the Tier 2 Vehicle & Gasoline Sulfur Program.

Higher CAFE standards would create an incentive to drive more because they would decrease the vehicle's fuel cost per mile. The total amount of passenger car and light truck VMT would increase slightly due to this "rebound effect." Emissions from passenger cars and light trucks would increase proportionately to the rebound effect. Although higher CAFE standards would decrease the total amount of fuel consumed despite the rebound effect, the decrease in fuel usage cannot be linked directly to any decrease in emissions. The EPA emissions standards and the NHTSA CAFE standards are separate sets of requirements and do not depend on each other. Vehicle manufacturers must meet both the EPA emissions standards and the CAFE standards simultaneously, but neither EPA nor NHTSA dictates the design and technology choices that manufacturers must make to comply. For example, a manufacturer could use a technique that increases fuel economy but also increases emissions, as long as the manufacturer's production still meets both the EPA emissions standards and the CAFE standards. For this reason, the air quality methodology does not assume any emissions benefits solely due to fuel economy improvements.

The new standards also would lead to reductions in "upstream" emissions, which are emissions associated with extraction, refining, storage, and distribution of the fuel. Upstream emissions would decrease with the new CAFE standards because the total amount of fuel used by passenger cars and light trucks would decrease. At the national scale, the reduction in upstream emissions would offset the rebound effect, resulting in a slight net decrease in emissions from passenger cars and light trucks.

While the rebound effect is assumed to affect all areas equally as a percentage of regional VMT, upstream emissions vary by region because fuel refining and storage facilities are not uniformly distributed across the country. An individual region could experience either a net increase or a net decrease in emissions due to the new CAFE standards. To assess regional differences in the effects of the alternatives, net emissions changes were calculated for individual nonattainment areas. Nonattainment areas were used because these are the regions in which are quality problems have been greatest. All nonattainment areas assessed were in nonattainment for ozone or $PM_{2.5}$ because these are the pollutants for which emissions from passenger cars and light trucks are of greatest concern. NHTSA did not quantify PM_{10} emissions separately from $PM_{2.5}$. The road-dust component of PM_{10} emissions from passenger cars and light trucks would increase in proportion to the rebound effect, but because almost all PM from vehicle exhaust consists of $PM_{2.5}$, the alternatives would have almost no effect on exhaust PM_{10}. There are no longer any nonattainment areas for annual PM_{10} because EPA revoked the annual PM_{10} standard.

3.3.2.2 Time Frames for Analysis

Ground-level concentrations of criteria and toxic air pollutants generally respond quickly to changes in emissions rates. The longest averaging period for NAAQS is 1 year. (The ozone and $PM_{2.5}$ NAAQS use annual averages over a 3-year period to account for meteorological variations). The air quality analysis considers the emissions that would occur over annual periods, consistent with NAAQS. Calendar years were selected that are meaningful for the timing of likely effects of the alternatives.

Passenger cars and light trucks remain in use for many years, so the change in emissions due to any change in the CAFE standards would also continue for many years. The influence of vehicles of a particular model year declines with age as vehicles are driven less or scrapped. The Volpe model defines

vehicle lifetime as the point at which 2 percent of the vehicles originally produced in a model year survive. Under this definition, cars can survive in the fleet to 26 years of age and light trucks can survive to 37. Any individual vehicle might not necessarily survive to these ages. The survival of vehicles and the amount they are driven can be forecast with reasonable accuracy for a decade or two, while the influences of fuel prices and general economic conditions are less certain. To evaluate air quality impacts, specific years must be selected for which emissions will be estimated and effects calculated. The air quality analysis was conducted in two ways that affect the choice of analysis years: for the NEPA environmental consequences analysis, we assumed that the CAFE standards for MY 2011-2015 would remain in force indefinitely at the 2015 level. Potential CAFE standards for MY 2016-2020 were not included because they are not within the scope of this rulemaking. However, under NEPA, the analysis of cumulative impacts must include potential future actions that are "reasonably foreseeable." In the cumulative impacts analysis (Chapter 4) we included potential CAFE standards for MY 2016-2020 because they are considered a reasonably foreseeable action. With the potential MY 2016-2020 standards, model years after 2020 would continue to meet the MY 2020 standards.

The analysis years used in this FEIS and the rationales for each are listed below.

- 2015 – Required attainment date for most $PM_{2.5}$ nonattainment areas; first year of complete implementation of the MY 2011-2015 CAFE standards; year of highest overall emissions from passenger cars and light trucks following complete implementation.

- 2020 – Latest required attainment date for 8-hour ozone nonattainment areas (2020 is latest full year, as last attainment date is June 2021 for South Coast Air Basin, California); by this point a large proportion of passenger car and light truck VMT would be in vehicles that meet the MY 2011-2015 standards; first year of complete implementation of potential MY 2016-2020 CAFE standards (Section 4.3).

- 2025 – By this point, a large proportion of passenger car and light truck VMT would be in vehicles that meet the potential MY 2016-2020 standards.

- 2035 – By 2035, almost all passenger cars and light trucks in operation would meet at least the MY 2011-2015 standards and the impact of the standards would start to come only from VMT growth rather than further tightening of the standards. The impacts of the CAFE and EPA standards on a year-by-year basis by 2035 will change little from model year turnover, and most changes in emissions from year to year will come from the rebound effect. Year 2035 represents a reasonable limit to the ability to forecast important variables such as survival rates and mileage accrual rates of vehicles in the fleet, future EPA emissions standards, emission control technologies, and the emissions rates from vehicles. NHTSA believes the year 2035 is a practical maximum for impacts of criteria and toxic air pollutants to be considered reasonably foreseeable rather than speculative.

- 2100 – Used for climate change effects but not criteria and toxic air pollutants; NHTSA believes that given the current state of the science, the year 2100 is a practical maximum for impacts of climate change to be considered reasonably foreseeable rather than speculative.

3.3.2.3 Treatment of Incomplete or Unavailable Information

As noted above, the estimates of emissions rely on models and forecasts that contain numerous assumptions and data that are uncertain. Examples of areas in which information is incomplete or unavailable include future emissions rates, vehicle manufacturers' decisions on vehicle technology and design, the mix of vehicle types and model years, emissions from fuel refining and distribution, and

economic factors. A full-scale photochemical air quality modeling analysis to estimate the ambient concentrations of PM, ozone, and air toxics was not conducted. The lack of air quality modeling data limited the conclusions that could be made about health and environmental impacts associated with each alternative. Instead, screening-level estimates of health outcomes in the form of cases per ton of criteria pollutant emissions reduced, and of monetized health benefits, in the form of dollars per ton of criteria pollutant emissions reduced, were used to approximate the health benefits associated with each alternative. The use of such dollars-per-ton numbers, however, does not account for all potential health and environmental benefits, which leads to an underestimate of total criteria pollutant benefits.

Where information in the analysis included in the FEIS is incomplete or unavailable, NHTSA has relied on CEQ regulations regarding incomplete or unavailable information. See 40 CFR § 1502.22(b). NHTSA has used the best available models and supporting data. The models used for the FEIS were subjected to scientific review and have received the approval of the agencies that sponsored their development. NHTSA believes that the FEIS assumptions regarding uncertain conditions reflect the best available information and are valid and sufficient for this analysis.

3.3.2.4 Allocation of Exhaust Emissions to Nonattainment Areas

The Volpe model provided national emissions estimates. The national emissions were allocated to the county level using VMT data and projected population for each county. Passenger car and light truck VMT was determined for all counties in the United States with data from the National County Database (NCD) included in the National Mobile Inventory Model (NMIM) (EPA 2006d). NMIM contains MOBILE6.2 and other models, and all parameters necessary to estimate on- and off-road mobile emissions in the United States. EPA uses NMIM in its rulemakings and NMIM is the best available tool for this purpose. The passenger car and light truck VMT data was queried from the NCD for all counties as the sum over all roadway types in each county, for all passenger-car and light-truck types included in MOBILE6.2. The VMT data used in the NCD were projected from traffic counts taken by counties and states on major roadways, and therefore are subject to some uncertainty. Most nonattainment areas comprise one or more counties, and because the county-level VMT are aggregated for each nonattainment, this uncertainty carries over to the estimates of VMT within each nonattainment area.

Over time, some counties will grow faster than others, and VMT growth rates will also vary. NTHSA accounted for differing growth rates by adjusting each county's fraction of national VMT according to United States Census population trends projected for 2007 through 2012 (the latest projection year available). Emissions for each county were calculated as national emissions times the population-adjusted fraction of national VMT that occurred in the county. This method assumes that population growth patterns across U.S. urban areas will follow 2007 through 2012 trends to 2035, and that per capita VMT will remain unchanged at the county level. For example, areas that currently are growing rapidly are assumed to continue to grow rapidly, and areas that currently have high per capita VMT are assumed to continue to have high per capita VMT. Because changes in urban growth patterns can alter driving behavior in an area, this adjustment introduces some uncertainty into the nonattainment area-level VMT estimates. This uncertainty increases as the projection period lengthens, such as analysis year 2035 compared to 2015. The adjusted VMT was used to derive the county-level emissions from the national emissions. From the county-level emissions, the emissions for each nonattainment area were derived by summing the emissions for the counties in each nonattainment area.

The geographical definitions of ozone and $PM_{2.5}$ nonattainment areas came from the current EPA Greenbook list (EPA 2008b). For nonattainment areas that include portions of counties, we calculated the proportion of county population that falls within the nonattainment area boundary as a proxy for the proportion of county VMT that occurs within the nonattainment area boundary. This method assumes that per capita VMT is constant within each county, so that the proportion of county population in the

partial county area reflects the VMT in that area. Partial county boundaries were taken from geographic information system files based on 2006 nonattainment area definitions. In some cases, partial counties within nonattainment areas as currently defined were not included in the 2006 nonattainment areas. In those cases, we did not add any part of the missing counties' VMT to our nonattainment area totals, on the basis that partial counties added to nonattainment areas between 2006 and 2008 likely represent relatively small additions to total nonattainment area VMT. Several urban areas are in nonattainment for both ozone and $PM_{2.5}$. Where boundary areas differ between the two pollutants, we use the ozone nonattainment area boundary, which is larger in all cases.

Table 3.3-2 lists the current nonattainment and maintenance areas.

Table 3.3-2

Nonattainment Areas for Ozone and $PM_{2.5}$

Nonattainment/Maintenance Area	Classification a/		General Conformity Threshold b/	
	O_3	$PM_{2.5}$	O_3	$PM_{2.5}$
Albany-Schenectady-Troy, NY	Subpart 1	-	100	-
Allegan Co., MI	Subpart 1	-	100	-
Amador and Calavaras Cos. (Central Mountain Counties), CA	Subpart 1	-	100	-
Atlanta, GA	Moderate	Nonattainment	100	100
Baltimore, MD	Moderate	Nonattainment	100	100
Baton Rouge, LA	Moderate	-	100	-
Beaumont/Port Arthur, TX	Moderate	-	100	-
Birmingham, AL	-	Nonattainment	-	100
Boston-Lawrence-Worcester (E. MA), MA	Moderate	-	100	-
Boston-Manchester-Portsmouth, MA-SE. NH	Moderate	-	100	-
Buffalo-Niagara Falls, NY	Subpart 1	-	100	-
Canton-Massillon, OH	-	Nonattainment	-	100
Charleston, WV	-	Nonattainment	-	100
Charlotte-Gastonia-Rock Hill, NC-SC	Moderate	-	100	-
Chattanooga, AL-TN-GA	-	Nonattainment	-	100
Chicago-Gary-Lake Co., IL-IN	Moderate	Nonattainment	100	100
Chico, CA	Subpart 1	-	100	-
Cincinnati-Hamilton, OH-KY-IN	Subpart 1	Nonattainment	100	100
Clearfield and Indiana Cos., PA	Subpart 1	-	100	-
Cleveland-Akron-Lorain, OH	Moderate	Nonattainment	100	100
Columbus, OH	Subpart 1	Nonattainment	100	100
Dallas-Fort Worth, TX	Moderate	-	100	-
Dayton-Springfield, OH	-	Nonattainment	-	100
Denver-Boulder-Greeley-Ft. Collins, CO	Subpart 1	-	100	-
Detroit-Ann Arbor, MI	Marginal	Nonattainment	100	100
Door Co., WI	Subpart 1	-	100	-
Essex Co., NY (Whiteface Mountain)	Subpart 1	-	100	-
Evansville, IN	-	Nonattainment	-	100

Table 3.3-2 (cont'd)

Nonattainment Areas for Ozone and $PM_{2.5}$

Nonattainment/Maintenance Area	Classification a/		General Conformity Threshold b/	
	O_3	$PM_{2.5}$	O_3	$PM_{2.5}$
Greater Connecticut, CT	Moderate	-	100	-
Greene Co., PA	Subpart 1	-	100	-
Greensboro-Winston Salem-High Point, NC	-	Nonattainment	-	100
Harrisburg-Lebanon-Carlisle, PA	-	Nonattainment	-	100
Haywood and Swain Cos. (Great Smoky Mountains National Park), NC	Subpart 1	-	100	-
Hickory, NC	-	Nonattainment	-	100
Houston-Galveston-Brazoria, TX	Moderate	-	100	-
Huntington-Ashland, WV-KY-OH	-	Nonattainment	-	100
Imperial Co., CA	Moderate	-	100	-
Indianapolis, IN	-	Nonattainment	-	100
Jamestown, NY	Subpart 1	-	100	-
Jefferson Co., NY	Moderate	-	100	-
Johnstown, PA	-	Nonattainment	-	100
Kern Co. (Eastern Kern), CA	Subpart 1	-	100	-
Knoxville, TN	Subpart 1	Nonattainment	100	100
Lancaster, PA	-	Nonattainment	-	100
Las Vegas, NV	Subpart 1	-	100	-
Libby, MT	-	Nonattainment	-	100
Liberty-Clairton, PA	-	Nonattainment	-	100
Los Angeles South Coast Air Basin, CA	Severe 17	Nonattainment	25	100
Los Angeles-San Bernardino Cos. (W. Mojave Desert), CA	Moderate	-	100	-
Louisville, KY-IN	-	Nonattainment	-	100
Macon, GA	-	Nonattainment	-	100
Manitowoc Co., WI	Subpart 1	-	100	-
Mariposa & Tuolumne Cos. (Southern Mountain Counties), CA	Subpart 1	-	100	-
Martinsburg, WV-Hagerstown, MD	-	Nonattainment	-	100
Memphis, TN-AR	Moderate	-	100	-
Milwaukee-Racine, WI	Moderate	-	100	-
Nevada (Western Part), CA	Subpart 1	-	100	-
New York-N. New Jersey-Long Island, NY-NJ-CT	Moderate	Nonattainment	100	100
Parkersburg-Marietta, WV-OH	-	Nonattainment	-	100
Philadelphia-Wilmington-Atlantic City, PA-DE-MD-NJ	Moderate	Nonattainment	100	100
Phoenix-Mesa, AZ	Subpart 1	-	100	-
Pittsburgh-Beaver Valley, PA	Subpart 1	Nonattainment	100	100
Poughkeepsie, NY	Moderate	Nonattainment	100	100
Providence (All RI), RI	Moderate	-	100	-
Reading, PA	-	Nonattainment	-	100
Riverside Co., CA (Coachella Valley)	Serious	-	50	-
Rochester, NY	Subpart 1	-	100	-
Rome, GA	-	Nonattainment	-	100
Sacramento Metro, CA	Serious	-	50	-
San Diego, CA	Subpart 1	-	100	-
San Francisco Bay Area, CA	Marginal	-	100	-

Table 3.3-2 (cont'd)

Nonattainment Areas for Ozone and $PM_{2.5}$

Nonattainment/Maintenance Area	Classification a/		General Conformity Threshold b/	
	O_3	$PM_{2.5}$	O_3	$PM_{2.5}$
San Joaquin Valley, CA	Serious	Nonattainment	50	100
Sheboygan, WI	Moderate	-	100	-
Springfield (Western MA), MA	Moderate	-	100	-
St. Louis, MO-IL	Moderate	Nonattainment	100	100
Steubenville-Weirton, OH-WV	-	Nonattainment	-	100
Sutter County (Sutter Buttes), CA	Subpart 1	-	100	-
Ventura Co., CA	Moderate	-	100	-
Washington, DC-MD-VA	Moderate	Nonattainment	100	100
Washington County (Hagerstown), MD	-	Nonattainment	-	100
Wheeling, WV-OH	-	Nonattainment	-	100
York, PA	-	Nonattainment	-	100

a/ Pollutants for which the area is designated nonattainment or maintenance as of 2008, and severity classification.
b/ Tons per year of VOCs or NO_x in ozone nonattainment areas; primary $PM_{2.5}$ in $PM_{2.5}$ nonattainment areas.
Source: EPA 2008b.

3.3.2.4.1 Allocation of Upstream Emissions to Nonattainment Areas

Upstream emissions from light-duty vehicles (LDV) are generated when fuel products are produced, processed, and transported. Upstream emissions are typically divided into four categories:

- Feedstock Recovery (petroleum extraction)
- Feedstock Transportation
- Fuel Refining
- Fuel Transportation, Storage, and Distribution (T&S&D)

Feedstock recovery refers to the extraction or production of fuel feedstocks. In the case of petroleum, this is the stage of crude oil extraction. During the next stage, feedstock transportation, crude oil is shipped to refineries. Fuel refining refers to the processing of crude oil into gasoline and diesel. T&S&D refers to the movement of gasoline and diesel from refineries to bulk terminals, storage at bulk terminals, and transportation of fuel from bulk terminals to retail outlets. Emissions of pollutants at each stage are associated with expenditure of energy and spillage and evaporation of fuel products.

The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model (Argonne 2002) estimates upstream emissions associated with various vehicle fuel pathways for light-duty vehicles in the United States. GREET includes various assumptions about the production and transportation of feedstocks and fuels. The model assumes that more than half of the crude oil supplied to U.S. refineries arrives by ocean tanker from foreign countries and Alaska. More than a third of crude oil is produced domestically. Once in the lower 48 states, almost all (92 percent) of crude oil is transported to refineries by pipeline.

The model assumes that nearly all (96 percent) of gasoline and diesel consumed in the United States comes from U.S. refineries. Around three quarters of that fuel is transported from refineries to bulk

terminals by pipeline, an average distance of 400 miles. Smaller shares are transported by ocean tanker, barge, and rail. Fuel is transported from bulk terminals to retail outlets by truck an average distance of 30 miles. The current version of GREET does not account for the most recent EPA emissions standards for heavy trucks, locomotives, and marine vessels. For the analysis of upstream emissions, we updated the model inputs to account for the most recent EPA emissions standards. This update reduces the modeled upstream emissions from fuel transport, and therefore lessens the effect of the alternatives in reducing upstream emissions.

GREET and Volpe modeling provided changes in upstream emissions of NO_x, PM, VOCs, SO_x, and CO and four air toxics (acetaldehyde, benzene, butadiene, DPM, and formaldehyde) associated with the proposed action and alternatives. The Volpe model shows that nationwide upstream emissions would be reduced by all of the alternatives examined. Increasing the fuel economy of light duty vehicles will cause less fuel to be consumed, which will in turn reduce upstream emissions of criteria pollutants associated with feedstock and fuel production, processing, and transportation.

The analysis of upstream emissions considered only emissions occurring domestically and did not consider emissions occurring internationally, such as during transport of crude oil or refined gasoline to the United States. The upstream emissions data used in the GREET model assumed that, first, 50 percent of the fuel savings with the alternatives would reduce imports of refined gasoline, and therefore would reduce domestic emissions only during fuel T&S&D and would not reduce emissions from feedstock recovery, feedstock transportation, and fuel refining. Second, 90 percent of the reduction in domestic fuel refining reduces imports of crude petroleum (and therefore does not reduce domestic emissions from feedstock recovery and feedstock transportation), while only 10 percent reduces domestic production of crude petroleum (which does reduce domestic emissions from feedstock recovery and feedstock transportation). NHTSA estimated these percentages using several scenarios from EIA's *Annual Energy Outlook* (AEO) (EIA 2008a).

To analyze the impact of the alternatives on individual nonattainment areas, we allocated emissions reductions to geographic areas according to the following methodology:

- Feedstock Recovery – We assumed that little to no extraction of crude oil occurs in nonattainment areas. Of the top 50 highest producing oil fields in the United States, only nine are in nonattainment areas. These nine fields account for just 10 percent of domestic production, or 3 percent of total crude-oil imports and domestic production (EIA 2006, EIa 2008b). Therefore, NHTSA ignored emissions reductions from feedstock recovery in nonattainment areas.

- Feedstock Transportation – We assumed that little to no crude oil is transported through nonattainment areas. Most refineries are outside of, or on the outskirts of, urban areas. Crude oil is typically transported hundreds of miles from extraction points and ports to reach refineries. Most transportation is by ocean tanker and pipeline. Probably only a very small proportion of criteria pollutants emitted in the transport of crude oil occur in nonattainment areas. Therefore, NHTSA ignored emissions reductions from feedstock transportation in nonattainment areas.

- Fuel Refining – Fuel refining is the largest source of upstream emissions of criteria pollutants. Depending on the specific fuel and pollutant, fuel refining accounts for between one third and three quarters of all upstream emissions (based on outputs of the Volpe model). NHTSA compiled a list of all crude oil refineries in the United States along with their locations and refining capacity, and then calculated each nonattainment area's share of total nationwide refining capacity (NPRA 2008, EIA 2008e). It is assumed that fuel refining will

decrease uniformly across all refineries nationwide as a result of the alternatives. For the nonattainment areas examined, we estimated the change in emissions from fuel refining as a share of the total national emissions, proportional to the area's share of national refining capacity.

- Fuel T&S&D – Based on the assumptions of the GREET model, we assume that most T&S&D emissions occur near the point of fuel sale and use. The pipelines that carry fuel from refineries to bulk hubs are a relatively low emissions mode. The trucks that carry the fuel to retail outlets are likely to be the largest source of emissions in this category. If the average distance a truck hauls the fuel is 30 miles, then the truck is likely to emit most criteria pollutants within the same airshed as that in which the fuel will be purchased and used. NHTSA used county-level light-duty VMT data from EPA's NMIM to estimate the proportion of national fuel demand in each nonattainment area, and population forecasts by county to account for likely shifts in demand in future years, as discussed above. Finally, we apportioned the national T&S&D emissions to nonattainment areas based on their total share of national fuel demand.

Because we ignore emissions changes from the first two upstream stages, our assumptions produce conservative estimates of emissions reductions in nonattainment areas.

For acetaldehyde, benzene, butadiene, and formaldehyde, the GREET modeling provided proportions of total upstream emissions by only two categories: feedstock recovery and transportation, and fuel refining and T&S&D. No split between emissions from fuel refining and emissions from T&S&D was provided. NHTSA assumed that all upstream emissions of these pollutants from fuel refining and T&S&D occur during fuel refining. This assumption results in over-assignment of emissions of these pollutants to nonattainment areas that have refineries and under-assignment of emissions to those that have none.

The GREET model also provided no information on upstream emissions of acrolein; therefore, we did not apply upstream emissions reductions for acrolein. As a result, the emissions of acrolein given in the FEIS are conservative (high) because they account only for the increase due to the rebound effect.

3.3.2.4.2 Health Outcomes and Costs

This section describes NHTSA's approach to addressing public comments on the need to provide more quantitative estimates of adverse health effects of conventional air pollutants associated with each alternative.

Adverse Health Impact Evaluation

The EPA *Report to Congress on The Benefits and Cost of the Clean Air Act 1990 to 2010* (EPA-410-R-99-001) (EPA 1999a) documents a quantitative assessment of air pollutant emissions impacts in 1990, 2000, and 2010 from implementation of the 1970 Clean Air Act, 1977 Amendments (CAAA), and the 1990 Amendments. The assessment includes air quality modeling of the impacts associated with and without implementation of the Clean Air Act and quantifying health-related outcomes on a nationwide basis. Appendix D of the EPA report to Congress describes the basis and methodology used to assess the impacts on human health from the effects of changes in criteria air pollutants. The study found substantial health benefits from implementation of the CAAA, especially as a consequence of reductions in fine particulate matter ($PM_{2.5}$). In particular, incidences of mortality, chronic bronchitis, and asthma are associated with changes in $PM_{2.5}$ concentrations. Thus, an approximation of changes in $PM_{2.5}$ emissions can be used to characterize impacts on the most adverse health effects for mortality, chronic

bronchitis, emergency room visits for asthma, and work-loss days. Other health endpoints have more complex relationships, either with other pollutants or by undergoing non-linear atmospheric transformation processes, which would require air quality modeling, exposure modeling, and application of unit risk factors to assess final health impacts.

In EPA's report (Appendix D,[6] Table D-21) endpoint outcomes for mortality, chromic bronchitis, emergency room visits for asthma, and work-loss days are reported on a nationwide basis for 2010 for the 5th, mean, and 95th percentiles. The report also quantifies the nationwide changes in $PM_{2.5}$ from pre-CAAA and post-CAAA for 2010 by source category (utility, point, area, non-road, and on-road motor vehicle). Because the CAFE standards will impact emissions nationwide and the CAAA also acts nationwide, it is anticipated that spatial patterns of mobile source emissions will have similar spatial distributions. Thus, in this assessment we use this information from Table 2-3 from the EPA report for pre- and post-CAAA $PM_{2.5}$ emissions reduction changes from motor vehicles to estimate adverse health impacts from changes in motor vehicle $PM_{2.5}$ emissions. Table 2-3 shows that emissions of $PM_{2.5}$ are reduced by 90,000 tons per year with implementation of the CAAA and are 30 percent (90,000/300,000) of the total $PM_{2.5}$ emissions reduction. This fraction would then be used with the endpoint values in Table D-21 (*e.g.*, mean mortality end point, MME_{CAAA}, along with the emissions reductions between alternatives (*e.g.*, Alternative 1 [No Action] and Alternative 6 [Total Costs Equal Total Benefits], $PM_{2.5\ A1\text{-}A6}$) to determine the mean mortality endpoint between alternatives.

This can be expressed mathematically as:

$$MME_{CAAA} \times (0.30) \times (PM_{2.5\ A1\text{-}An}/90{,}000) = MME_{A1\text{-}An}$$

Where n refers to the each of the alternatives:

A1 is the No Action Alternative and
An is the alternative number.

For example, the mean mortality (number of deaths > 30 years of age) avoided in 2010 for post-CAAA versus pre-CAAA is 23,000 (see Table D-21). In 2035, Alternative 3 (Optimized) would reduce $PM_{2.5}$ emissions by 498 tons per year compared to Alternative 1 (No Action) (see Table 3.3-3 in Section 3.3.3.2.1). Then the number of deaths avoided with Alternative 3 is (23,000) x (0.30) x (498/90,000) = 38.

This procedure is applied for each year analyzed (2015, 2020, 2025, and 2035) for each alternative for the mean health outcome, which provides an estimate of the credible interval of the number of avoided cases for each endpoint.

[6] The approach used in this study followed the design of EPA's retrospective Section 812 study (EPA 1997b) using a sequence of linked analytical models (emissions, air quality, and health benefits) to estimate benefits. The most important aspects of the health benefit analysis are the forecasted change in pollutant concentrations over the study period and the concentration response functions that quantify the relationship between the forecasted changes in exposure and expected change in specific health outcomes. Further details on the underlying assumptions and uncertainty in the pre- and post-CAAA scenarios are discussed in Appendix A (emissions), Appendix C (air quality models) and Appendix D (health benefit models) in EPA (1999a).

Underlying Assumptions

The assumptions used in the analysis are based on extrapolation of the EPA 1999b health impact numbers to this analysis:

- That motor vehicle related changes pre- and post-CAAA have the same spatial distribution in motor vehicle emissions as in the FEIS.
- That the health effects scale linearly with the emissions and that the PM health effects are attributable to primary $PM_{2.5}$ emissions. This is conservative because the secondary PM formation is responsible for a portion of the $PM_{2.5}$. Also, not considering the associated reductions in other air pollutants in the CAAA study might underestimate the health benefits of the CAAA reductions.
- That at least for $PM_{2.5}$ we can assign the pre-CAAA and post-CAAA motor vehicle emissions proportionately to the other source categories. This is a reasonable assumption because nearly all of the $PM_{2.5}$ in 2010 pre- and post-CAAA is from on-road, non-road, and area sources. These are generally low-level sources close to populations.
- The population distribution across the United States is the same now as it was when the analysis was done for the CAAA report, and the future population projections would be the same (because the change in incidence is calculated for each population grid cell).
- The baseline mortality and respiratory disease rate have remained the same. The prior analysis used county-specific incidence rates and national incidence rates, and baseline incidence rates from the health studies.
- That the CAAA analysis assumed that the concentration-response (C-R) relationships should only be applied to those subpopulations matching the original study population. This might underestimate the whole population benefits of reductions in pollutant exposures.

Although more recent data are available on air pollution and mortality effects, the studies used here are generally considered to be appropriate for air quality impact analysis. These studies have been used in other EPA documents published since 1999, in analyses for the private sector, and by international health agencies.

Economic Impacts Evaluation

The EPA Office of Transportation and Air Quality (OTAQ) funded a study (EPA 2003) that examined the economic impacts from future changes in VMT. The study looked at 10-percent increase and 10-percent decrease in VMT nationwide, and evaluated the economic costs through air quality modeling of emissions changes in the motor vehicle fleet. The study examined the economic impacts from changes in ambient PM concentrations and ozone. The study looked at target years 2015, 2020, and earlier years. For this analysis, we use 2015 and 2020 and the associated economic impacts associated with a 10-percent decrease in VMT for 2015 and 2020 associated with the air quality impacts on ozone and particulate matter. The associated changes in air emissions from the study are available for on-road motor vehicles for 2015 and 2020.

Table 3-2 of the OTAQ study (EPA 2003) provides an estimate of the daily average emissions changes for NO_x,, VOCs, SO_2 and $PM_{2.5}$ for all on-road vehicles separated into light and heavy-duty vehicles. The study developed an ACCESS™-database display tool that has information on a wide variety

of economic scenarios, including the economic costs over the entire U.S. modeling domain for each analysis year. This information, in conjunction with the emissions changes calculated from Table 3.2 of the OTAQ report can be used to estimate the economic impacts for each of the alternative emissions changes in the FEIS (see Table 3.3-4) in a manner analogous to the health impact assessment. However, because the economic impacts from the EPA/OTAQ study are only available for ozone and particulate matter, an assumption was made as to the emissions contribution from each of the major emissions types: SO_2, VOCs, NO_x, $PM_{2.5}$, and NO_x. For ozone, the principal precursors are NO_x and VOCs. EPA's policy for addressing $PM_{2.5}$ concentrations is to include the precursor emissions of NO_x, $PM_{2.5}$, and SO_2 (EPA 2007a). As a first approximation, we split the emissions change for NO_x equally between ozone and PM formation. This enables an economic impact analysis for each alternative for each year and can be expressed mathematically for ozone as:

$$E_{A1\text{-}An,\ YYYY,\ O3} = (0.5*NOX_{A1\text{-}An,\ YYYY} + VOC_{A1\text{-}An,YYYY})/(0.5*NOX_{-10\%,YYYY} + VOC_{-10\%,YYYY}) * E_{-10\%,YYYY,O3}$$

Where:

E = dollar value of economic impact in year 2000 dollars
A1 = Alternative 1 (No Action)
An = the alternative number
VOC = emissions rate for volatile organic compounds
NO_x = emissions rate for nitrogen oxides
O_3 = ozone
YYYY = analysis year
10% = 10 percent reduction scenario

So for example, in 2020, the 10-percent VMT reduction in the EPA/OTAQ study found a 12.73 million dollar economic improvement. The sum of one-half NO_x emissions and VOCs for the EPA/OTAQ study is 2,281 tons per day, while the sum of one-half NO_x emissions and VOCs for Alternative 1 (No Action) versus Alternative 3 (Optimized) in 2020 High Scenario cumulative is only 206 tons per day. Thus, the economic impact between Alternative 1 and Alternative 3 can be determined as follows:

$$(206)/(2{,}281) \times (12.73 \text{ million dollars}) = 1.15 \text{ million dollars}$$

This same procedure is applied for 2015 and a similar approach is used to estimate the impacts for 2025 and 2035, but with the base year emissions based on the best available future year of 2020 year.

The same approach can be applied for $PM_{2.5}$, but instead of VOCs, both SO_2 and $PM_{2.5}$ emissions are added. Expressed mathematically,

$$E_{A1\text{-}An,\ YYYY,\ PM2.5} = (0.5*NOX_{A1\text{-}An,\ YYYY} + SO_{2A1\text{-}An,YYYY} + PM_{2.5A1\text{-}An,YYYY})/ (0.5*NOX_{-10\%,YYYY} + SO_{2\text{-}10\%,YYYY} + PM_{2.5\text{-}10\%,YYYY}) * E_{-10\%,YYYY,,PM2.5}$$

Where:

E = dollar value of economic impact in year 2000 dollars
A1 = Alternative 1 (No Action)
An = the alternative number
$PM_{2.5}$ = emissions rate for particulate matter less than 2.5 microns

SO_2 = emissions rate for sulfur dioxide
NO_x = emissions rates for nitrogen oxides
YYYY = analysis year
10% = 10 percent reduction scenario

Underlying Assumptions

The assumptions used in the analysis are based on the EPA/OTAQ 2003 social costs of air pollution analysis, as follows:

- That motor vehicle emissions changes from the 10-percent reduction in VMT are spatially distributed the same in the FEIS. This assumes that the VMT reductions are spread equally as a percent reduction of baseline VMT and that the fuel economy improvements are approximately proportional to the VMT.

- That the economic effects scale linearly with the emissions changes.

- That the ozone and particulate matter changes capture the economic effects that emissions contribution for ozone is principally from NO_x and VOCs, that the important precursor for $PM_{2.5}$ is the emissions of NO_x, and SO_2, and as a first approximation, that the emissions change for NO_x is equal between ozone and PM formation.

- The population distribution across the United States is the same now as it was when the analysis was done for the EPA/OTAQ study and the future population projections would be the same.

- The 10-percent change in VMT is assumed proportionality to the vehicle emissions change. This is not strictly true, because emissions associated with different vehicle classes do vary within each class, but these changes are relatively small.

- Assuming linear scaling of emissions with only a 10-percent reduction in VMT allows an estimate of the associated economic impact, assuming linear economic effects.

- That the concentration-response (C-R) functions as used in the EPA/OTAQ and Abt Associates (2001) are appropriate for the FEIS. Both studies focus on changes in motor vehicle emissions, so C-R functions should behave similarly.

- The unit dollar values of the economic endpoints used in the EPA/OTAQ study for the value of a statistical life, willingness to pay to reduce chronic bronchitis, value of hospital admissions due to respiratory problems, and other respiratory ailments not causing hospital admissions.

3.3.3 Environmental Consequences

3.3.3.1 Results of the Emissions Analysis

The CAA has been a success in reducing emissions from on-road mobile sources. As discussed in Section 3.3.1, pollutant emissions from vehicles have been declining since 1970 and EPA projects that they will continue to decline. However, as future trends show, vehicle travel is having a smaller and smaller impact on emissions as a result of stricter EPA standards for vehicle emissions and the chemical composition of fuels, even with additional growth in VMT (Smith 2002). This general trend will

continue, to a greater or lesser degree, with implementation of any of the alternative CAFE standards. The analysis by alternative in this section shows that the alternative CAFE standards will lead to both reductions and increases in emissions from passenger cars and light trucks, compared to current trends without the alternative CAFE standards. The amounts of the reductions and increases would vary by pollutant, calendar year, and alternative CAFE standard. The more restrictive alternatives generally would result in greater emissions reductions compared to the No Action Alternative. Under some of the action alternatives there would be emissions increases that would exceed the general conformity thresholds in some nonattainment areas.

Sections 3.3.3.2 through 3.3.3.8 describe the results of the emissions analysis for Alternatives 1 through 7 for the Reference Case.

3.3.3.2 Reference Case Alternative 1: No Action

3.3.3.2.1 Criteria Pollutants

With the No Action Alternative, the CAFE standards would remain at the MY 2010 level in future years. Current trends in the levels of emissions from vehicles would continue, with emissions continuing to decline due to the EPA emissions standards, despite a growth in total VMT. The EPA vehicle emissions standards regulate all criteria pollutants except SO_2, which is regulated through fuel sulfur content. The No Action Alternative would not change the current CAFE standards and so would not result in any change in criteria pollutant emissions, other than current trends, in nonattainment and maintenance areas throughout the United States.

Table 3.3-3 summarizes the total national emissions from passenger cars and light trucks for the No Action Alternative for each of the criteria pollutants and analysis years. The action alternatives (Alternatives 2 through 7) are presented left to right in order of increasing fuel economy requirements. Figure 3.3-2 illustrates this information graphically. Table 3.3-3 and Figure 3.3-2 show that emissions change very little between the No Action Alternative and Alternatives 2 and 3. In the case of PM, SO_X, NO_x, and VOC, the No Action Alternative results in the highest emissions. Emissions of PM, SO_X, NO_x, and VOC generally decline as fuel economy standards increase across alternatives. In the case of CO, emissions under Alternative 2 or 3 are slightly higher than under the No Action Alternative. Emissions of CO decline as fuel economy standards increase across Alternatives 4 through 7.

Table 3.3-3

Reference Case Alternative CAFE Standards
Nationwide Criteria Pollutant Emissions from Passenger Cars and Light Trucks (tons/year)

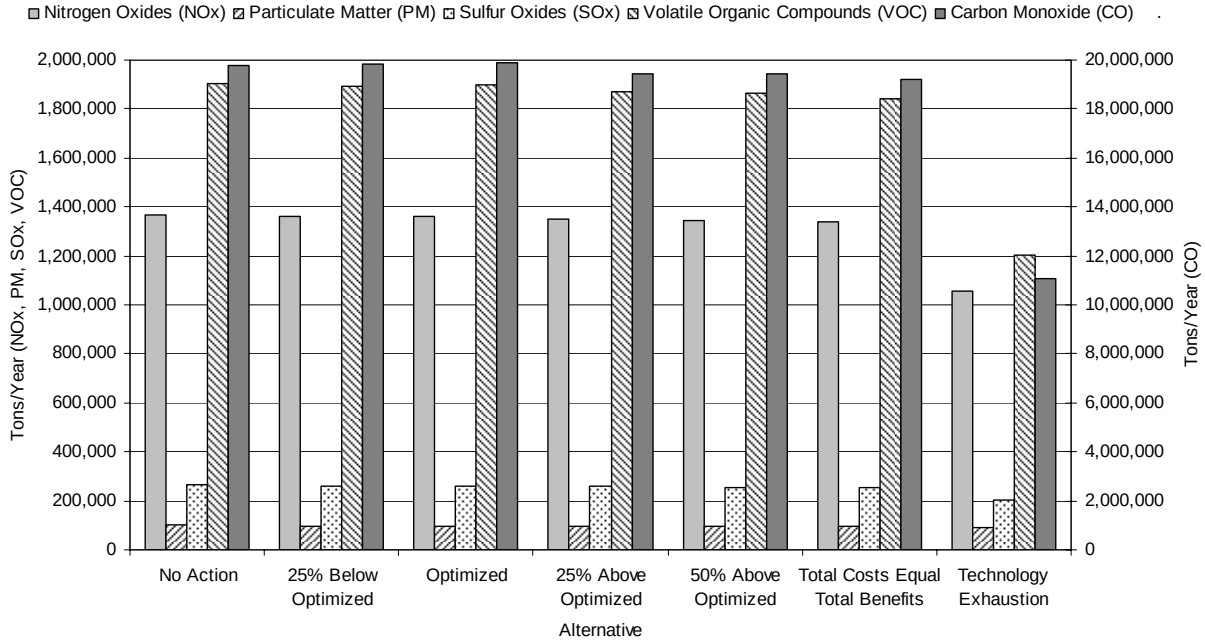
Pollutant and Year	Alt. 1 No Action	Alt. 2 25% Below Optimized	Alt. 3 Optimized	Alt. 4 25% Above Optimized	Alt. 5 50% Above Optimized	Alt. 6 Total Costs Equal Total Benefits	Alt. 7 Technology Exhaustion
Carbon monoxide (CO)							
2015	20,241,797	20,253,448	20,257,990	20,228,142	20,224,747	20,189,468	19,529,683
2020	18,133,965	18,161,733	18,180,168	18,056,231	18,041,063	17,951,050	15,292,056
2025	18,103,174	18,147,381	18,181,664	17,945,665	17,916,463	17,771,020	12,734,499
2035	19,745,847	19,809,449	19,866,650	19,460,737	19,411,428	19,219,623	11,050,380
Nitrogen oxides (NO_x)							
2015	2,305,222	2,303,592	2,303,383	2,303,044	2,302,880	2,302,005	2,287,093
2020	1,670,131	1,665,605	1,665,327	1,663,051	1,662,166	1,658,899	1,591,775
2025	1,426,220	1,419,408	1,419,329	1,413,528	1,411,801	1,406,061	1,257,625
2035	1,369,135	1,360,018	1,360,519	1,347,773	1,344,759	1,336,616	1,057,996

Table 3.3-3 (cont'd)

Reference Case Alternative CAFE Standards
Nationwide Criteria Pollutant Emissions from Passenger Cars and Light Trucks (tons/year)

Pollutant and Year	Alt. 1 No Action	Alt. 2 25% Below Optimized	Alt. 3 Optimized	Alt. 4 25% Above Optimized	Alt. 5 50% Above Optimized	Alt. 6 Total Costs Equal Total Benefits	Alt. 7 Technology Exhaustion
Particulate matter ($PM_{2.5}$)							
2015	80,400	80,255	80,243	80,154	80,125	80,063	78,983
2020	82,456	81,999	81,968	81,713	81,620	81,578	78,508
2025	87,471	86,748	86,701	86,309	86,162	86,145	81,455
2035	99,707	98,692	98,625	98,064	97,853	97,861	91,101
Sulfur Oxides (SO_x)							
2015	208,833	207,885	207,789	207,454	207,308	206,810	196,733
2020	217,490	214,628	214,365	213,513	213,006	212,032	186,949
2025	232,179	227,690	227,288	226,014	225,200	223,848	186,356
2035	265,792	259,517	258,951	257,164	255,984	254,228	203,047
Volatile organic compounds (VOCs)							
2015	2,261,550	2,259,725	2,259,693	2,257,466	2,256,869	2,253,612	2,185,850
2020	1,896,683	1,890,797	1,890,924	1,883,693	1,881,584	1,873,852	1,671,209
2025	1,817,495	1,808,487	1,809,038	1,795,600	1,791,963	1,779,392	1,417,725
2035	1,906,119	1,894,399	1,896,272	1,869,506	1,863,351	1,844,280	1,205,722

Figure 3.3-2. Reference Case Alternative CAFE Standards Nationwide Criteria Pollutant Emissions from Passenger Cars and Light Trucks for 2035 (tons/year)



Total emissions are composed of four components: tailpipe emissions and upstream emissions for light duty vehicles, and tailpipe emissions and upstream emissions for light-duty trucks. To show the relationship among these four components for criteria pollutants, Table 3.3-4 breaks down the total emissions of criteria pollutants by component for calendar year 2035.

Table 3.3-4

Reference Case Alternative CAFE Standards
Nationwide Criteria Pollutant Emissions in 2035 from Passenger Cars and Light Trucks, by Vehicle Type (tons/year)

Pollutant and Year	Alt. 1 No Action	Alt. 2 25% Below Optimized	Alt. 3 Optimized	Alt. 4 25% Above Optimized	Alt. 5 50% Above Optimized	Alt. 6 Total Costs Equal Total Benefits	Alt. 7 Technology Exhaustion
Carbon Monoxide (CO)							
Car Tailpipe	8,232,048	8,259,930	8,262,246	8,264,154	8,257,155	8,062,037	5,340,998
Car Upstream	58,993	57,008	56,921	56,842	56,690	56,400	46,240
Truck Tailpipe	11,385,451	11,424,837	11,480,102	11,072,930	11,031,252	11,035,398	5,609,016
Truck Upstream	69,355	67,674	67,381	66,811	66,330	65,788	54,127
Total	19,745,847	19,809,449	19,866,650	19,460,737	19,411,428	19,219,623	11,050,380
Nitrogen Oxides (NO_x)							
Car Tailpipe	265,972	266,933	267,007	267,064	266,875	261,223	182,669
Car Upstream	198,946	192,270	191,976	191,710	191,205	190,362	157,962
Truck Tailpipe	670,063	672,334	674,063	663,283	662,549	662,733	531,460
Truck Upstream	234,154	228,481	227,473	225,716	224,129	222,299	185,905
Total	1,369,135	1,360,018	1,360,519	1,347,773	1,344,759	1,336,616	1,057,996
Particulate Matter ($PM_{2.5}$)							
Car Tailpipe	26,878	27,077	27,085	27,092	27,122	27,430	32,798
Car Upstream	21,270	20,550	20,519	20,490	20,433	20,291	16,108
Truck Tailpipe	26,626	26,737	26,794	26,505	26,504	26,541	23,618
Truck Upstream	24,933	24,328	24,228	23,977	23,794	23,598	18,577
Total	99,707	98,692	98,625	98,064	97,853	97,861	91,101
Sulfur Oxides (SO_x)							
Car Tailpipe	16,297	16,365	16,370	16,374	16,367	16,094	12,432
Car Upstream	103,558	100,068	99,915	99,777	99,507	98,946	80,413
Truck Tailpipe	24,289	24,385	24,474	23,883	23,837	23,866	16,449
Truck Upstream	121,649	118,699	118,192	117,131	116,274	115,321	93,753
Total	265,792	259,517	258,951	257,164	255,984	254,228	203,047
Volatile Organic Compounds (VOCs)							
Car Tailpipe	503,670	505,435	505,573	505,662	505,301	494,490	342,794
Car Upstream	254,720	245,658	245,280	244,938	244,029	238,717	138,880
Truck Tailpipe	856,201	858,940	861,713	842,568	840,777	840,185	591,527
Truck Upstream	291,528	284,366	283,707	276,339	273,244	270,888	132,522
Total	1,906,119	1,894,399	1,896,272	1,869,506	1,863,351	1,844,280	1,205,722

Table 3.3-5 lists the net change in nationwide emissions from passenger cars and light trucks for the No Action Alternative for each of the criteria pollutants and analysis years. The table presents the action alternatives (Alternatives 2 through 7) left to right in order of increasing fuel economy requirements. In Table 3.3-5 the nationwide emissions reductions generally become greater from left to right, reflecting the increasing fuel economy requirements that are assumed under successive alternatives. Emissions of CO under Alternatives 2 and 3 are exceptions, showing increases compared to the No Action Alternative.

Table 3.3-5

Reference Case Alternative CAFE Standards
Nationwide Changes in Criteria Pollutant Emissions from Passenger Cars and Light Trucks
(tons/year) a/ b/

Pollutant and Year	Alt. 1 No Action c/	Alt. 2 25% Below Optimized	Alt. 3 Optimized	Alt. 4 25% Above Optimized	Alt. 5 50% Above Optimized	Alt. 6 Total Costs Equal Total Benefits	Alt. 7 Technology Exhaustion
Carbon Monoxide (CO)							
2015	0	11,651	16,193	-13,655	-17,049	-52,329	-712,114
2020	0	27,768	46,202	-77,734	-92,902	-182,915	-2,841,909
2025	0	44,207	78,490	-157,510	-186,711	-332,154	-5,368,675
2035	0	63,602	120,803	-285,110	-334,419	-526,225	-8,695,467
Nitrogen Oxides (NO_x)							
2015	0	-1,630	-1,839	-2,178	-2,342	-3,217	-18,130
2020	0	-4,526	-4,804	-7,080	-7,965	-11,232	-78,356
2025	0	-6,812	-6,891	-12,692	-14,419	-20,159	-168,595
2035	0	-9,117	-8,616	-21,363	-24,376	-32,519	-311,140
Particulate Matter ($PM_{2.5}$)							
2015	0	-146	-157	-246	-275	-337	-1,418
2020	0	-457	-488	-743	-836	-879	-3,948
2025	0	-722	-770	-1,162	-1,309	-1,326	-6,016
2035	0	-1,015	-1,082	-1,643	-1,854	-1,846	-8,606
Sulfur Oxides (SO_x)							
2015	0	-947	-1,043	-1,379	-1,525	-2,023	-12,099
2020	0	-2,862	-3,125	-3,977	-4,484	-5,458	-30,541
2025	0	-4,489	-4,891	-6,165	-6,979	-8,332	-45,823
2035	0	-6,275	-6,842	-8,628	-9,808	-11,565	-62,746
Volatile Organic Compounds (VOCs)							
2015	0	-1,825	-1,857	-4,084	-4,681	-7,938	-75,700
2020	0	-5,886	-5,758	-12,990	-15,099	-22,830	-225,474
2025	0	-9,008	-8,457	-21,895	-25,532	-38,103	-399,770
2035	0	-11,721	-9,847	-36,613	-42,768	-61,839	-700,397

a/ Emissions changes have been rounded to the nearest whole number.
b/ Negative emissions changes indicate reductions; positive emissions changes are increases.
c/ Emissions changes for the No Action Alternative are shown as zero because the No Action Alternative is the baseline to which the emissions for the other alternatives are compared.

3.3.3.2.2 Air Toxics

Under Alternative 1, No Action, the CAFE standards would remain at the MY 2010 level in future years. As with the criteria pollutants, current trends in the levels of air toxics emissions from vehicles would continue, with emissions continuing to decline due to the EPA emissions standards, despite a growth in total VMT. An exception to this general trend is DPM, for which emissions are projected to increase over time with the No Action Alternative. Also, the trends of declining emissions of benzene and formaldehyde are projected to reverse by 2035 absent other regulatory action, although emissions of benzene and formaldehyde in 2035 with the No Action Alternative will still be well below existing levels. The EPA regulates air toxics from motor vehicles through vehicle emissions standards and fuel quality standards, as discussed in Section 3.3.1. The No Action Alternative would not change the current CAFE standards and therefore would not result in any change in toxic air pollutant emissions, other than current trends, in nonattainment and maintenance areas throughout the United States.

Table 3.3-6 summarizes the total national emissions of air toxics from passenger cars and light trucks under the No Action Alternative for each of the pollutants and analysis years. Figure 3.3-3 lists the total national emissions of air toxics from passenger cars and light trucks by alternative. Emissions of benzene, 1,3-butadiene, and DPM are generally highest with the No Action Alternative and decrease with successive alternatives as fuel economy requirements increase. Emissions of formaldehyde, on the other hand, generally increase with successive alternatives and are highest with Alternative 7. The trend for acetaldehyde across the alternatives is mixed. Table 3.3-6 shows increases for acrolein generally with successive alternatives because data on upstream emissions reductions were not available. The emissions for acrolein in Table 3.3-6 reflect only the changes due to the rebound effect and technological changes

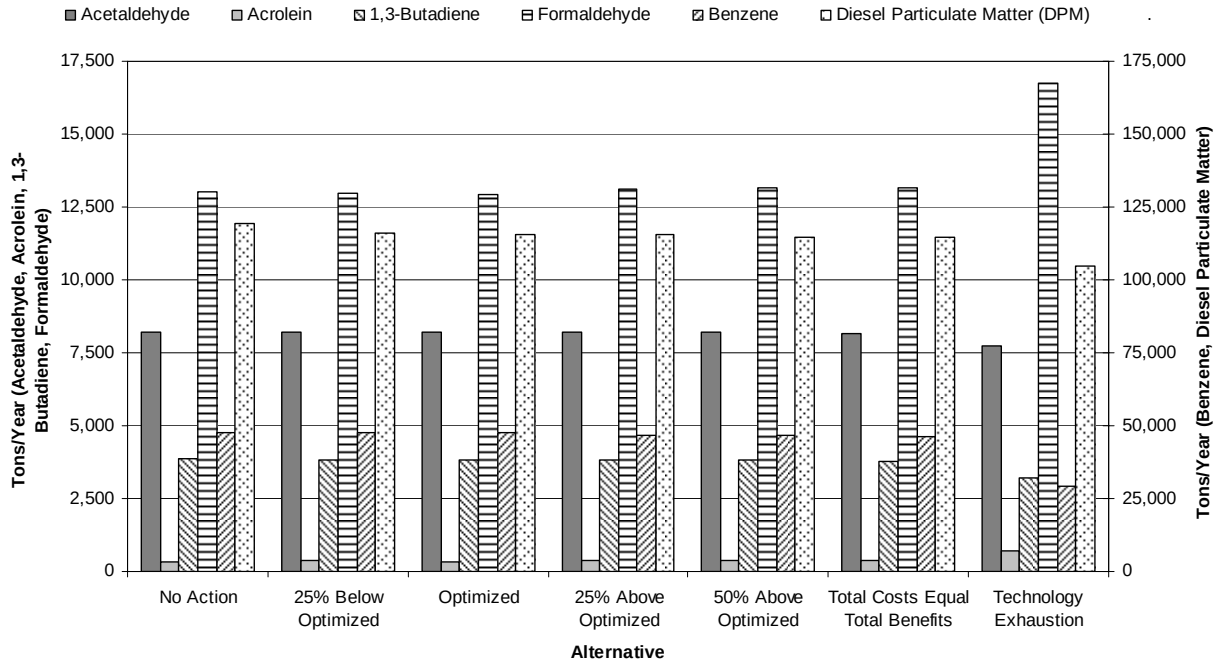
Table 3.3-6

Reference Case Alternative CAFE Standards
Nationwide Toxic Air Pollutant Emissions from Passenger Cars and Light Trucks (tons/year)

	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7
Pollutant and Year	**No Action**	**25% Below Optimized**	**Optimized**	**25% Above Optimized**	**50% Above Optimized**	**Total Costs Equal Total Benefits**	**Technology Exhaustion**
Acetaldehyde							
2015	11,982	11,978	11,976	11,985	11,987	11,991	12,093
2020	9,420	9,415	9,412	9,431	9,433	9,424	9,585
2025	8,401	8,396	8,395	8,408	8,409	8,388	8,372
2035	8,209	8,206	8,208	8,198	8,197	8,165	7,733
Acrolein a/							
2015	569	569	569	571	571	574	626
2020	429	430	429	436	437	442	596
2025	371	372	371	382	383	390	634
2035	351	354	353	367	369	378	720
Benzene							
2015	64,524	64,510	64,514	64,458	64,447	64,374	62,953
2020	51,781	51,731	51,751	51,531	51,490	51,310	46,246
2025	47,378	47,304	47,348	46,919	46,843	46,550	36,937
2035	47,515	47,428	47,517	46,703	46,570	46,154	29,324
1,3-butadiene							
2015	6,134	6,133	6,133	6,133	6,134	6,133	6,141
2020	4,698	4,689	4,689	4,687	4,685	4,680	4,617
2025	4,092	4,069	4,068	4,061	4,059	4,044	3,815
2035	3,885	3,834	3,834	3,818	3,815	3,781	3,231
Diesel particulate patter (DPM)							
2015	94,873	94,358	94,294	94,200	94,133	94,036	92,008
2020	98,292	96,762	96,587	96,387	96,154	95,993	91,105
2025	104,603	102,211	101,945	101,659	101,286	101,083	93,862
2035	119,499	116,161	115,786	115,400	114,858	114,592	104,644
Formaldehyde							
2015	17,382	17,359	17,351	17,388	17,393	17,421	18,018
2020	14,106	14,056	14,037	14,147	14,158	14,183	15,975
2025	12,930	12,862	12,835	12,995	13,010	13,035	15,713
2035	13,035	12,949	12,915	13,122	13,142	13,169	16,745

a/ Data on upstream emissions reductions were not available for acrolein. Thus, the emissions for acrolein reflect only the change in tailpipe emissions.

Figure 3.3-3. Reference Case Alternative CAFE Standards Nationwide Toxic Air Pollutant Emissions from Passenger Cars and Light Trucks for 2035 (tons/year)



analyzed in the Volpe model. Because the upstream emissions reductions result from the decline in the amount of fuel processed, it is reasonable that upstream acrolein emissions actually should vary as the other pollutants' upstream emissions do. Thus, the acrolein emissions given in Table 3.3-6 are an upper-bound estimate.

Total emissions are composed of four components: tailpipe emissions and upstream emissions for light duty vehicles, and tailpipe emissions and upstream emissions for light-duty trucks. To show the relationship among these four components for toxic air pollutants, Table 3.3-7 breaks down the total emissions of toxic air pollutants by component for calendar year 2035. The unavailability of data on upstream emissions of acrolein, as discussed in relation to Table 3.3-6, is evident in the zero values reported for upstream acrolein emissions in Table 3.3-7.

Table 3.3-8 lists the net change in nationwide emissions from passenger cars and light trucks for each of the air toxic pollutants and analysis years. After the No Action Alternative (Alternative 1), the action alternatives (Alternatives 2 through 7) are presented left to right in order of increasing fuel economy requirements. In Table 3.3-8, the nationwide emissions changes are uneven with respect to pollutant and alternative though most demonstrate reductions, reflecting the changes in VMT and emissions by cars versus trucks and gasoline versus diesel engines that are projected to occur with the increasing fuel economy requirements assumed under successive alternatives. Data on upstream emissions reductions were not available for acrolein, as noted above. Thus, the acrolein emissions changes given in Table 3.3-8 are an upper-bound estimate.

Table 3.3-7

Reference Case Alternative CAFE Standards
Nationwide Toxic Air Pollutant Emissions in 2035 from Passenger Cars and Light Trucks, by Vehicle Type (tons/year)

Pollutant and Year	Alt. 1 No Action	Alt. 2 25% Below Optimized	Alt. 3 Optimized	Alt. 4 25% Above Optimized	Alt. 5 50% Above Optimized	Alt. 6 Total Costs Equal Total Benefits	Alt. 7 Technology Exhaustion
Acetaldehyde							
Car Tailpipe	2,350	2,361	2,361	2,362	2,362	2,335	1,999
Car Upstream	509	491	491	490	488	485	378
Truck Tailpipe	4,755	4,773	4,777	4,774	4,779	4,782	4,923
Truck Upstream	595	581	578	572	567	563	433
Total	8,209	8,206	8,208	8,198	8,197	8,165	7,733
Acrolein a/							
Car Tailpipe	110	112	112	112	113	121	252
Car Upstream	0	0	0	0	0	0	0
Truck Tailpipe	241	242	241	254	257	257	467
Truck Upstream	0	0	0	0	0	0	0
Total	351	354	353	367	369	378	720
Benzene							
Car Tailpipe	14,071	14,118	14,122	14,125	14,113	13,780	9,100
Car Upstream	3,447	3,328	3,323	3,318	3,307	3,261	2,268
Truck Tailpipe	26,000	26,083	26,187	25,442	25,368	25,363	15,516
Truck Upstream	3,996	3,898	3,886	3,817	3,782	3,750	2,440
Total	47,515	47,428	47,517	46,703	46,570	46,154	29,324
1,3-butadiene							
Car Tailpipe	1,190	1,198	1,200	1,197	1,196	1,198	1,114
Car Upstream	156	144	143	141	140	138	115
Truck Tailpipe	2,355	2,319	2,320	2,311	2,313	2,285	1,873
Truck Upstream	183	174	171	168	166	160	130
Total	3,885	3,834	3,834	3,818	3,815	3,781	3,231
Diesel particulate matter (DPM)							
Car Tailpipe	56	129	129	129	165	804	10,409
Car Upstream	54,828	52,967	52,885	52,812	52,662	52,256	40,933
Truck Tailpipe	424	433	391	772	826	832	6,396
Truck Upstream	64,191	62,632	62,380	61,686	61,205	60,700	46,906
Total	119,499	116,161	115,786	115,400	114,858	114,592	104,644
Formaldehyde							
Car Tailpipe	2,630	2,652	2,653	2,653	2,658	2,711	3,581
Car Upstream	2,153	2,080	2,077	2,074	2,068	2,054	1,628
Truck Tailpipe	5,729	5,755	5,734	5,968	6,008	6,016	9,660
Truck Upstream	2,523	2,462	2,452	2,426	2,408	2,388	1,875
Total	13,035	12,949	12,915	13,122	13,142	13,169	16,745

a/ Data on upstream emissions reductions were not available for acrolein. Thus, the emissions for acrolein reflect only the change in tailpipe emissions.

Table 3.3-8

Reference Case Alternative CAFE Standards Nationwide Changes in Toxic Air Pollutant Emissions from Passenger Cars and Light Trucks (tons/year) a/ b/

Pollutant and Year	Alt. 1 No Action c/	Alt. 2 25% Below Optimized	Alt. 3 Optimized	Alt. 4 25% Above Optimized	Alt. 5 50% Above Optimized	Alt. 6 Total Costs Equal Total Benefits	Alt. 7 Technology Exhaustion
Acetaldehyde							
2015	0	-4	-6	3	5	9	111
2020	0	-5	-8	10	12	4	164
2025	0	-5	-6	7	8	-13	-29
2035	0	-3	-1	-11	-12	-44	-475
Acrolein d/							
2015	0	0	0	2	2	5	57
2020	0	1	0	7	8	12	167
2025	0	2	1	11	13	19	264
2035	0	3	1	15	18	27	368
Benzene							
2015	0	-13	-10	-66	-76	-150	-1,570
2020	0	-50	-30	-250	-291	-471	-5,535
2025	0	-74	-30	-459	-535	-828	-10,441
2035	0	-87	2	-812	-945	-1,361	-18,191
1,3-butadiene							
2015	0	-1	-1	-1	-1	-1	7
2020	0	-9	-10	-12	-13	-19	-81
2025	0	-23	-24	-31	-33	-48	-277
2035	0	-51	-52	-67	-70	-104	-654
Diesel particulate matter (DPM)							
2015	0	-515	-579	-673	-740	-837	-2,865
2020	0	-1,530	-1,704	-1,905	-2,138	-2,298	-7,187
2025	0	-2,392	-2,658	-2,944	-3,317	-3,519	-10,740
2035	0	-3,339	-3,713	-4,100	-4,641	-4,907	-14,855
Formaldehyde							
2015	0	-24	-32	6	11	39	636
2020	0	-50	-69	42	52	77	1,870
2025	0	-68	-95	65	80	105	2,783
2035	0	-86	-120	87	106	133	3,709

a/ Emissions changes have been rounded to the nearest whole number.
b/ Negative emissions changes indicate reductions; positive emissions changes are increases.
c/ Emissions changes for the No Action Alternative are shown as zero because the No Action Alternative is the baseline to which emissions from the action alternatives are compared.
d/ Data on upstream emissions reductions were not available for acrolein. Thus, the emissions for acrolein reflect only the change in tailpipe emissions.

3.3.3.2.3 Health Outcomes and Costs

Under Alternative 1, No Action, the CAFE standards would remain at the MY 2010 level in future years. Current trends in the levels of criteria pollutants and air toxics emissions from vehicles would continue, with emissions continuing to decline due to the EPA emissions standards, despite a growth in total VMT. The human health effects and health-related costs that occur under current trends would continue, and are expected to decline in the future as a result of declines in pollutant emissions. The No Action Alternative would not result in any other increase or decrease in human health effects and health-related costs throughout the United States.

3.3.3.3 Reference Case Alternative 2: 25 Percent Below Optimized

3.3.3.3.1 Criteria Pollutants

Under the 25 Percent Below Optimized Alternative (Alternative 2), generally the CAFE standards would require increased fuel economy compared to the No Action Alternative (Alternative 1). Alternative 2 would increase fuel economy less than would Alternatives 3 through 7. There would be reductions in nationwide emissions of NO_x, $PM_{2.5}$, SO_x, and VOC under Alternative 2 compared to the No Action Alternative. Depending on the year, NO_x emissions would be reduced 0.1 to 0.7 percent, $PM_{2.5}$ emissions would be reduced 0.2 to 1.0 percent, SO_x emissions would be reduced 0.5 to 2.4 percent, and VOC emissions would be reduced 0.1 to 0.6 percent. There would be increases of CO emissions. CO emissions would increase 0.1 to 1.3 percent with Alternative 2 depending on the year.

At the nationwide level, the reduction in upstream emissions of criteria air pollutants tends to offset the increase in VMT and emissions due to the rebound effect. However, the reductions in upstream emissions are not uniformly distributed to individual nonattainment areas. For example, a nonattainment area that contains petroleum refining facilities, such as Houston-Galveston-Brazoria, Texas, would experience more reductions in upstream emissions than an area that has none. Net emissions reductions can occur if the reduction in upstream emissions in the nonattainment area more than offsets the increase within the area due to the rebound effect. With Alternative 2, all nonattainment areas would experience reductions in emissions of NO_x, SO_x and VOC. Most nonattainment areas would experience increases of CO and $PM_{2.5}$ emissions. The increases in CO and $PM_{2.5}$ emissions are the result of increased tailpipe emissions due to the rebound effect. Although $PM_{2.5}$ emissions would increase in most nonattainment areas the increase in each area is quite small. The decreases in nationwide $PM_{2.5}$ emissions are the result of the decreases in upstream emissions and do not occur in all nonattainment areas. Although $PM_{2.5}$ emissions would decrease in fewer nonattainment areas the decreases in each area are much larger. The net result is decreased $PM_{2.5}$ emissions nationwide.

Tables in Appendix B-2 list the emissions reductions for each nonattainment area. Table 3.3-9 summarizes the criteria air pollutant results by nonattainment area.

Table 3.3-9

Reference Case Alternative CAFE Standards
Changes in Criteria Pollutant Emissions from Passenger Cars and Light Trucks,
Maximum Changes by Nonattainment Area a/

Criteria Pollutant	Increase/ Decrease	Change (tons/year)	Year	Alt. No.	Nonattainment Area
CO	Maximum Increase	5,956	2035	3	Los Angeles South Coast Air Basin, CA
	Maximum Decrease	-432,141	2035	7	Los Angeles South Coast Air Basin, CA
NO_x	Maximum Increase	1	2035	3	Charlotte-Gastonia-Rock Hill, NC-SC
	Maximum Decrease	-16,115	2035	7	Los Angeles South Coast Air Basin, CA
$PM_{2.5}$	Maximum Increase	62	2035	7	Atlanta, GA
	Maximum Decrease	-1,344	2035	7	Houston-Galveston-Brazoria, TX
SO_x	Maximum Increase	No SO_x increases			
	Maximum Decrease	-5,624	2035	7	Houston-Galveston-Brazoria, TX
VOCs	Maximum Increase	No VOC increases			
	Maximum Decrease	-35,062	2035	7	Los Angeles South Coast Air Basin, CA

a/ Emissions changes have been rounded to the nearest whole number.

3.3.3.3.2 Air Toxics

There would be reductions in nationwide emissions of all toxic air pollutants (except acrolein) under Alternative 2 compared to the No Action Alternative.

Alternative 2 would have the same or higher emissions of acetaldehyde, acrolein, 1,3-butadiene, DPM, and formaldehyde, but lower emissions of benzene, compared to Alternative 3. Compared to Alternatives 4 through 7, Alternative 2 would have higher emissions of benzene, 1,3-butadiene (except in 2015), and DPM, but lower emissions of acrolein and formaldehyde, and mixed results for acetaldehyde depending on the year and alternative. At the nationwide level, the reduction in upstream emissions of toxic air pollutants tends to offset the increase in VMT and emissions due to the rebound effect. However, as noted above, the reductions in upstream emissions are not uniformly distributed to individual nonattainment areas. For example, a nonattainment area that contains petroleum refining facilities, such as Houston-Galveston-Brazoria, Texas, would experience more reductions in upstream emissions than an area that has none. Net emissions reductions can occur if the reduction in upstream emissions in the nonattainment area more than offsets the increase within the area due to the rebound effect.

Under Alternative 2, many nonattainment areas would experience net increases in emissions of one or more toxic air pollutants in at least one of the analysis years (see Appendix B-2). However, the sizes of the emissions increases would be quite small, as shown in Appendix B-2, and emissions increases would be distributed throughout each nonattainment area.

3.3.3.3.3 Health Outcomes and Costs

There would be reductions in adverse health effects nationwide under Alternative 2 compared to the No Action Alternative (see Table 3.3-10). These reductions primarily reflect the projected $PM_{2.5}$ reductions, because $PM_{2.5}$ tends to be the largest contributor to adverse health effects. In comparison to the No Action Alternative, Alternative 2 would reduce mortalities by 78 and the number of work-loss days by 13,877 in 2035. Data are not available to estimate reliably the number of adverse health effects due to the other pollutants. Table 3.3-11 lists the corresponding reductions in health costs under Alternative 2 compared to the No Action Alternative. Alternative 2 would reduce health costs by $173 million in 2035.

Table 3.3-10

Reference Case Alternative CAFE Standards
Nationwide Changes in Health Outcomes from Criteria Pollutant Emissions from Passenger Cars and Light Trucks (cases/year) a/

Health Outcome and Year	Alt. 1 No Action b/	Alt. 2 25% Below Optimized	Alt. 3 Optimized	Alt. 4 25% Above Optimized	Alt. 5 50% Above Optimized	Alt. 6 Total Costs Equal Total Benefits	Alt. 7 Technology Exhaustion
Mortality (ages 30 and older)							
2015	0	-11	-12	-19	-21	-26	-109
2020	0	-35	-37	-57	-64	-67	-303
2025	0	-55	-59	-89	-100	-102	-461
2035	0	-78	-83	-126	-142	-142	-660
Chronic bronchitis							
2015	0	-10	-10	-16	-18	-22	-95
2020	0	-30	-33	-50	-56	-59	-263
2025	0	-48	-51	-77	-87	-88	-401
2035	0	-68	-72	-110	-124	-123	-574

Table 3.3-10 (cont'd)

Reference Case Alternative CAFE Standards
Nationwide Changes in Health Outcomes from Criteria Pollutant Emissions from Passenger Cars and Light Trucks (cases/year) a/

Health Outcome and Year	Alt. 1 No Action b/	Alt. 2 25% Below Optimized	Alt. 3 Optimized	Alt. 4 25% Above Optimized	Alt. 5 50% Above Optimized	Alt. 6 Total Costs Equal Total Benefits	Alt. 7 Technology Exhaustion
Emergency room visits for asthma							
2015	0	-2	-3	-4	-4	-5	-23
2020	0	-7	-8	-12	-13	-14	-63
2025	0	-12	-12	-19	-21	-21	-96
2035	0	-16	-17	-26	-30	-30	-138
Work-loss days							
2015	0	-1,991	-2,147	-3,362	-3,756	-4,603	-19,376
2020	0	-6,251	-6,675	-10,159	-11,428	-12,007	-53,957
2025	0	-9,874	-10,523	-15,885	-17,886	-18,116	-82,216
2035	0	-13,877	-14,789	-22,456	-25,339	-25,233	-117,617

a/ Negative changes indicate reductions; positive emissions changes are increases.
b/ Changes in health outcome for the No Action Alternative are shown as zero because the No Action Alternative is the baseline to which emissions under the action alternatives are compared.

Table 3.3-11

Reference Case Alternative CAFE Standards
Nationwide Changes in Health Costs from Criteria Pollutant Emissions from Passenger Cars and Light Trucks (U.S. million dollars/year) a/

Year	Alt. 1 No Action b/	Alt. 2 25% Below Optimized	Alt. 3 Optimized	Alt. 4 25% Above Optimized	Alt. 5 50% Above Optimized	Alt. 6 Total Costs Equal Total Benefits	Alt. 7 Technology Exhaustion
2015	0	-20	-22	-29	-31	-42	-239
2020	0	-82	-88	-121	-136	-175	-1,081
2025	0	-126	-133	-200	-227	-289	-1,997
2035	0	-173	-179	-307	-349	-435	-3,329

a/ Negative changes indicate economic benefit; positive emissions changes are economic costs.
b/ Changes for the No Action Alternative are shown as zero because the No Action Alternative is the baseline to which emissions under the action alternatives are compared.

3.3.3.4 Reference Case Alternative 3: Optimized

3.3.3.4.1 Criteria Pollutants

Under the Optimized Alternative (Alternative 3), generally the CAFE standards would increase fuel economy more than would Alternative 2 but less than would Alternatives 4 through 7. There would be reductions in nationwide emissions of NO_x, $PM_{2.5}$, SO_x, and VOC under Alternative 3 compared to the No Action Alternative. Depending on the year, NO_x emissions would be reduced 0.1 to 0.6 percent,

$PM_{2.5}$ emissions would be reduced 0.2 to 1.1 percent SO_x emissions would be reduced 0.5 to 2.6 percent, and VOC emissions would be reduced 0.1 to 0.5 percent. These emissions reductions are generally greater (except for VOC) than would occur with Alternative 2 but less than would occur with Alternatives 4 through 7. There would be increases of CO emissions. CO emissions would increase 0.1 to 0.6 percent depending on the year. With Alternative 3, all nonattainment areas would experience reductions in emissions of SO_x and VOC, and almost all would experience reductions in NO_x emissions. Most nonattainment areas would experience increases of CO and $PM_{2.5}$ emissions. The increases in CO and $PM_{2.5}$ emissions are the result of increased tailpipe emissions due to the rebound effect. Although $PM_{2.5}$ emissions would increase in most nonattainment areas the increase in each area is quite small. The decreases in nationwide $PM_{2.5}$ emissions are the result of the decreases in upstream emissions and do not occur in all nonattainment areas. Although $PM_{2.5}$ emissions would decrease in fewer nonattainment areas the decreases in each area are much larger. The net result is decreased $PM_{2.5}$ emissions nationwide.

Tables in Appendix B-2 list the emissions reductions for each nonattainment area. Table 3.3-12 summaries the criteria air pollutant results by nonattainment area.

Table 3.3-12

Reference Case Alternative CAFE Standards
Changes in Toxic Air Pollutant Emissions from Passenger Cars and Light Trucks,
Maximum Changes by Nonattainment Area

Hazardous Air Pollutant	Increase/Decrease	Change (tons/year)	Year	Alt. No.	Nonattainment Area
Acetaldehyde	Maximum increase	11	2020	7	New York-N. New Jersey-Long Island, NY-NJ-CT
	Maximum decrease	-41	2035	7	Houston-Galveston-Brazoria, TX
Acrolein	Maximum increase	18	2035	7	Los Angeles South Coast Air Basin, CA
	Maximum decrease	-0.02	2015	3	Los Angeles South Coast Air Basin, CA
Benzene	Maximum increase	7	2035	3	Atlanta, GA
	Maximum decrease	-960	2035	7	Los Angeles South Coast Air Basin, CA
1,3-butadiene	Maximum increase	1	2015	7	New York-N. New Jersey-Long Island, NY-NJ-CT
	Maximum decrease	-35	2035	7	Los Angeles South Coast Air Basin, CA
Diesel particulate matter	Maximum increase	No increase			
	Maximum decrease	-697	2035	7	Los Angeles South Coast Air Basin, CA
Formaldehyde	Maximum increase	161	2035	7	Los Angeles South Coast Air Basin, CA
	Maximum decrease	-72	2035	7	Houston-Galveston-Brazoria, TX

a/ Emissions changes have been rounded to the nearest whole number except to present values greater than zero but less than one.

3.3.3.4.2 Air Toxics

Alternative 3 would reduce air toxics emissions compared to the No Action Alternative for all air toxics (except acrolein in all analysis years and benzene in 2035). Alternative 3 would have higher emissions of benzene, 1,3-butadiene (except in 2015), and DPM compared to Alternatives 4 through 7. Alternative 3 would have lower emissions of acrolein and formaldehyde compared to Alternatives 4 through 7, and mixed results for acetaldehyde depending on the year and alternative.

At the nationwide level, emissions of toxic air pollutants can decrease because the reduction in upstream emissions more than offsets the increase in VMT and emissions due to the rebound effect.

However, as with Alternative 2, the reductions in upstream emissions are not uniformly distributed to individual nonattainment areas. Under Alternative 3, many nonattainment areas would experience net increases in emissions of one or more toxic air pollutants in at least one of the analysis years (see Appendix B-2). However, the sizes of the emissions increases would be quite small, as shown in Appendix B-2, and emissions increases would be distributed throughout each nonattainment area.

3.3.3.4.3 Health Outcomes and Costs

There would be reductions in adverse health effects nationwide with the Optimized Alternative compared to the No Action Alternative, as shown in Table 3.3-10. These reductions primarily reflect the projected $PM_{2.5}$ reductions, because $PM_{2.5}$ tends to be the largest contributor to adverse health effects. In comparison to the No Action Alternative, Alternative 3 would reduce mortalities by 83 and the number of work-loss days by 14,789 in 2035. Data are not available to estimate reliably the number of adverse health effects due to the other pollutants. Table 3.3-11 lists the corresponding reductions in health costs under Alternative 3 compared to the No Action Alternative. Alternative 3 would reduce health costs by $179 million in 2035.

3.3.3.5 Reference Case Alternative 4: 25 Percent Above Optimized

3.3.3.5.1 Criteria Pollutants

Under the 25 Percent Above Optimized Alternative (Alternative 4), the CAFE standards would increase fuel economy more than would Alternatives 1 through 3 but less than would Alternatives 5 through 7. There would be reductions in nationwide emissions of all criteria pollutants under Alternative 4. Percent reductions would range from 0.1 to 3.2, depending on the year and pollutant. These emissions reductions are greater than would occur with Alternative 3 but less than would occur with Alternatives 5 through 7. With Alternative 4, all nonattainment areas would experience reductions in emissions of CO, NO_x, SO_x and VOC. Most nonattainment areas would experience increases of $PM_{2.5}$ emissions in 2015 and 2020 compared to the No Action Alternative. Tables in Appendix B-2 list the emissions reductions for each nonattainment area.

3.3.3.5.2 Air Toxics

Alternative 4 would reduce air toxics emissions of acetaldehyde (in 2035), benzene, 1,3-butadiene, and DPM, but would increase emissions of acetaldehyde (except in 2035), acrolein, and formaldehyde compared to the No Action Alternative.

Alternative 4 would have higher emissions of benzene, 1,3-butadiene (except in 2015), and DPM compared to Alternatives 5 through 7. Alternative 4 would have lower emissions of acrolein and formaldehyde compared to Alternatives 5 through 7, and mixed results for acetaldehyde depending on the year and alternative.

At the nationwide level, emissions of toxic air pollutants might decrease, because the reduction in upstream emissions more than offsets the increase in VMT and emissions due to the rebound effect. However, as with Alternative 3, the reductions in upstream emissions are not uniformly distributed to individual nonattainment areas. Under Alternative 4, many nonattainment areas would experience net increases in emissions of one or more toxic air pollutants in at least one of the analysis years (see Appendix B-2). However, the sizes of the emissions increases would be quite small, as shown in Appendix B-2. Potential air quality impacts from these increases would be minor, because the VMT and emissions increases would be distributed throughout each nonattainment area.

3.3.3.5.3 Health Outcomes and Costs

There would be reductions in adverse health effects nationwide under Alternative 4 compared to the No Action Alternative, as shown in Table 3.3-10. These reductions primarily reflect the projected $PM_{2.5}$ reductions, because $PM_{2.5}$ tends to be the largest contributor to adverse health effects. In comparison to the No Action Alternative, Alternative 4 would reduce mortalities by 126 and the number of work-loss days by 22,456 in 2035. Data are not available to estimate reliably the number of adverse health effects due to the other pollutants. Table 3.3-11 lists the corresponding reductions in health costs under Alternative 4 compared to the No Action Alternative. Alternative 4 would reduce health costs by $307 million in 2035.

3.3.3.6 Reference Case Alternative 5: 50 Percent Above Optimized

3.3.3.6.1 Criteria Pollutants

Under the 50 Percent Above Optimized Alternative (Alternative 5), the CAFE standards would increase fuel economy more than would Alternatives 1 through 4 but less than would Alternatives 6 and 7. There would be reductions in nationwide emissions of all criteria pollutants under Alternative 5. Reductions would be greater than under Alternative 4 but less than under Alternatives 6 and 7. Percent reductions would range from 0.1 to 3.7 compared to the No Action Alternative, depending on the year and pollutant. All individual nonattainment areas would experience reductions in emissions of CO, NO_x, SO_x, and VOCs. $PM_{2.5}$ emissions would increase in most nonattainment areas in 2015 and 2020 and would decrease in some compared to the No Action Alternative. Tables in Appendix B-2 list the emissions reductions for each nonattainment area.

3.3.3.6.2 Air Toxics

Alternative 5 would reduce air toxics emissions of acetaldehyde (in 2035), benzene, 1,3-butadiene, and DPM, but would increase emissions of acetaldehyde (except 2035), acrolein, and formaldehyde compared to the No Action Alternative. Alternative 5 would have higher emissions of benzene, 1,3-butadiene (except for Alternative 7 in 2015), and DPM compared to Alternatives 6 and 7. Alternative 5 would have lower emissions of acrolein and formaldehyde compared to Alternatives 6 and 7, and mixed results for acetaldehyde depending on the year and alternative.

At the nationwide level, emissions of toxic air pollutants could decrease because the reduction in upstream emissions more than offsets the increase in VMT and emissions due to the rebound effect. However, as with the Alternative 4, the reductions in upstream emissions are not uniformly distributed to individual nonattainment areas. Under Alternative 5, many nonattainment areas would experience net increases in emissions of one or more toxic air pollutants in at least one of the analysis years (see Appendix B-2). However, the sizes of the emissions increases would be quite small, as shown in Appendix B-2, and emissions increases would be distributed throughout each nonattainment area.

3.3.3.6.3 Health Outcomes and Costs

There would be reductions in adverse health effects nationwide under Alternative 5 compared to the No Action Alternative, as shown in Table 3.3-10. These reductions primarily reflect the projected $PM_{2.5}$ reductions, because $PM_{2.5}$ tends to be the largest contributor to adverse health effects. Compared to the No Action Alternative, Alternative 5 would reduce mortalities by 142 and the number of work-loss days by 25,339 in 2035. Data are not available to estimate reliably the number of adverse health effects due to the other pollutants. Table 3.3-11 lists the corresponding reductions in health costs under

Alternative 5 compared to the No Action Alternative. Alternative 5 would reduce health costs by $349 million in 2035.

3.3.3.7 Reference Case Alternative 6: Total Costs Equal Total Benefits

3.3.3.7.1 Criteria Pollutants

Under the Total Costs Equal Total Benefits Alternative (Alternative 6), the CAFE standards would increase fuel economy more than would Alternatives 1 through 5 but less than would Alternative 7. There would be reductions in nationwide emissions of all criteria pollutants under Alternative 6 compared to the No Action Alternative. Reductions would be greater than under Alternative 5 (except for $PM_{2.5}$ in 2035) but less than under Alternative 7. Compared to the No Action Alternative, percent reductions would range from 0.1 to 4.4, depending on the year and pollutant. All individual nonattainment areas would experience reductions in emissions of CO, NO_x, SO_x, and VOCs. $PM_{2.5}$ emissions would increase in most nonattainment areas and decrease in some compared to the No Action Alternative. Tables in Appendix B-2 list the emissions reductions for each nonattainment area.

3.3.3.7.2 Air Toxics

Alternative 6 would reduce air toxics emissions of acetaldehyde (in 2025 and 2035), benzene, 1,3-butadiene, and DPM, but would increase emissions of acetaldehyde (in 2015 and 2020), acrolein, and formaldehyde compared to the No Action Alternative. Alternative 6 would have higher emissions of acetaldehyde (in 2025 and 2035), benzene, 1,3-butadiene (except in 2015), and DPM compared to Alternative 7. Alternative 6 would have lower emissions of acetaldehyde (in 2015 and 2020), acrolein, 1,3-butadiene (except in 2015), and formaldehyde compared to Alternative 7.

At the nationwide level, emissions of toxic air pollutants could decrease because the reduction in upstream emissions more than offsets the increase in VMT and emissions due to the rebound effect. However, as with the Alternative 6, the reductions in upstream emissions are not uniformly distributed to individual nonattainment areas. Under Alternative 6, many nonattainment areas would experience net increases in emissions of one or more toxic air pollutants in at least one of the analysis years (see Appendix B-2). However, the sizes of the emissions increases would be quite small, as shown in Appendix B-2, and emissions increases would be distributed throughout each nonattainment area.

3.3.3.7.3 Health Outcomes and Costs

There would be reductions in adverse health effects nationwide under Alternative 6 compared to the No Action Alternative, as shown in Table 3.3-10. These reductions primarily reflect the projected $PM_{2.5}$ reductions, because $PM_{2.5}$ tends to be the largest contributor to adverse health effects. Compared to the No Action Alternative, the Alternative 6 would reduce mortalities by 142 and the number of work-loss days by 25,233 in 2035. Data are not available to estimate reliably the number of adverse health effects due to the other pollutants. Table 3.3-11 lists the corresponding reductions in health costs under Alternative 6 compared to the No Action Alternative. Alternative 6 would reduce health costs by $435 million in 2035.

3.3.3.8 Reference Case Alternative 7: Technology Exhaustion

3.3.3.8.1 Criteria Pollutants

Under the Technology Exhaustion Alternative (Alternative 7), the CAFE standards would increase fuel economy more than all the other alternatives. There would be greater reductions in

nationwide emissions of criteria pollutants under Alternative 7 than with any other alternative: between 0.8 percent and 44 percent compared to the No Action Alternative, depending on year and pollutant. All individual nonattainment areas would experience reductions in emissions of CO, NO_x, SO_x, and VOCs. $PM_{2.5}$ emissions would increase in most nonattainment areas and decrease in some compared to the No Action Alternative. Tables in Appendix B-2 list the emissions reductions for each nonattainment area.

3.3.3.8.2 Air Toxics

Alternative 7 would reduce air toxics emissions of acetaldehyde (in 2025 and 2035), benzene, 1,3-butadiene (except in 2015), and DPM, but would increase emissions of acetaldehyde (in 2015 and 2020), acrolein, 1,3-butadiene (in 2015), and formaldehyde compared to the No Action Alternative.

At the nationwide level, emissions of toxic air pollutants could decrease because the reduction in upstream emissions more than offsets the increase in VMT and emissions due to the rebound effect. However, as with the Alternative 6, the reductions in upstream emissions are not uniformly distributed to individual nonattainment areas. Under Alternative 7, many nonattainment areas would experience net increases in emissions of one or more toxic air pollutants in at least one of the analysis years (see Appendix B-2). In general, of all the Alternatives, Alternative 7 results in the largest emissions changes (either increases or decreases) relative to the No Action Alternative. As shown in Appendix B-2, and emissions increases would be distributed throughout each nonattainment area.

3.3.3.8.3 Health Outcomes and Costs

There would be reductions in adverse health effects nationwide under Alternative 7 compared to the No Action Alternative, as shown in Table 3.3-10. These reductions primarily reflect the projected $PM_{2.5}$ reductions, because $PM_{2.5}$ tends to be the largest contributor to adverse health effects. Compared to the No Action Alternative, Alternative 7 would reduce mortalities by 660 and the number of work-loss days by 117,617 in 2035. Data are not available to estimate reliably the number of adverse health effects due to the other pollutants. Table 3.3-11 lists the corresponding reductions in health costs under Alternative 7 compared to the No Action Alternative. Alternative 7 would reduce health costs by $3.329 billion in 2035.

3.3.4 Input Scenarios

3.3.4.1 Results of the Emissions Analysis

The CAA has been a success in reducing emissions from on-road mobile sources. As discussed in Section 3.3.1, pollutant emissions from vehicles have been declining since 1970, and EPA projects that they will continue to decline. This trend will continue regardless of the alternative chosen for future CAFE standards. The analysis by alternatives in this section shows that the alternative CAFE standards from the High, Mid-1, and Mid-2 Scenarios would lead to further reductions in emissions from passenger cars and light trucks. The amount of the reductions would vary by alternative. The more restrictive High Scenario alternatives would result in greater emissions reductions compared to the No Action Alternative. Under all of the High Scenario action alternatives, there are no emissions increases that would exceed any of the general conformity thresholds.

3.3.4.2 High Scenario Alternative 1: No Action

3.3.4.2.1 Criteria Pollutants

With the High Scenario No Action Alternative, the CAFE standards would remain at the MY 2010 level in future years. Current trends in the levels of emissions from vehicles would continue, with emissions continuing to decline due to the EPA emissions standards, despite a growth in total VMT. The EPA vehicle emissions standards regulate all criteria pollutants except SO_2, which is regulated through fuel sulfur content. The High Scenario No Action Alternative would not change the current CAFE standards and so would not result in any change in criteria pollutant emissions, other than current trends, in nonattainment and maintenance areas throughout the United States.

Table 3.3-13 summarizes the total national emissions from passenger cars and light trucks for the High Scenario No Action Alternative for each of the criteria pollutants and analysis years. The table presents the other High Scenario alternatives (Alternatives 2 through 7) left to right in order of increasing fuel economy requirements. Table 3.3-13 shows that the No Action Alternative has the highest emissions of all the High Scenario alternatives for all criteria pollutants.

Table 3.3-13

High Scenario Alternative CAFE Standards
Nationwide Criteria Pollutant Emissions from Passenger Cars and Light Trucks (tons/year)

	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7
Pollutant and Year	**No Action**	**25% Below Optimized**	**Optimized**	**25% Above Optimized**	**50% Above Optimized**	**Total Costs Equal Total Benefits**	**Technology Exhaustion**
Carbon monoxide (CO)							
2015	18,861,709	18,819,943	18,808,145	18,754,377	18,733,187	18,676,711	18,198,147
2020	16,619,854	16,400,691	16,407,324	16,205,551	16,099,145	15,924,287	14,015,233
2025	16,403,499	15,959,939	16,005,225	15,620,887	15,415,228	15,106,788	11,538,880
2035	17,713,991	16,946,492	17,052,955	16,475,978	16,127,830	15,629,753	9,913,291
Nitrogen oxides (NO_x)							
2015	2,148,052	2,144,337	2,143,274	2,141,461	2,140,580	2,139,457	2,131,158
2020	1,530,682	1,516,245	1,514,017	1,507,360	1,504,399	1,499,924	1,458,868
2025	1,292,315	1,264,972	1,262,749	1,249,455	1,243,068	1,233,920	1,139,549
2035	1,228,251	1,181,455	1,180,414	1,159,073	1,146,599	1,129,532	949,127
Particulate matter ($PM_{2.5}$)							
2015	74,919	74,512	74,388	74,358	74,277	74,101	73,597
2020	75,571	74,304	74,071	74,100	73,822	73,539	71,953
2025	79,258	77,281	76,963	77,052	76,611	76,253	73,807
2035	89,447	86,654	86,251	86,389	85,756	85,318	81,727
Sulfur oxides (SO_x)							
2015	194,594	192,146	191,518	190,557	189,965	189,139	183,320
2020	199,331	191,631	190,421	188,360	186,988	185,366	171,340
2025	210,380	198,302	196,642	193,696	191,711	189,468	168,860
2035	238,442	221,475	219,361	215,533	212,881	209,978	182,153
Volatile organic compounds (VOCs)							
2015	2,107,357	2,098,536	2,096,674	2,089,984	2,087,215	2,082,262	2,036,819
2020	1,738,318	1,707,595	1,705,389	1,687,741	1,679,750	1,666,745	1,531,670
2025	1,646,853	1,593,668	1,592,155	1,561,539	1,547,465	1,525,528	1,284,617
2035	1,709,979	1,620,442	1,621,526	1,572,211	1,546,659	1,507,558	1,081,653

Table 3.3-14 lists the net change in nationwide emissions from passenger cars and light trucks for the High Scenario No Action Alternative for each of the criteria pollutants and analysis years. The table presents Alternatives 2 through 7 left to right in order of increasing fuel economy requirements. In Table 3.3-14, the nationwide emissions reductions tend to become greater from left to right, reflecting the increasing fuel economy requirements that are assumed under successive High Scenario alternatives.

Table 3.3-14

High Scenario Alternative CAFE Standards
Nationwide Changes in Criteria Pollutant Emissions from Passenger Cars and Light Trucks (tons/year) a/ b/

Pollutant and Year	Alt. 1 No Action c/	Alt. 2 25% Below Optimized	Alt. 3 Optimized	Alt. 4 25% Above Optimized	Alt. 5 50% Above Optimized	Alt. 6 Total Costs Equal Total Benefits	Alt. 7 Technology Exhaustion
Carbon monoxide (CO)							
2015	0	-41,765	-53,563	-107,331	-128,521	-184,997	-663,562
2020	0	-219,163	-212,530	-414,303	-520,709	-695,567	-2,604,621
2025	0	-443,561	-398,274	-782,612	-988,271	-1,296,712	-4,864,620
2035	0	-767,499	-661,036	-1,238,012	-1,586,160	-2,084,237	-7,800,700
Nitrogen oxides (NO_x)							
2015	0	-3,715	-4,778	-6,591	-7,472	-8,595	-16,893
2020	0	-14,437	-16,665	-23,322	-26,283	-30,758	-71,814
2025	0	-27,343	-29,565	-42,859	-49,247	-58,394	-152,765
2035	0	-46,796	-47,837	-69,178	-81,652	-98,719	-279,123
Particulate matter ($PM_{2.5}$)							
2015	0	-407	-531	-561	-642	-817	-1,321
2020	0	-1,268	-1,501	-1,471	-1,750	-2,032	-3,618
2025	0	-1,977	-2,295	-2,206	-2,647	-3,005	-5,451
2035	0	-2,793	-3,196	-3,058	-3,691	-4,130	-7,721
Sulfur oxides (SO_x)							
2015	0	-2,448	-3,077	-4,037	-4,629	-5,455	-11,274
2020	0	-7,699	-8,910	-10,971	-12,343	-13,964	-27,991
2025	0	-12,079	-13,738	-16,685	-18,670	-20,913	-41,521
2035	0	-16,967	-19,081	-22,909	-25,562	-28,464	-56,289
Volatile organic compounds (VOCs)							
2015	0	-8,821	-10,683	-17,373	-20,143	-25,095	-70,539
2020	0	-30,723	-32,929	-50,576	-58,568	-71,573	-206,648
2025	0	-53,185	-54,699	-85,314	-99,389	-121,326	-362,236
2035	0	-89,537	-88,453	-137,767	-163,320	-202,421	-628,326

a/ Emissions changes have been rounded to the nearest whole number.
b/ Negative changes indicate reductions; positive emissions changes are increases.
c/ Changes for the No Action Alternative are shown as zero because the No Action Alternative is the baseline to which emissions under the action alternatives are compared.

3.3.4.2.2 Air Toxics

With the High Scenario No Action Alternative, the CAFE standards would remain at the MY 2010 level in future years. As with the criteria pollutants, current trends in the levels of air toxics emissions from vehicles would continue, with emissions continuing to decline due to the EPA emissions standards, despite a growth in total VMT. The EPA regulates air toxics from motor vehicles through vehicle emissions standards and fuel quality standards, as discussed in Section 3.3.1. The High Scenario No Action Alternative would not change the current CAFE standards and therefore would not result in any change in toxic air pollutant emissions, other than current trends, in nonattainment and maintenance areas throughout the United States.

Table 3.3-15 summarizes the total national emissions of air toxics from passenger cars and light trucks with the High Scenario No Action Alternative for each of the pollutants and analysis years. The Table presents Alternatives 2 through 7 left to right in order of increasing fuel economy requirements. Emissions of acetaldehyde (except in 2015 and 2020), benzene, 1,3-butadiene (except in 2015), and DPM

Table 3.3-15

High Scenario Alternative CAFE Standards
Nationwide Toxic Air Pollutant Emissions from Passenger Cars and Light Trucks (tons/year)

Pollutant and Year	Alt. 1 No Action	Alt. 2 25% Below Optimized	Alt. 3 Optimized	Alt. 4 25% Above Optimized	Alt. 5 50% Above Optimized	Alt. 6 Total Costs Equal Total Benefits	Alt. 7 Technology Exhaustion
Acetaldehyde							
2015	11,165	11,174	11,177	11,176	11,180	11,194	11,268
2020	8,634	8,651	8,649	8,630	8,644	8,658	8,784
2025	7,613	7,612	7,612	7,565	7,576	7,577	7,586
2035	7,364	7,318	7,326	7,244	7,239	7,211	6,938
Acrolein a/							
2015	530	535	536	540	542	546	583
2020	393	410	410	421	428	438	547
2025	336	364	363	381	391	405	575
2035	315	356	353	379	393	412	646
Benzene							
2015	60,125	59,974	59,938	59,809	59,756	59,640	58,661
2020	47,458	46,853	46,823	46,428	46,220	45,882	42,385
2025	42,930	41,796	41,810	41,077	40,678	40,081	33,469
2035	42,626	40,639	40,753	39,588	38,860	37,822	26,306
1,3-butadiene							
2015	6,134	6,134	6,133	6,133	6,134	6,134	6,141
2020	4,698	4,689	4,688	4,683	4,679	4,672	4,617
2025	4,092	4,064	4,064	4,048	4,034	4,014	3,815
2035	3,885	3,815	3,821	3,790	3,754	3,709	3,231
Diesel particulate matter (DPM)							
2015	88,405	87,309	87,001	86,862	86,662	86,383	85,735
2020	90,085	86,724	86,018	85,878	85,419	85,009	83,498
2025	94,782	89,537	88,510	88,394	87,730	87,230	85,050
2035	107,203	99,856	98,495	98,385	97,499	96,932	93,876
Formaldehyde							
2015	16,197	16,228	16,237	16,264	16,282	16,346	16,790
2020	12,928	13,044	13,027	13,086	13,173	13,300	14,641
2025	11,716	11,893	11,857	11,946	12,080	12,250	14,238
2035	11,694	11,933	11,878	12,000	12,178	12,394	15,022

a/ Data on upstream emissions reductions were not available for acrolein. Thus, the emissions for acrolein reflect only the change in tailpipe emissions.

are generally highest under the No Action Alternative. Emissions of acetaldehyde (in 2015 and 2020), acrolein, and formaldehyde are generally lowest with High Scenario Alternative 1. Table 3.3-15 shows increases for acrolein with High Scenario Alternatives 2 through 7, because data on upstream emissions reductions were not available. The emissions for acrolein in Table 3.3-15 reflect only the increases due to the rebound effect and manufacturer changes in response to the fuel economy standards. Thus, the acrolein emissions given in Table 3.3-15 are an upper-bound estimate.

Table 3.3-16 lists the net change in nationwide emissions from passenger cars and light trucks for the High Scenario No Action Alternative for each of the air toxic pollutants and analysis years. The table presents Alternatives 2 through 7 left to right in order of increasing fuel economy requirements. In Table 3.3-16 the nationwide emissions reductions or increases tend to become greater from left to right, reflecting the increasing fuel economy requirements that are assumed under successive alternatives, except for the cases noted above and for acrolein.

Table 3.3-16

High Scenario Alternative CAFE Standards
Nationwide Changes in Toxic Air Pollutant Emissions from
Passenger Cars and Light Trucks (tons/year) a/ b/

	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7
Pollutant and Year	**No Action c/**	**25% Below Optimized**	**Optimized**	**25% Above Optimized**	**50% Above Optimized**	**Total Costs Equal Total Benefits**	**Technology Exhaustion**
Acetaldehyde							
2015	0	9	12	11	15	29	103
2020	0	17	15	-4	10	24	151
2025	0	0	0	-48	-36	-35	-27
2035	0	-46	-37	-120	-125	-153	-426
Acrolein d/							
2015	0	5	6	10	12	16	53
2020	0	17	17	28	34	44	153
2025	0	28	27	45	55	69	239
2035	0	40	38	64	77	97	330
Benzene							
2015	0	-150	-187	-316	-369	-484	-1,463
2020	0	-605	-634	-1,030	-1,238	-1,575	-5,073
2025	0	-1,134	-1,119	-1,853	-2,252	-2,849	-9,461
2035	0	-1,986	-1,872	-3,037	-3,766	-4,803	-16,320
1,3-butadiene							
2015	0	0	-1	-1	0	-1	7
2020	0	-9	-11	-15	-19	-27	-81
2025	0	-29	-28	-44	-58	-79	-277
2035	0	-71	-64	-95	-131	-177	-654
Diesel particulate matter (DPM)							
2015	0	-1,095	-1,403	-1,543	-1,743	-2,021	-2,670
2020	0	-3,361	-4,067	-4,206	-4,665	-5,075	-6,587
2025	0	-5,245	-6,271	-6,387	-7,052	-7,552	-9,732
2035	0	-7,346	-8,707	-8,818	-9,704	-10,271	-13,326
Formaldehyde							
2015	0	31	39	66	85	148	592
2020	0	117	99	158	246	372	1,714
2025	0	177	141	230	364	534	2,522
2035	0	239	185	306	484	700	3,328

a/ Emissions changes have been rounded to the nearest whole number.
b/ Negative changes indicate reductions; positive emissions changes are increases.
c/ Changes for the No Action Alternative are shown as zero because the No Action Alternative is the baseline to which emissions under the action alternatives are compared.
d/ Data on upstream emissions reductions were not available for acrolein. Thus, the emissions for acrolein reflect only the change in tailpipe emissions.

3.3.4.2.3 Health Outcomes and Costs

With the High Scenario No Action Alternative, the CAFE standards would remain at the MY 2010 level in future years. Current trends in the levels of criteria pollutants and air toxics emissions from vehicles would continue, with emissions continuing to decline due to the EPA emissions standards, despite a growth in total VMT. The human health effects and health-related costs that occur under current trends would continue and are expected to decline in the future as a result of declines in pollutant emissions. The High Scenario No Action Alternative would not result in any other increase or decrease in human health effects and health-related costs throughout the United States.

3.3.4.3 High Scenario Alternative 2: 25 Percent Below Optimized

3.3.4.3.1 Criteria Pollutants

With High Scenario Alternative 2, the CAFE standards would require increased fuel economy compared to the High Scenario No Action Alternative. Generally, High Scenario Alternative 2 would increase fuel economy less than would High Scenario Alternatives 3 through 7. There would be reductions in nationwide emissions of criteria pollutants with High Scenario Alternative 2 compared to the High Scenario No Action Alternative in 2020. High Scenario Alternative 2 would reduce emissions less than would High Scenario Alternatives 3 through 7.

All individual nonattainment areas would experience reductions in emissions of all criteria pollutants except $PM_{2.5}$ for all analysis years. Emissions of criteria pollutants decrease in part because the reduction in upstream emissions, among other effects related to technology changes introduced by manufacturers in response to CAFE standards, more than offsets the increase in VMT and emissions due to the rebound effect in every nonattainment area. Emissions of $PM_{2.5}$ are projected to increase in some nonattainment areas with the High Scenario as a result of the combined effects of technology changes introduced by manufacturers in response to CAFE standards, the rebound effect, and travel-demand changes due to population changes. Appendix B-2 contains tables that list the emissions reductions for each nonattainment area. Table 3.3-17 summarizes maximum and minimum criteria air pollutant results by nonattainment area.

Table 3.3-17

High Scenario Alternative CAFE Standards
Changes in Criteria Pollutant Emissions from Passenger Cars and Light Trucks,
Maximum Changes by Nonattainment Area a/

Criteria Pollutant	Increase/ Decrease	Change (tons/year)	Year	Alt. No.	Nonattainment Area
CO	Maximum increase	No increase			
	Maximum decrease	-387,673	2035	7	Los Angeles South Coast Air Basin, CA
NO_x	Maximum increase	No increase			
	Maximum decrease	-14,457	2035	7	Los Angeles South Coast Air Basin, CA
$PM_{2.5}$	Maximum increase	56	2035	7	Atlanta, GA
	Maximum decrease	-1,206	2035	7	Houston-Galveston-Brazoria, TX
SO_x	Maximum increase	No increase			
	Maximum decrease	-5,045	2035	7	Houston-Galveston-Brazoria, TX
VOCs	Maximum increase	No increase			
	Maximum decrease	-31,454	2035	7	Los Angeles South Coast Air Basin, CA

a/ Emissions changes have been rounded to the nearest whole number.

3.3.4.3.2 Air Toxics

There would be reductions in nationwide emissions of benzene, 1,3-butadiene, and DPM under the High Scenario Alternative 2 compared to the High Scenario No Action Alternative. There would be increases in nationwide emissions of acetaldehyde (except in 2025 and 2035), acrolein, and formaldehyde compared to the High Scenario No Action Alternative.

The High Scenario Alternative 2 would have generally higher emissions than would High Scenario Alternatives 3 through 7 for acetaldehyde (in 2025 and 2035 except Alternative 3), benzene (except Alternative 3 in 2025 and 2035), 1,3-butadiene (except Alternative 3 in 2025 and 2035), and DPM. High Scenario Alternative 2 would have generally lower emissions than would High Scenario Alternatives 3 through 7 for acetaldehyde (in 2015), acrolein, and formaldehyde (except Alternative 3 in 2020-2035). Emissions under the High Scenario tend to be lower than those under the Reference Case for Alternative 2.

At the nationwide level, the reduction in upstream emissions of toxic air pollutants tends to offset the increase in VMT and emissions due to the rebound effect. However, the reductions in upstream emissions are not uniformly distributed to individual nonattainment areas. Net emissions reductions can occur if the reduction in upstream emissions in the nonattainment area more than offsets the increase within the area due to the rebound effect. With High Scenario Alternative 2, many nonattainment areas would experience net increases in emissions of one or more toxic air pollutants in at least one of the analysis years (see Appendix B-2). Table 3.3-18 summarizes the maximum and minimum criteria air pollutant results by nonattainment area.

Table 3.3-18

High Scenario Alternative CAFE Standards
Changes in Toxic Air Pollutant Emissions from Passenger Cars and Light Trucks,
Maximum Changes by Nonattainment Area a/

Hazardous Air Pollutant	Increase/Decrease	Change (tons/year)	Year	Alt. No.	Nonattainment Area
Acetaldehyde	Maximum Increase	10	2020	7	New York-N. New Jersey-Long Island, NY-NJ-CT
	Maximum Decrease	-37	2035	7	Houston-Galveston-Brazoria, TX
Acrolein	Maximum Increase	16	2035	7	Los Angeles South Coast Air Basin, CA
	Maximum Decrease	No decreases (upstream emissions decreases not included for acrolein)			
Benzene	Maximum Increase	No increases			
	Maximum Decrease	-862	2035	7	Los Angeles South Coast Air Basin, CA
1,3-butadiene	Maximum Increase	1	2015	7	New York-N. New Jersey-Long Island, NY-NJ-CT
	Maximum Decrease	-35	2035	7	Los Angeles South Coast Air Basin, CA
Diesel particulate matter	Maximum Increase	No increases			
	Maximum Decrease	-625	2035	7	Los Angeles South Coast Air Basin, CA
Formaldehyde	Maximum Increase	145	2035	7	Los Angeles South Coast Air Basin, CA
	Maximum Decrease	-65	2035	7	Houston-Galveston-Brazoria, TX

a/ Emissions changes have been rounded to the nearest whole number.

3.3.4.3.3 Health Outcomes and Costs

There would be reductions in adverse health effects nationwide with High Scenario Alternative 2 compared to the High Scenario No Action Alternative, as shown in Table 3.3-19. These reductions primarily reflect the projected $PM_{2.5}$ reductions, because $PM_{2.5}$ tends to be the largest contributor to adverse health effects. In comparison to the High Scenario No Action Alternative, High Scenario Alternative 2 would reduce mortalities by 214 and the number of work-loss days by 38,172 in 2035. Data are not available to estimate reliably the number of adverse health effects due to the other pollutants. Table 3.3-20 lists the corresponding reductions in health costs with High Scenario Alternative 2 compared to the High Scenario No Action Alternative. High Scenario Alternative 2 would reduce health costs by $632 million in 2035.

Table 3.3-19

High Scenario Alternative CAFE Standards
Nationwide Changes in Health Outcomes from Criteria Pollutant Emissions from Passenger Cars and Light Trucks (cases/year) a/

Health Outcome and Year	Alt. 1 No Action b/	Alt. 2 25% Below Optimized	Alt. 3 Optimized	Alt. 4 25% Above Optimized	Alt. 5 50% Above Optimized	Alt. 6 Total Costs Equal Total Benefits	Alt. 7 Technology Exhaustion
Mortality (ages 30 and older)							
2015	0	-31	-41	-43	-49	-63	-101
2020	0	-97	-115	-113	-134	-156	-277
2025	0	-152	-176	-169	-203	-230	-418
2035	0	-214	-245	-234	-283	-317	-592
Chronic bronchitis							
2015	0	-27	-35	-37	-43	-54	-88
2020	0	-85	-100	-98	-117	-135	-241
2025	0	-132	-153	-147	-176	-200	-363
2035	0	-186	-213	-204	-246	-275	-515
Emergency-room visits for asthma							
2015	0	-7	-8	-9	-10	-13	-21
2020	0	-20	-24	-24	-28	-33	-58
2025	0	-32	-37	-35	-42	-48	-87
2035	0	-45	-51	-49	-59	-66	-124
Work-loss days							
2015	0	-5,563	-7,257	-7,665	-8,769	-11,169	-18,055
2020	0	-17,326	-20,508	-20,108	-23,915	-27,776	-49,452
2025	0	-27,021	-31,365	-30,153	-36,181	-41,072	-74,497
2035	0	-38,172	-43,678	-41,794	-50,445	-56,437	-105,514

a/ Negative changes indicate reductions; positive emissions changes are increases.
b/ Changes in health outcome for the No Action Alternative are shown as zero because the No Action Alternative is the baseline to which emissions under the action alternatives are compared.

Table 3.3-20

High Scenario Alternative CAFE Standards
Nationwide Changes in Health Costs from Criteria Pollutant Emissions
from Passenger Cars and Light Trucks (U.S. million dollars/year) a/

	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7
Year	No Action b/	25% Below Optimized	Optimized	25% Above Optimized	50% Above Optimized	Total Costs Equal Total Benefits	Technology Exhaustion
2015	0	-50	-63	-84	-95	-112	-223
2020	0	-237	-275	-353	-399	-460	-990
2025	0	-406	-451	-591	-673	-779	-1,809
2035	0	-632	-677	-888	-1,027	-1,202	-2,987

a/ Negative changes indicate economic benefit; positive emissions changes are economic costs.
b/ Changes for the No Action Alternative are shown as zero because the No Action Alternative is the baseline to which emissions under the action alternatives are compared.

3.3.4.4 High Scenario Alternative 3: Optimized

3.3.4.4.1 Criteria Pollutants

With High Scenario Alternative 3, generally the CAFE standards would increase fuel economy more than would the High Scenario No Action Alternative and High Scenario Alternative 2, but less than would High Scenario Alternatives 4 through 7. There would be greater reductions in nationwide emissions of criteria pollutants with High Scenario Alternative 3 compared to High Scenario Alternative 2, except for CO in 2020-2035 and VOC in 2035. High Scenario Alternative 3 would reduce emissions less than would High Scenario Alternatives 4 through 7, except that High Scenario Alternative 3 would reduce $PM_{2.5}$ emissions more than would High Scenario Alternative 4 in 2020-2035.

All individual nonattainment areas would experience reductions in emissions of all criteria pollutants, except for $PM_{2.5}$, for all analysis years. Emissions of criteria pollutants decrease in part because the reduction in upstream emissions, among other effects related to technology changes introduced by manufacturers in response to CAFE standards, more than offsets the increase in VMT and emissions due to the rebound effect in every nonattainment area. Emissions of $PM_{2.5}$ are projected to increase in some nonattainment areas with the High Scenarios as a result of the combined effects of technology changes introduced by manufacturers in response to CAFE standards, the rebound effect, and travel-demand changes due to population changes. Appendix B-2 contains tables that list the emissions reductions for each nonattainment area.

3.3.4.4.2 Air Toxics

There would be reductions in nationwide emissions of benzene, 1,3-butadiene, and DPM under the High Scenario Alternative 3 compared to the High Scenario No Action Alternative. There would be increases in nationwide emissions of acetaldehyde (except in 2025 and 2035), acrolein, and formaldehyde compared to the High Scenario No Action Alternative.

The High Scenario Alternative 3 would have generally higher emissions than would High Scenario Alternatives 4 through 7 for acetaldehyde (in 2025 and 2035), benzene, 1,3-butadiene, and DPM. High Scenario Alternative 3 would have generally lower emissions than would High Scenario Alternatives 4 through 7 for acetaldehyde (in 2015 except Alternative 4 and 2020 except Alternatives 4

and 5), acrolein, and formaldehyde. Emissions under the High Scenario tend to be lower than those under the Reference Case for Alternative 3.

At the nationwide level, the reduction in upstream emissions of toxic air pollutants tends to offset the increase in VMT and emissions due to the rebound effect. However, the reductions in upstream emissions are not uniformly distributed to individual nonattainment areas. Net emissions reductions can occur if the reduction in upstream emissions in the nonattainment area more than offsets the increase within the area due to the rebound effect. With High Scenario Alternative 3, many nonattainment areas would experience net increases in emissions of one or more toxic air pollutants in at least one of the analysis years (see Appendix B-2).

3.3.4.4.3 Health Outcomes and Costs

There would be reductions in adverse health effects nationwide with High Scenario Alternative 3 compared to the No Action Alternative, as shown in Table 3.3-19. These reductions primarily reflect the projected $PM_{2.5}$ reductions, because $PM_{2.5}$ tends to be the largest contributor to adverse health effects. In comparison to the High Scenario No Action Alternative, High Scenario Alternative 3 would reduce mortalities by 245 and the number of work-loss days by 43,678 in 2035. Data are not available to estimate reliably the number of adverse health effects due to the other pollutants. Table 3.3-20 lists the corresponding reductions in health costs with High Scenario Alternative 3 compared to the No Action Alternative. High Scenario Alternative 3 would reduce health costs by $677 million in 2035.

3.3.4.5 High Scenario Alternative 4: 25 Percent Above Optimized

3.3.4.5.1 Criteria Pollutants

With High Scenario Alternative 4, generally the CAFE standards would increase fuel economy more than would High Scenarios Alternatives 1 through 3 but less than would High Scenario Alternatives 5 through 7. There would be greater reductions in nationwide emissions of criteria pollutants with High Scenario Alternative 4 than with High Scenario Alternatives 1 through 3 (except for $PM_{2.5}$ in 2020-2035). High Scenario Alternative 4 would produce smaller reductions in criteria pollutant emissions than with High Scenario Alternatives 5 through 7.

All individual nonattainment areas would experience reductions in emissions of all criteria pollutants, except $PM_{2.5}$, for all analysis years, compared to the High Scenario No Action Alternative. Emissions of criteria pollutants decrease in part because the reduction in upstream emissions, among other effects related to technology changes introduced by manufacturers in response to CAFE standards, more than offsets the increase in VMT and emissions due to the rebound effect in every nonattainment area. Emissions of $PM_{2.5}$ are projected to increase in some nonattainment areas with the High Scenarios because of the combined effects of technology changes introduced by manufacturers in response to CAFE standards, the rebound effect, and travel-demand changes due to population changes. Appendix B-2 contains tables that list the emissions reductions for each nonattainment area.

3.3.4.5.2 Air Toxics

There would be reductions in nationwide emissions of acetaldehyde (except in 2015), benzene, 1,3-butadiene, and DPM under the High Scenario Alternative 4 compared to the High Scenario No Action Alternative. There would be increases in nationwide emissions of acetaldehyde (in 2015), acrolein, and formaldehyde compared to the High Scenario No Action Alternative.

The High Scenario Alternative 4 would have generally higher emissions than would High Scenario Alternatives 5 through 7 for acetaldehyde (in 2035), benzene, 1,3-butadiene (except in 2015), and DPM. High Scenario Alternative 4 would have generally lower emissions than would High Scenario Alternatives 5 through 7 for acetaldehyde (except in 2035), acrolein, and formaldehyde. Emissions under the High Scenario tend to be lower than those under the Reference Case for Alternative 4.

At the nationwide level, the reduction in upstream emissions of toxic air pollutants tends to offset the increase in VMT and emissions due to the rebound effect. However, the reductions in upstream emissions are not uniformly distributed to individual nonattainment areas. Net emissions reductions can occur if the reduction in upstream emissions in the nonattainment area more than offsets the increase within the area due to the rebound effect. With High Scenario Alternative 4, many nonattainment areas would experience net increases in emissions of one or more toxic air pollutants in at least one of the analysis years (see Appendix B-2).

3.3.4.5.3 Health Outcomes and Costs

There would be reductions in adverse health effects nationwide with High Scenario Alternative 4 compared to the No Action Alternative, as shown in Table 3.3-19. These reductions primarily reflect the projected $PM_{2.5}$ reductions, because $PM_{2.5}$ tends to be the largest contributor to adverse health effects. In comparison to the High Scenario No Action Alternative, High Scenario Alternative 4 would reduce mortalities by 234 and the number of work-loss days by 41,794 in 2035. Data are not available to estimate reliably the number of adverse health effects due to the other pollutants. Table 3.3-20 lists the corresponding reductions in health costs with High Scenario Alternative 4 compared to the High Scenario No Action Alternative. High Scenario Alternative 4 would reduce health costs by $888 million in 2035.

3.3.4.6 High Scenario Alternative 5: 50 Percent Above Optimized

3.3.4.6.1 Criteria Pollutants

With High Scenario Alternative 5, the CAFE standards would increase fuel economy more than would High Scenario Alternatives 1 through 4 but less than would High Scenario Alternatives 6 and 7. There would be greater reductions in nationwide emissions of all criteria pollutants with High Scenario Alternative 5 than with High Scenario Alternatives 1 through 4. There would be smaller reductions than with High Scenario Alternatives 6 and 7.

All individual nonattainment areas would experience reductions in emissions of all criteria pollutants, except for $PM_{2.5}$, for all analysis years. Emissions of criteria pollutants decrease in part because the reduction in upstream emissions, among other effects related to technology changes introduced by manufacturers in response to CAFE standards, more than offsets the increase in VMT and emissions due to the rebound effect in every nonattainment area. Emissions of $PM_{2.5}$ are projected to increase in some nonattainment areas with the High Scenarios as a result of the combined effects of technology changes introduced by manufacturers in response to CAFE standards, the rebound effect, and travel-demand changes due to population changes. Tables in Appendix B-2 list the emissions reductions for each nonattainment area.

3.3.4.6.2 Air Toxics

There would be reductions in nationwide emissions of acetaldehyde (except in 2015 and 2020), benzene, 1,3-butadiene (except in 2015), and DPM under the High Scenario Alternative 5 compared to the High Scenario No Action Alternative. There would be increases in nationwide emissions of

acetaldehyde (in 2015 and 2020), acrolein, and formaldehyde compared to the High Scenario No Action Alternative.

The High Scenario Alternative 5 would have generally higher emissions than would High Scenario Alternatives 6 through 7 for acetaldehyde (in 2035), benzene, 1,3-butadiene (except in 2015), and DPM. High Scenario Alternative 5 would have generally lower emissions than would High Scenario Alternatives 6 through 7 for acetaldehyde (except in 2035), acrolein, and formaldehyde. Emissions under the High Scenario tend to be lower than those under the Reference Case for Alternative 5.

At the nationwide level, the reduction in upstream emissions of toxic air pollutants tends to offset the increase in VMT and emissions due to the rebound effect. However, the reductions in upstream emissions are not uniformly distributed to individual nonattainment areas. Net emissions reductions can occur if the reduction in upstream emissions in the nonattainment area more than offsets the increase within the area due to the rebound effect. With High Scenario Alternative 5, many nonattainment areas would experience net increases in emissions of one or more toxic air pollutants in at least one of the analysis years (see Appendix B-2).

3.3.4.6.3 Health Outcomes and Costs

There would be reductions in adverse health effects nationwide with High Scenario Alternative 5 compared to the High Scenario No Action Alternative, as shown in Table 3.3-19. These reductions primarily reflect the projected $PM_{2.5}$ reductions, because $PM_{2.5}$ tends to be the largest contributor to adverse health effects. In comparison to the High Scenario No Action Alternative, High Scenario Alternative 5 would reduce mortalities by 283 and the number of work-loss days by 50,445 in 2035. Data are not available to estimate reliably the number of adverse health effects due to the other pollutants. Table 3.3-20 lists the corresponding reductions in health costs with High Scenario Alternative 5. High Scenario Alternative 5 would reduce health costs by $1.027 billion in 2035.

3.3.4.7 High Scenario Alternative 6: Total Costs Equal Total Benefits

3.3.4.7.1 Criteria Pollutants

With High Scenario Alternative 6, the CAFE standards would increase fuel economy more than would High Scenario Alternatives 1 through 5 but less than would High Scenario Alternative 7. There would be greater reductions in nationwide emissions of criteria pollutants with the High Scenario Alternative 6 than with High Scenario Alternatives 1 through 5. There would be lesser reductions than with High Scenario Alternative 7.

All individual nonattainment areas would experience reductions in emissions of all criteria pollutants except $PM_{2.5}$ for all analysis years. Emissions of criteria pollutants except $PM_{2.5}$ decrease because the reduction in upstream emissions more than offsets the increase in VMT and emissions due to the rebound effect and technology changes introduced by manufacturers in response to CAFE standards in every nonattainment area. Emissions of $PM_{2.5}$ are projected to increase in some nonattainment areas with the High Scenarios as a result of the combined effects of technology changes introduced by manufacturers in response to CAFE standards, the rebound effect, and travel-demand changes due to population changes. Appendix B-2 contains tables that list the emissions reductions for each nonattainment area.

3.3.4.7.2 Air Toxics

There would be reductions in nationwide emissions of acetaldehyde (except in 2015 and 2020), benzene, 1,3-butadiene, and DPM under the High Scenario Alternative 6 compared to the High Scenario

No Action Alternative. There would be increases in nationwide emissions of acetaldehyde (in 2015 and 2020), acrolein, and formaldehyde compared to the High Scenario No Action Alternative.

The High Scenario Alternative 6 would have generally higher emissions than would High Scenario Alternative 7 for acetaldehyde (in 2035), benzene, 1,3-butadiene (except in 2015), and DPM. High Scenario Alternative 6 would have generally lower emissions than would High Scenario Alternative 7 for acetaldehyde (except in 2035), acrolein, 1,3-butadiene (in 2015), and formaldehyde. Emissions under the High Scenario tend to be lower than those under the Reference Case for Alternative 6.

At the nationwide level, the reduction in upstream emissions of toxic air pollutants tends to offset the increase in VMT and emissions due to the rebound effect. However, the reductions in upstream emissions are not uniformly distributed to individual nonattainment areas. For example, a nonattainment area that contains petroleum refining facilities, such as Houston-Galveston-Brazoria, Texas, would experience more reductions in upstream emissions than an area that has none. Net emissions reductions can occur if the reduction in upstream emissions in the nonattainment area more than offsets the increase within the area due to the rebound effect. With High Scenario Alternative 6, many nonattainment areas would experience net increases in emissions of one or more toxic air pollutants in at least one of the analysis years (see Appendix B-2).

3.3.4.7.3 Health Outcomes and Costs

There would be reductions in adverse health effects nationwide with High Scenario Alternative 6 compared to the High Scenario No Action Alternative, as shown in Table 3.3-19. These reductions primarily reflect the projected $PM_{2.5}$ reductions, because $PM_{2.5}$ tends to be the largest contributor to adverse health effects. In comparison to the High Scenario No Action Alternative, High Scenario Alternative 6 would reduce mortalities by 317 and the number of work-loss days by 56,437 in 2035. Data are not available to estimate reliably the number of adverse health effects due to the other pollutants. Table 3.3-20 lists the corresponding reductions in health costs with Alternative 6 compared to the High Scenario No Action Alternative. In comparison to the High Scenario No Action Alternative, High Scenario Alternative 6 would reduce health costs by $1.202 billion in 2035.

3.3.4.8 High Scenario Alternative 7: Technology Exhaustion

3.3.4.8.1 Criteria Pollutants

With the High Scenario Alternative 7, the CAFE standards would increase fuel economy the most of all the alternatives. There would be greater reductions in nationwide emissions of criteria pollutants with the High Scenario Alternative 7 than with any other alternative. All individual nonattainment areas would experience reductions in emissions of all criteria pollutants except $PM_{2.5}$ for all analysis years. Emissions of criteria pollutants decrease in part because the reduction in upstream emissions, among other effects related to technology changes introduced by manufacturers in response to CAFE standards, more than offsets the increase in VMT and emissions due to the rebound effect in every nonattainment area. Emissions of $PM_{2.5}$ are projected to increase in some nonattainment areas under High Scenario Alternative 7 because of the combined effects of technology changes introduced by manufacturers in response to CAFE standards, the rebound effect, and travel-demand changes due to population changes. Appendix B-2 contains tables that list the emissions reductions for each nonattainment area.

3.3.4.8.2 Air Toxics

There would be reductions in nationwide emissions of acetaldehyde (in 2025 and 2035), benzene, 1,3-butadiene (except in 2015), and DPM with High Scenario Alternative 7 compared to the High Scenario No Action Alternative.

At the nationwide level, the reduction in upstream emissions of toxic air pollutants tends to offset the increase in VMT and emissions due to the rebound effect. However, the reductions in upstream emissions are not uniformly distributed to individual nonattainment areas. Net emissions reductions can occur if the reduction in upstream emissions in the nonattainment area more than offsets the increase within the area due to the rebound effect. With High Scenario Alternative 7, many nonattainment areas would experience net increases in emissions of one or more toxic air pollutants in at least one of the analysis years (see Appendix B-2).

3.3.4.8.3 Health Outcomes and Costs

There would be reductions in adverse health effects nationwide with High Scenario Alternative 7 compared to the High Scenario No Action Alternative, as shown in Table 3.3-19. These reductions primarily reflect the projected $PM_{2.5}$ reductions, because $PM_{2.5}$ tends to be the largest contributor to adverse health effects. In comparison to the High Scenario No Action Alternative, High Scenario Alternative 7 would reduce mortalities by 592 and the number of work-loss days by 105,514 in 2035. Data are not available to estimate reliably the number of adverse health effects due to the other pollutants. Table 3.3-20 lists the corresponding reductions in health costs with High Scenario Alternative 7 compared to the High Scenario No Action Alternative. In comparison to the High Scenario No Action Alternative, High Scenario Alternative 7 would reduce health costs by $2.987 billion in 2035.

3.3.4.9 Mid-1 and Mid-2 Scenarios

For the Mid-1 Scenario, NHTSA used the AEO 2008 high fuel prices, a social cost of carbon of $33 per ton (2007 dollars), oil import externalities of $0.116 per gallon, and discount rates of 3 percent for the present value of carbon reduction benefits and 7 percent for other costs and benefits (*see* Table 2.2-1).

Compared to the Reference Case, total emissions of criteria and toxic air pollutants under the Mid-1 Scenario were generally lower for all alternatives. Emissions with the Mid-1 Scenario Alternative 6 were higher for acrolein in 2025 and 2035. Emissions with the Mid-1 Scenario Alternatives 2 through 6 were higher for 1,3-butadiene in some years. Most of the differences between the action alternatives and the No Action Alternative are greater under the Mid-1 Scenario than under the Reference Case. The emissions differences between the Reference Case and the Mid-1 Scenario reflect the differences in the forecast levels of fuel economy, VMT, and diesel vehicle share of the vehicle fleet.

For the Mid-2 Scenario, NHTSA used the AEO 2008 high fuel prices, a social cost of carbon of $2.00 per ton (2007 dollars), oil import externalities of $0.382 per gallon, and discount rates of 3 percent for the present value of carbon reduction benefits and 7 percent for other costs and benefits (*see* Table 2.2-1).

Compared to the Reference Case, total emissions of criteria and toxic air pollutants under the Mid-2 Scenario were lower for all action alternatives. Most of the differences between the action alternatives and the No Action Alternative are greater under the Mid-2 Scenario than under the Reference Case. The emissions differences between the Reference Case and the Mid-2 Scenario reflect the differences in the forecast levels of fuel economy, VMT, and diesel vehicle share of the vehicle fleet.

Emissions of criteria pollutants would be generally higher with the Mid-2 Scenario than with the Mid-1 Scenario for Alternatives 2 through 6, and equivalent for Alternative 7. Emissions of toxic air pollutants would be generally higher with the Mid-2 Scenario than with the Mid-1 Scenario for benzene, 1,3-butadiene, and DPM for Alternatives 2 through 6. Emissions of toxic air pollutants would be generally lower with the Mid-2 Scenario than with the Mid-1 Scenario for acrolein and formaldehyde for Alternatives 2 through 6. Results between the Mid-1 and Mid-2 Scenarios for acetaldehyde vary by year for Alternatives 2 through 6. Emissions of toxic air pollutants with the Mid-1 and Mid-2 Scenarios would be equivalent for Alternative 7.

Appendix B-2, Tables B2-97 through B2-113, list the full results from the Mid-1 and Mid-2 Scenarios.

3.4 CLIMATE

This section describes the environment the CAFE standards would affect. Because there is little precedent for addressing climate change within the structure of an EIS, several reasonable judgments were called for when deciding where to draw the line between the direct and indirect effects of the alternatives (Chapter 3) and the cumulative impacts associated with the alternatives (Chapter 4).

NHTSA determined that the scope of climate change issues covered in Chapter 3 would be more tailored than the scope of those in Chapter 4 in two respects: (1) the discussion in Chapter 3 focuses on impacts associated with GHGs only due to the MY 2011-2015 CAFE standards (which affect cars and light trucks built from 2010-2015, and are then assumed to remain in place at the MY 2015 levels from 2015 through 2100), and (2) the discussion of consequences focuses on emissions and effects on the climate system, for example, atmospheric CO_2 concentrations, temperature, sea level, and precipitation. Chapter 4 is broader in that it (1) covers foreseeable effects of the MY 2011-2015 standards, which include a set of more stringent CAFE standards for MY 2016-2020 (the MY 2020 levels would affect cars and light trucks built from 2020-2100), and (2) extends the discussion of consequences to include not only the effects on the climate system, but also the impacts of climate on key resources (such as freshwater resources, terrestrial ecosystems, coastal ecosystems). Thus, the reader is encouraged to explore the cumulative impacts discussion in Chapter 4 to fully understand NHTSA's approach to climate change in this FEIS.

Section 3.4.1 introduces key topics in GHGs and climate change, Section 3.4.2 outlines the methodology NHTSA used to evaluate climate effects, Section 3.4.3 describes the affected environment, and Section 3.4.4 describes consequences.

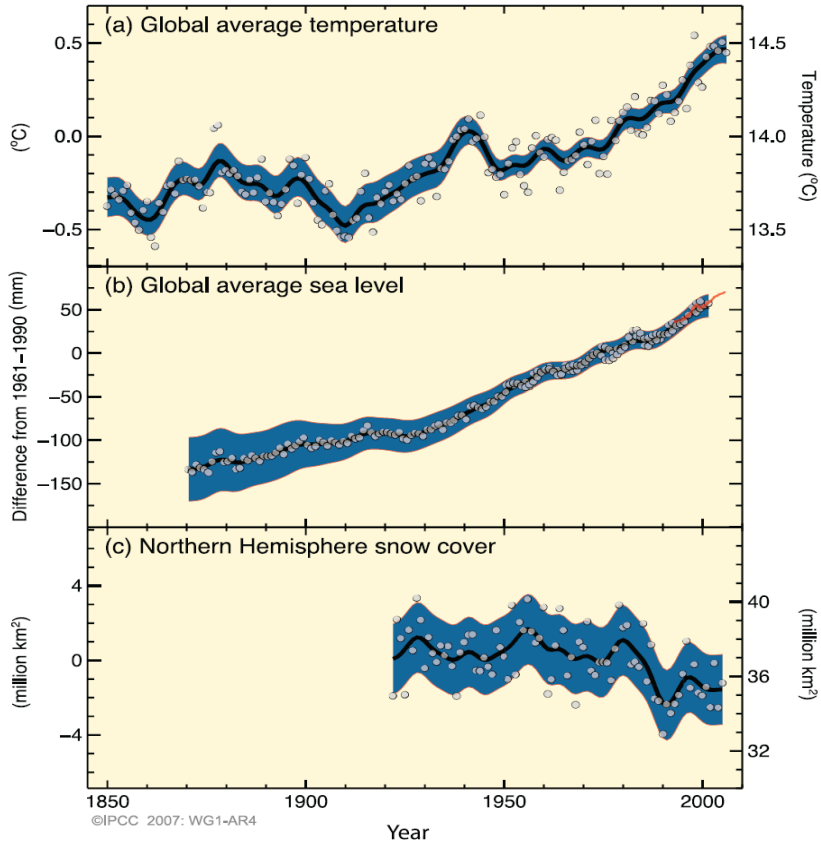
3.4.1 Introduction - Greenhouse Gases and Climate Change

A series of intensive and extensive analyses have been conducted by the Intergovernmental Panel on Climate Change (IPCC), the scientific body tasked by the United Nations to evaluate the risk of human-induced climate change, the U.S. Climate Change Science Program (USCCSP), and many other government-, non-government-, and industry-sponsored programs. Our discussion relies heavily on the most recent, thoroughly peer-reviewed, and credible assessments of global and U.S. climate change: the IPCC Fourth Assessment Report (*Climate Change 2007*), and reports by the USCCSP and the National Science and Technology Council that include the *Scientific Assessment of the Effects of Global Change on the United States* and Synthesis and Assessment Products. These sources and the studies they review are quoted frequently throughout this FEIS. Because new evidence is continuously emerging on the subject of climate change impacts, the discussions on climate impacts in this FEIS also draw on more recent studies, where possible.

3.4.1.1 What is Climate Change?

Global climate change refers to long-term fluctuations in global surface temperatures, precipitation, ice cover, sea levels, cloud cover, ocean temperatures and currents, and other climatic conditions. Scientific research has shown that in the past century, Earth's surface temperature has risen by an average of about 1.3 degrees Fahrenheit (°F) (0.74 degree Centigrade [°C]) (IPCC 2007c); sea levels have risen 6.7 inches (0.17 meter) (IPCC 2007c); Arctic sea ice has shrunk by 2.7 percent per decade, with larger decreases of 7.4 percent in summer, and mountain glaciers and snow cover have decreased (IPCC 2007c) (*see* Figure 3.4-1).

Figure 3.4-1. Changes in Temperature, Sea Level, and Northern Hemisphere Snow Cover (source: IPCC 2007c)



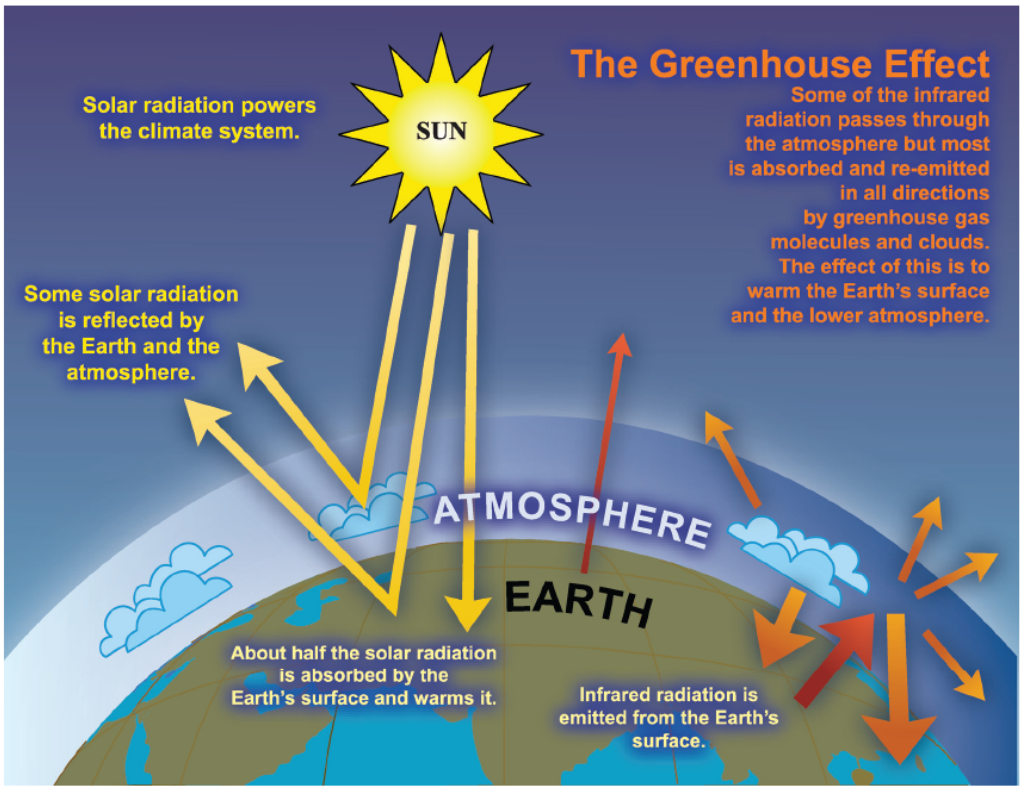
3.4.1.2 What Causes Climate Change?

Earth absorbs heat energy from the sun and returns some of this heat to space as terrestrial infrared radiation. GHGs trap heat in the troposphere (the atmosphere close to Earth's surface) and reradiate it back to Earth, thereby causing warming. This process—known as the "greenhouse effect"—is responsible for maintaining surface temperatures that are warm enough to sustain life (*see* Figure 3.4-2). Human activities, particularly fossil-fuel combustion, contribute to the presence of GHGs in the atmosphere. There are increasing concerns that the buildup of GHGs in the atmosphere is upsetting Earth's energy balance.

Most scientists now agree that this climate change is largely a result of GHG emissions from human activities. The IPCC recently asserted that, "Most of the observed increase in global average temperatures since the mid-20th Century is *very likely* due to the observed increase in anthropogenic [human-caused] greenhouse gas concentrations" (IPCC 2007c).[7]

[7] The IPCC uses standard terms to "define the likelihood of an outcome or result where this can be estimated probabilistically." The term "very likely," cited in italics above and elsewhere in this section, corresponds to a greater than 90-percent probability of an occurrence or outcome, whereas the term "likely" corresponds to a greater than 66-percent probability. This section uses these two terms; Section 4.5 uses and defines a more expansive set of IPCC terminology regarding likelihood

Figure 3.4-2. The Greenhouse Effect (source: Le Treut *et al.* 2007)



Most GHGs, including CO_2, methane (CH_4), nitrous oxide (N_2O), water vapor, and ozone, are naturally occurring. Human activities such as the combustion of fossil fuel, the production of agricultural commodities, and the harvesting of trees can contribute to increased concentrations of these gases in the atmosphere. In addition, a number of very potent anthropogenic (human-made) GHGs, including hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6), are created and emitted through industrial processes.

3.4.1.3 What are the Anthropogenic Sources of Greenhouse Gases?

Human activities that emit GHGs to the atmosphere include the combustion of fossil fuels, industrial processes, solvent use, land-use change and forestry, agriculture production, and waste management. Atmospheric concentrations of CO_2, CH_4, and N_2O—the most important anthropogenic GHGs—have increased approximately 35, 150, and 18 percent, respectively, since the beginning of the Industrial Revolution in the mid-1700s (IPCC 2007c). The rise in GHGs in the past century is widely attributed to the combustion of fossil fuels (coal, petroleum, and gas) used to produce electricity, heat buildings, and run motor vehicles and planes, among other uses.

Contributions to the build-up of GHG in the atmosphere vary greatly from country to country, and depend heavily on the level of industrial and economic activity. The U.S. transportation sector contributed 31.3 percent of total U.S. CO_2 emissions in 2006 (EPA 2008a), with cars and light trucks accounting for 61.4 percent of total U.S. CO_2 emissions from transport (EPA 2008a). Thus, 19.2 percent of total U.S. CO_2 emissions come from cars and light trucks. With the United States accounting for 19.6 percent of global CO_2 emissions (WRI 2008), cars and light trucks in the United States account for roughly 3.8 percent of global CO_2 emissions.

3.4.1.4 Evidence of Climate Change

Observations and studies across the globe are reporting evidence that the earth is currently undergoing climatic change much more quickly than would be expected from natural variations. Global temperatures are increasing, with 11 of the hottest 12 years on record occurring over the past 12 years (IPCC 2007c). Sea levels have risen, caused by thermal expansion of the ocean and melting snow and ice. More frequent weather extremes such as droughts, floods, severe storms, and heat waves have also been observed (IPCC 2007c).

3.4.1.5 Future Climactic Trends and Expected Impacts

As the world population grows and developing countries industrialize, fossil fuel use and resulting GHG emissions are expected to grow substantially over the next century. Based on the current trajectory, the IPCC predicts that CO_2 concentrations could rise to more than three times the pre-industrial level by 2100 (Meehl *et al.* 2007).

Among other trends forecasted, the average global surface temperature is *likely* to rise 2.0 to 11.5 °F (1.1 to 6.4 °C) over the next century, accompanied by a *likely* sea level rise of approximately 0.6 to 1.9 feet (0.18 to 0.59 meter) (IPCC 2007c). In addition to rising temperatures and sea levels, climate change is expected to have many environmental, human health, and economic consequences.

For a more in-depth analysis on the future impacts of climate change on various sectors, *see* the Cumulative Impacts discussion in Chapter 4.

3.4.2 Affected Environment

This section describes the affected environment in terms of current and anticipated trends in GHG emissions and climate. Both emissions and climate involve very complex processes with considerable variability, which complicates the measurement and detection of change. Recent advances in the state of the science, however, are contributing to an increasing body of evidence that anthropogenic GHG emissions are affecting climate in detectable ways.

This section opens with a discussion of emissions, and then turns to climate. Both discussions start with a description of conditions in the United States, followed by a description in the global environment. As global conditions are a macrocosm of U.S. conditions, many themes in the U.S. discussions reappear in the global discussions.[8]

3.4.2.1 Greenhouse Gas Emissions (Historic and Current)

3.4.2.1.1 U.S. Emissions

GHG emissions for the United States in 2006 were estimated at 7,054 million metric tons of carbon dioxide ($MMTCO_2$) equivalent[9] (EPA 2008a), and, as noted earlier, comprise about 15 to 20

[8] For NEPA purposes, it is appropriate for NHTSA to consider global environmental impacts. *See* CEQ, *Council on Environmental Quality Guidance on NEPA Analyses for Transboundary Impacts* (July 1, 1997), *available at* http://ceq.hss.doe.gov/nepa/regs/transguide.html (last visited June 16, 2008) (stating that "agencies must include analysis of reasonably foreseeable transboundary effects of proposed actions in their [NEPA] analysis of proposed actions in the United States").

[9] Each GHG has a different level of radiative forcing, that is, the ability to trap heat. To compare their relative contributions, gases are converted to carbon dioxide equivalent using their unique global warming potential (GWP).

percent of total global emissions[10] (WRI 2008). Annual U.S. emissions, which have increased 15 percent since 1990 and typically increase each year, are heavily influenced by "general economic conditions, energy prices, weather, and the availability of non-fossil alternatives" (EPA 2008a).

Carbon dioxide is by far the primary GHG emitted in the United States, representing nearly 85 percent of all U.S. GHG emissions in 2006 (EPA 2008a). The other gases include CH_4, N_2O, and a variety of fluorinated gases, including HFCs, PFCs, and SF_6. The fluorinated gases are collectively referred to as high global warming potential (GWP) gases. Methane accounts for 8 percent of the remaining GHGs on a GWP-weighted basis, followed by N_2O (5 percent), and the high-GWP gases (2 percent) (EPA 2008a).

GHGs are emitted from a wide variety of sectors, including energy, industrial processes, waste, agriculture, and forestry. Most U.S. emissions are from the energy sector, largely due to CO_2 emissions from the combustion of fossil fuels, which alone account for 80 percent of total U.S. emissions (EPA 2008a). These emissions are due to fuels consumed in the electric power (41 percent of fossil fuel emissions); transportation (33 percent); industry (15 percent); residential (6 percent); and commercial (4 percent) sectors (EPA 2008a). However, when U.S. CO_2 emissions are apportioned by end use, transportation is the single leading source of U.S. emissions from fossil fuels, at approximately one-third of total CO_2 emissions from fossil fuels (EPA 2008a).

Cars and light-duty trucks, which include SUVs, pickup trucks, and minivans, accounted for more than half of U.S. transportation emissions, and emissions from these vehicles have increased by 21 percent since 1990 (EPA 2008a). This increase was driven by two factors: an increase in travel demand and a relatively stagnant average fuel economy. Population growth and expansion, economic growth, and low fuel prices led to more miles traveled, while the rising popularity of SUVs and other light trucks resulted in a slight decline in average combined fuel economy of new cars and light trucks (EPA 2008a).

3.4.2.1.2 Global Emissions

Although humans have always contributed to some level of GHG emissions to the atmosphere through activities like farming and land clearing, substantial contributions did not begin until the mid-1700s, with the onset of the Industrial Revolution. People began burning coal, oil, and natural gas to light their homes, power trains and cars, and run factories and industrial operations. Today the burning of fossil fuels is still the predominant source of GHG emissions.

Levels of atmospheric CO_2 have been rising rapidly. For about 10,000 years prior to the Industrial Revolution, atmospheric CO_2 levels were 280 ppm (plus or minus 20 ppm). Since the Industrial Revolution, CO_2 levels have risen to 367 ppm in 1999 and to 379 ppm in 2005. In addition, other GHGs have been on the increase. Direct atmospheric measurements since 1970 have detected a 150-percent increase in CH_4 and an 18-percent increase in N_2O (IPCC 2007c).

In 2000, global GHG emissions were estimated at 44,378 $MMTCO_2$ equivalent, a 6-percent increase since 1990[11] (WRI 2008). In general, global GHG emissions have increased regularly, though annual increases vary according to a variety of factors (weather, energy prices, and economic factors).

As in the United States, the primary GHGs emitted globally are CO_2, CH_4, N_2O, and the fluorinated gases HFCs, PFCs, and SF_6. In 2000, CO_2 emissions comprised 79 percent of global

[10] The United States contributes about 20 percent of gross GHG emissions, but only 15 percent of net emissions, which take into account carbon sinks from forestry and agriculture.
[11] All GHG estimates cited in this section include contributions from land-use change and forestry, where applicable.

emissions on a GWP-weighted basis, followed by CH_4 (14 percent) and N_2O (7 percent). Collectively, fluorinated gases represented 1 percent of global emissions (WRI 2008).

Various sectors contribute to global GHG emissions, including energy, industrial processes, waste, agriculture, land-use change and forestry, and international bunkers. The energy sector is the largest contributor of global GHG emissions, accounting for 61 percent of global emissions in 2000. In this sector, the generation of electricity and heat accounts for 26 percent of total global emissions. The next highest contributors to emissions are land-use change and forestry (17 percent), agriculture (13 percent), and transportation (12 percent; this is included in the 61 percent for the energy sector) (WRI 2008).

Emissions from transportation are primarily due to the combustion of petroleum to power vehicles such as cars, trucks, trains, planes, and ships. In 2000, transportation represented 12 percent of total emissions and 15 percent of CO_2 emissions; transportation emissions have increased 11 percent since 1990 (WRI 2008).

3.4.2.2 Climate Change Effects and Impacts (Historic and Current)

3.4.2.2.1 U.S. Climate Change Effects

This section describes observed historical and current climate change effects and impacts for the United States. Much of the discussion that follows is drawn from the USCCSP's *Scientific Assessment of the Effects of Global Change on the United States* (CCSP 2008d) and citations therein.

Observed Changes to the Climate

The past decade has been the warmest in more than a century of direct observations, with average temperatures for the contiguous United States rising at a rate near 0.6 °F per decade in the past few decades. Since 1950, the frequency of heat waves has increased, although those recorded in the 1930s remain the most severe. There were also fewer unusually cold days in the past few decades with fewer severe cold waves for the most recent 10-year period in the record (CCSP 2008d).

Over the contiguous United States, total annual precipitation increased about 6 percent from 1901 to 2005, with the greatest increases occurring in the northern Midwest and the South; heavy precipitation also increased, primarily during the last three decades of the 20th Century, and mainly over eastern regions. Most regions experienced decreases in drought severity and duration during the second half of the 20th Century, although there was severe drought in the Southwest from 1999 to 2007; the Southeast has also recently experienced severe drought (CCSP 2008d).

Relative sea level is rising 0.8 to 1.2 inches per decade along most of the Atlantic and Gulf Coasts, and a few inches per decade along the Louisiana Coast (due to land subsidence); sea level is falling (due to land uplift) at the rate of a few inches per decade in parts of Alaska (CCSP 2008d).

Observed Impacts from the Changing Climate

Streamflow decreased about 20 percent over the past century in the central Rocky Mountain region, while in the East it increased 25 percent in the past 60 years. Annual peak streamflow (dominated by snowmelt) in western mountains is occurring at least a week earlier than in the middle of the 20th Century. Winter streamflow is increasing in seasonal snow-covered basins and the fraction of annual precipitation falling as rain (rather than snow) has increased in the past half century (CCSP 2008d). Spring and summer snow cover has decreased in the West, and in mountainous regions of the western

United States, April snow water equivalent has declined 15 to 30 percent since 1950, particularly at lower elevations and primarily due to warming (Field *et al.* 2007 as cited in CCSP 2008d). However, total snow-cover area in the United States increased in the November-to-January season from 1915 to 2004 (CCSP 2008d).

Annual average Arctic sea ice extent decreased 2.7 plus or minus 0.6 percent per decade from 1978 to 2005. In 2007, sea ice extent was approximately 23 percent less than the previous all-time minimum observed in 2005. Average sea ice thickness in the central Arctic *very likely* has decreased up to approximately 3 feet from 1987 to 1997. These area and thickness reductions allow winds to generate stronger waves, which have increased shoreline erosion along the Alaskan coast. Alaska has also experienced permafrost thawing of up to 1.6 inches per year since 1992 (CCSP 2008d).

Rivers and lakes are freezing over later (at an average rate of 5.8 plus or minus 1.6 days per century) with ice breakup taking place earlier (at an average rate of 6.5 plus or minus 1.2 days per century). Loss of glacier mass is occurring in the Northwest and has been especially rapid in Alaska since the mid-1990s (CCSP 2008d).

Sea-level rise extends the zone of impact from storm surge and waves from tropical and other storms, causing coastal erosion and other damage. It is *likely* that the numbers of tropical storms, hurricanes, and major hurricanes each year in the North Atlantic have increased during the past 100 years (CCSP SAP 3.3 2008 as cited in CCSP 2008d) and that Atlantic sea-surface temperatures have increased over the same period; however, these trends are complicated by multi-decadal variability and data-quality issues. In addition, there is evidence of an increase in extreme wave-height characteristics over the past 2 decades, associated with more frequent and more intense hurricanes (CCSP 2008d).

3.4.2.2.2 Global Climate Change Effects

This section describes observed historical and current climate change effects and impacts at a global scale. As with the discussion of effects for the United States, much of the material that follows is drawn from the following studies, including the citations therein: the IPCC WGI *Summary for Policymakers* (IPCC 2007c) and the USCCSP *Scientific Assessment of the Effects of Global Change on the United States* (CCSP 2008d).

In their most recent assessment of climate change, the IPCC states that “Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level” (IPCC 2007c).

<u>Observed Changes to the Climate</u>

Global temperatures have been increasing over the past century. The 100-year linear trend (1906 to 2005) is 0.13 plus or minus 0.03 °F per decade, while the corresponding 50-year linear trend of 0.23 plus or minus 0.05 °F per decade is nearly twice that (CCSP 2008d). Average Arctic temperatures have increased at almost twice the global average rate in the past 100 years. Permafrost top layer temperatures have generally increased since the 1980s (about 5 °F in the Arctic), while the maximum area covered by seasonal frozen ground has decreased since 1900 by about 7 percent in the Northern Hemisphere, with a decrease in spring of up to 15 percent (IPCC 2007c).

Extreme temperatures have been observed to change extensively over the past 50 years. Hot days, hot nights, and heat waves have become more frequent; cold days, cold nights, and frost have become less frequent (IPCC 2007c).

Average atmospheric water vapor content has increased since at least the 1980s over land and the oceans, and in the upper troposphere, largely consistent with air temperature increases. As a result, heavy precipitation events have increased in frequency over most land areas (CCSP 2008d).

Average ocean temperatures have increased since 1961 to depths of at least 10,000 feet, with the ocean absorbing more than 80 percent of the heat added to the climate system. As seawater warms, it expands and sea levels rise. Mountain glaciers, ice caps, and snow cover have declined on average, contributing to further sea-level rise. Losses from the Greenland and Antarctica ice sheets have *very likely* contributed to sea level rise from 1993 to 2003. Dynamical ice loss explains most of the Antarctic net mass loss and about half of the Greenland net mass loss; the other half occurred because melting has exceeded snowfall accumulation (IPCC 2007c).

Global average sea level rose at an average rate of 0.07 plus or minus 0.02 inch per year from 1961 to 2003 with the rate increasing to about 0.12 plus or minus 0.03 inch per year from 1993 to 2003. Total 20th-Century rise is estimated at 0.56 plus or minus 0.16 foot (IPCC 2007c). However, since the IPCC Fourth Assessment Report was published, a recent study improved the historical estimates of upper-ocean (300 meters and 700 meters) warming from 1950 to 2003 (by correcting for expendable bathy-thermographs instrument bias). Domingues *et al.* (2008) found the improved estimates demonstrate clear agreement with the decadal variability of the climate models that included volcanic forcing. Further, this study estimated the globally averaged sea-level trend from 1961 to 2003 to be 0.063 plus or minus 0.01 inch per year with a rise of 0.094 inch per year evident from 1993 to 2003, consistent with the estimated trend of 0.091 inch per year from tide gauges after taking into account thermal expansion in the upper-ocean and deep ocean, variations in the Antarctica and Greenland ice sheets, glaciers and ice caps, and terrestrial storage.

Observed Impacts from the Changing Climate

The IPCC concludes that, “At continental, regional and ocean basin scales, numerous long-term changes in climate have been observed. These include changes in arctic temperatures and ice, widespread changes in precipitation amounts, ocean salinity, wind patterns and aspects of extreme weather including droughts, heavy precipitation, heat waves and the intensity of tropical cyclones” (IPCC 2007c).

Long-term trends in global precipitation amounts have been observed since 1900. Precipitation has substantially increased in eastern parts of North and South America, northern Europe, and northern and central Asia. Drying has been observed in the Sahel, the Mediterranean, southern Africa, and parts of southern Asia. Spatial and temporal variability for precipitation is high, and data are limited for some regions (IPCC 2007c).

Droughts that are more intense and longer have been observed since the 1970s, particularly in the tropics and subtropics, and have been caused by higher temperatures and decreased precipitation. Changes in sea-surface temperatures, wind patterns, and decreased snowpack and snow cover have also been linked to droughts (IPCC 2007c).

Long-term trends in tropical cyclone activity have been reported, but there is no clear trend in the number of tropical cyclones each year. There is observational evidence for an increase in intense tropical cyclone activity in the North Atlantic since about 1970, correlated with increases of tropical sea surface temperatures. However, concerns over data quality and multi-decadal variability persist (IPCC 2007c). The World Meteorological Organization (WMO) Sixth International Workshop on Tropical Cyclones in 2006 agreed that “no firm conclusion can be made” on anthropogenic influence on tropical cyclone activity because “there is evidence both for and against the existence of a detectable anthropogenic signal in the tropical cyclone climate record” (WMO 2006a).

Other characteristics of the global climate have not changed. The diurnal temperature range has not changed from 1979 to 2004; day- and night-time temperatures have risen at similar rates. Antarctic sea-ice extent shows no substantial average trends – despite inter-annual variability and localized changes – consistent with the lack of warming across the region from average atmospheric temperatures. There is also insufficient evidence to determine whether trends exist in large-scale phenomena such as the meridional overturning circulation (a mechanism for heat transport in the North Atlantic Ocean, where warm waters are carried north and cold waters are carried toward the equator) or in small-scale phenomena such as tornadoes, hail, lightning, and dust storms (IPCC 2007c).

3.4.3 Methodology

The methodology NHTSA used to characterize the effects of the alternatives on climate has two key elements:

1. Analyzing the effects of the alternatives on GHG emissions
2. Analyzing how the GHG emissions affect the climate system (climate effects)

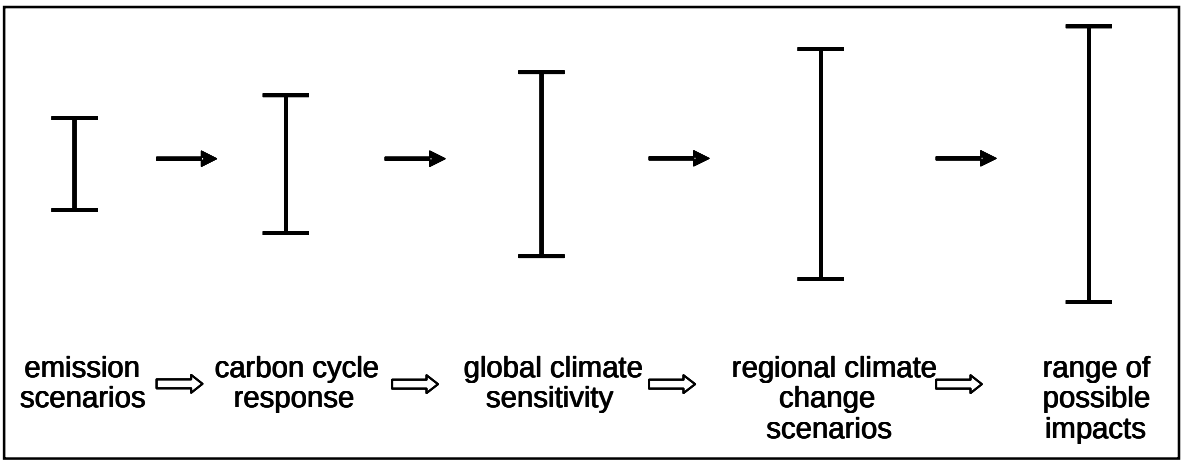
For both the effects on GHG emissions and the effects on the climate system, this FEIS expresses results – for each alternative – in terms of the environmental attribute being characterized (emissions, CO_2 concentrations, temperature, precipitation, and sea level). Comparisons between the No Action Alternative (Alternative 1) and each action alternative (Alternatives 2 through 7) are also presented to illustrate the differences in environmental effects among the alternative CAFE standards.

The methods used to characterize emissions and climate effects involve considerable uncertainty. Sources of uncertainty include the pace and effects of technology change in the transportation sector and other sectors that emit GHGs; changes in the future fuel supply that could affect emissions; sensitivity of climate to increased GHG concentrations; rate of change in the climate system in response to changing GHG concentrations; potential existence of thresholds in the climate system (which cannot be predicted or simulated); regional differences in the magnitude and rate of climate changes; and many other factors.

Moss and Schneider (2000) characterize the “cascade of uncertainty” in climate change simulations (Figure 3.4-3). As indicated in the figure, the emissions estimates used in this FEIS have narrower bands of uncertainty than the global climate effects, which are less uncertain than the regional climate change effects. The effects on climate are, in turn, less uncertain than the impacts of climate changes on affected resources (such as terrestrial and coastal ecosystems, human health, and other resources discussed in Section 4.5).

Where information in the analysis included in this FEIS is incomplete or unavailable, NHTSA has relied on the CEQ regulations regarding incomplete or unavailable information (*see* 40 CFR § 1502.22(b)). The understanding of the climate system is incomplete; like any analysis of complex, long-term changes to support decisionmaking, evaluating reasonably foreseeable significant adverse impacts on the human environment involves many assumptions and uncertainties. This FEIS uses methods and data that represent the best available information on this topic, and have been subjected to peer review and scrutiny. In fact, the information cited throughout this section that is extracted from the IPCC and USCCSP has endured a more thorough and systematic review process than information on virtually any other topic in environmental science and policy. The MAGICC (Model for the Assessment of Greenhouse-gas Induced Climate Change) model and the IPCC emissions scenarios described below are generally accepted in the scientific community.

Figure 3.4-3. Cascade of Uncertainty in Climate Change Simulations a/



a/ Source: Moss and Schneider (2000) – "Cascade of uncertainties typical in impact assessments showing the 'uncertainty explosion' as these ranges are multiplied to encompass a comprehensive range of future consequences, including physical, economic, social, and political impacts and policy responses."

NHTSA is aware of the USCCSP's recent release of the Final Report of Synthesis and Assessment Product (SAP) 3.1 regarding the strengths and limitations of climate models (CCSP 2008g). The reader might find the discussions in this draft Synthesis and Assessment Product useful to grasp a better understanding of the methodological limitations regarding modeling the environmental impacts of the proposed action and the range of alternatives on climate change.

3.4.3.1 Methodology for Modeling Greenhouse Gas Emissions

GHG emissions were estimated using the Volpe model, as described in Section 3.1.4. The emissions estimates include CO_2, CH_4, and N_2O emissions from both direct fuel combustion and upstream sources. The Volpe model also accounted for and estimated the following non-GHGs: SO_2, NO_x, CO, and VOCs.

The Volpe model assumes that major manufacturers will utilize all available technology before paying noncompliance civil penalties. In the more stringent alternatives, the Volpe model predicts that increasing numbers of manufacturers will run out of technology to apply and, theoretically, resort to penalty payment. Setting standards this high might not be technologically feasible, and doing so might not serve the need of the Nation to conserve fuel or reduce emissions.

Fuel savings from stricter CAFE standards also result in lower emissions of CO_2, the main GHG emitted as a result of refining, distribution, and use of transportation fuels.[12] There is a direct relationship between fuel economy and CO_2 emissions. Lower fuel consumption reduces CO_2 emissions directly because the primary source of transportation-related CO_2 emissions is fuel combustion in internal-combustion engines. NHTSA estimates reductions in CO_2 emissions resulting from fuel savings by assuming that the carbon content of gasoline, diesel, and other fuels is converted entirely to CO_2 during

[12] For this rulemaking, NHTSA estimated emissions of vehicular CO_2, CH_4, and N_2O emissions, but did not estimate vehicular emissions of HFCs. Methane and nitrous oxide account for less than 3 percent of the tailpipe GHG emissions from passenger cars and light trucks, and CO_2 emissions account for the remaining 97 percent. Of the total (including non-tailpipe) GHG emissions from passenger cars and light trucks, tailpipe CO_2 represents about 93.1 percent, tailpipe methane and nitrous oxide represent about 2.4 percent, and HFCs (from air conditioner leaks) represent about 4.5 percent. (Values calculated from EPA 2008a.)

the combustion process.[13] Reduced fuel consumption also reduces CO_2 emissions that result from the use of carbon-based energy sources during fuel production and distribution. NHTSA currently estimates the reductions in CO_2 emissions during each phase of fuel production and distribution using CO_2 emissions rates obtained from the GREET (Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation) model, using the previous assumptions about how fuel savings are reflected in reductions in each phase (NHTSA 2008b). The total reduction in CO_2 emissions from improving fuel economy under each alternative CAFE standard is the sum of the reductions in emissions from reduced fuel use and from lower fuel production and distribution.

3.4.3.2 Methodology for Estimating Climate Effects

This FEIS estimates and reports on four direct and indirect effects of climate change, driven by alternative scenarios of GHG emissions, including:

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

The change in CO_2 concentration is a direct effect of the changes in GHG emissions and influences each of the other factors.

This FEIS uses a climate model to estimate the changes in CO_2 concentrations, global mean surface temperature, and changes in sea level for each alternate CAFE standard and uses increases in global mean surface temperature combined with an approach and coefficients from the IPCC Fourth Assessment Report (IPCC 2007a) to estimate changes in global precipitation. NHTSA used MAGICC version 5.3 (Wigley 2003 to 2008) to estimate changes in key direct and indirect effects. The application of MAGICC version 5.3 uses the emissions estimates for CO_2, CH_4, and N_2O from the Volpe model. Sensitivity analyses were completed to examine the relationship among various CAFE alternatives, climate sensitivities, and scenarios of global emissions paths and the associated direct and indirect effects for each combination. These relationships can be used to infer the effect of emissions associated with the regulatory alternatives on direct and indirect climate effects.

Sections 3.4.3.2.1 through 3.4.3.2.4 describe MAGICC, the climate sensitivity analyses, and the emissions scenarios used in the analysis.

3.4.3.2.1 MAGICC Version 5.3

The selection of MAGICC for this analysis was driven by a number of factors, as follows:

- MAGICC has been used in the peer-reviewed literature to evaluate changes in global mean surface temperature and sea-level rise, including the IPCC Fourth Assessment Report for WGI (IPCC 2007a) in which it was used to scale the results from the atmospheric-ocean general circulation models (AOGCMs)[14] to estimate the global mean surface temperature and the sea-level rise for global emissions scenarios that the AOGCMs did not run.

[13] This assumption results in a slight overestimate of CO_2 emissions, because a small fraction of the carbon content of gasoline is emitted as carbon monoxide and unburned hydrocarbons. However, the magnitude of this overestimate is likely to be extremely small. This approach is consistent with the recommendation of the IPCC for "Tier 1" national GHG emissions inventories (IPCC 2006).
[14] For a discussion of AOGCMs, *see* WGI, Chapter 8 in IPCC (2007a).

- MAGICC is publicly available and is already populated with the Special Report on Emission Scenarios (SRES) scenarios. The SRES scenarios are long-term emissions scenarios representing different assumptions about key drivers of GHG emissions. They are described in more detail below.

- MAGICC was designed for the type of analysis performed in this FEIS.

- More complex AOGCMs are not designed for the type of sensitivity analysis performed here and are best used to provide results for groups of scenarios with much greater differences in emissions such as the B1 (low), A1B (medium), and A2 (high) scenarios.[15]

- MAGICC has been updated to version 5.3 to incorporate the science from the IPCC Fourth Assessment Report (Wigley 2003 to 2008).

For the analysis using MAGICC, we have assumed that global emissions consistent with the No Action Alternative (Alternative 1) follow the trajectory provided by the SRES A1B (medium) scenario.

3.4.3.2.2 Modeling Runs and Sensitivity Analyses

The modeling runs and climate sensitivity analyses are designed to use information on CAFE alternatives, climate sensitivities, and SRES emissions scenarios provided by the IPCC (IPCC 2007a)[16] to model relative changes in atmospheric concentrations, global mean surface temperature, precipitation, and sea-level rise.

The modeling runs are based on the results provided for the seven CAFE alternatives using the Reference Case Volpe model assumptions, a climate sensitivity of 3 °C for a doubling of CO_2 concentrations in the atmosphere, and the SRES A1B (medium) scenario.

The approach uses the following steps to estimate these changes:

1. NHTSA assumed that global emissions consistent with the No Action Alternative follow the trajectories provided by the SRES A1B scenario, providing results illustrating the uncertainty due to factors influencing future global emissions of GHGs.

2. NHTSA assumed that global emissions for the CAFE alternatives are equal to the global emissions from the No Action Alternative minus the emissions reductions from the Volpe model for CO_2, CH_4, N_2O, SO_2, NO_x, CO, and VOCs. All SO_2 reductions were applied to the Aerosol region 1 of MAGICC, which includes North America.

3. NHTSA used MAGICC 5.3 to estimate the changes in CO_2 concentrations, global mean surface temperature, and sea-level rise through 2100 using the No Action Alternative and CAFE alternatives developed in Steps 1 and 2 above.

[15] The IPCC SRES scenarios were developed in the late 1990s and published in 2000 (Nakicenovic *et al.* 2000). The SRES scenarios were developed around four storylines. The A1 storyline included a strong commitment to market based solutions, high savings, high economic growth, and globalization. The A2 storyline differs from A1 with lower trade flows and slower rates of technological improvement. The B1 storyline includes a global integrated approach to sustainable development. The B2 storyline includes increased local awareness of environmental issues with strong efforts at the local level and less reliance on international institutions.
[16] The use of different emissions scenarios provides insight into the impact of alternative global emissions scenarios on the effect of the CAFE alternatives.

4. For the core results, NHTSA used the increase in global mean surface temperature, along with factors relating increase in global average precipitation to this increase in global mean surface temperature, to estimate the increase in global averaged precipitation for each CAFE alternative for the A1B (medium) scenario.

The approach uses the following steps to estimate the climate sensitivity of the results to the selection of the SRES global emissions scenario:

1. NHTSA assumed that global emissions consistent with the No Action Alternative follow four potential trajectories represented by the SRES A2, B1, B2, and A1FI scenarios. The results of these simulations illustrate the uncertainty due to factors influencing future global emissions of GHGs (that is, factors other than the CAFE rulemaking).

2. For each SRES scenario from Step 1, NHTSA assumed that global emissions for the CAFE alternatives are equal to the global emissions from the No Action Alternative minus the emissions reductions from the Volpe model for CO_2, CH_4, N_2O, SO_2, NO_x, CO, and VOCs. All SO_2 reductions were applied to the Aerosol region 1 of MAGICC, which includes North America.

3. NHTSA used MAGICC 5.3 to estimate the changes in CO_2 concentrations, global mean surface temperature, and sea-level rise through 2100 using the No Action Alternative and CAFE alternatives developed in Steps 1 and 2.

Section 3.4.4 presents the results of the model runs for the alternatives. Section 3.4.5 presents the results from similar runs in which the CAFE alternatives use the high- and mid-level Volpe model assumptions (for this analysis, called the High, Mid-1, and Mid-2 Scenarios), in effect providing a "CAFE assumption sensitivity analysis."

3.4.3.2.3 Emissions Scenarios

As described above, MAGICC uses long-term emissions scenarios representing different assumptions about key drivers of GHG emissions. All scenarios used are based on the IPCC effort to develop a set of long-term (1990 to 2100) emissions scenarios to provide some standardization in climate-change modeling. The most widely used scenarios are those from the SRES (Nakicenovic *et al.* 2000).

The results rely primarily on the SRES scenario referred to as "A1B" to represent a Reference Case emissions scenario; that is, emissions for the No Action Alternative. NHTSA selected this scenario because it is regarded as a moderate emissions case and has been widely used in AOGCMs, including several AOGCM runs developed for the IPCC Fourth Assessment Report (IPCC 2007a).

NHTSA chose the A1B scenario based on the following factors:

- IPCC Working Group I evaluated the climate effects from A1B extensively in the Fourth Assessment Report (IPCC 2007a) and provides a basis for comparing the results from the analysis using MAGICC to those in the IPCC Fourth Assessment Report.

- The A1B and B2 scenarios are "middle-of-the-road" scenarios and provide the best comparison (see below) to the Energy Information Administration (EIA) Annual Energy Outlook (AEO) 2008 and International Energy Outlook (IEO) 2008 forecasts of liquid energy use, and the AEO 2008/IEO 2008 provide the base assumptions for key parameters in the Volpe model scenarios.

The A1B (medium) scenario provides a global context for emissions of a full suite of GHGs and ozone precursors. There are some inconsistencies between the overall assumptions IPCC used in its SRES (Nakicenovic *et al.* 2000) to develop global emissions scenarios and the assumptions used in the Volpe model in terms of economic growth, energy prices, energy supply, and energy demand. However, these inconsistencies affect the characterization of each CAFE alternative in equal proportion, so the relative estimates provide a reasonable approximation of the differences in environmental impacts among the alternatives. NHTSA used the A1B scenario as the primary scenario for the evaluation of climate effects, but used the A2, B1, B2, and the A1FI scenarios to provide an evaluation of the sensitivity of the results to alternative emissions scenarios.[17]

Each of the alternatives was simulated by calculating the difference in annual GHG emissions in relation to the No Action Alternative and subtracting this change from the A1B (medium) scenario to generate modified global-scale emissions scenarios, which each show the effect of the various regulatory alternatives on the global emissions path. For example, emissions from U.S. autos and light trucks in 2020 under Alternative 1, No Action, are 1,651 $MMTCO_2$; the emissions in 2020 under the Optimized Alternative (Alternative 3) are 1,622 $MMTCO_2$. The difference is 29 $MMTCO_2$. Global emissions for the A1B (medium) scenario in 2020 are 46,339 $MMTCO_2$, and represent the No Action Alternative. Global emissions for the Optimized Alternative are 29 $MMTCO_2$ less, or 46,310 $MMTCO_2$.

NHTSA based its assumptions in the Volpe model for growth in the number of vehicles and miles driven for cars and light trucks in the United States on those in the AEO because the IPCC SRES results are reported for four global regions, including the OECD, and not for the United States separately. The EIA also published the IEO for 2008 (EIA 2008c), which provides a global forecast of energy use and CO_2 from energy use through 2030, and which is consistent with assumptions in the 2008 IEO.[18]

Figures 3.4-4 to 3.4-7 provide the forecast of gross domestic product (GDP), CO_2 emissions from energy use, primary energy use from the IEO 2008, and the five SRES scenarios for the world and OECD 90 region.[19] The GDP growth assumptions for A1B for the OECD are close to those of the IEO 2008, but the A1B scenario has much higher GDP growth outside the OECD. This leads to higher global primary energy use by 2030, as shown in Figure 3.4-6, with much of the increase in natural gas use and higher emissions of CO_2 as shown in Figure 3.4-5. The global primary liquids energy use in A1B and the IEO 2008 compare well considering that the IEO forecast for liquid fuels includes about 10 percent of the total in unconventional sources, which are accounted for elsewhere in the SRES scenarios.

The forecast estimates for the OECD 90 region vary differently than the global numbers. The EIA shows a similar increase in primary energy use in the OECD 90 region but much greater increase in the use of primary liquid fuels, even considering the reporting differences between the IEO and SRES.

[17] From SRES, NHTSA used the A1B-AIM scenario to represent the A1B storyline, the A2-ASF scenario to represent the A2 storyline, the B1-IMAGE scenario to represent the B1 storyline, the B2-MESSAGE scenario to represent the B2 storyline, and the A1G-MINICAM scenario to represent the A1FI storyline.
[18] The IEO 2008 uses energy supply and consumption from the AEO 2008 for the United States and the same forecast for world oil prices.
[19] The IEO nuclear primary energy forecast numbers were adjusted to account for differences in reporting primary energy use for nuclear energy and all IEO energy-use estimates were converted to exajoules (EJ).

Figure 3.4-4. Average GDP Growth Rates (1990 to 2030)

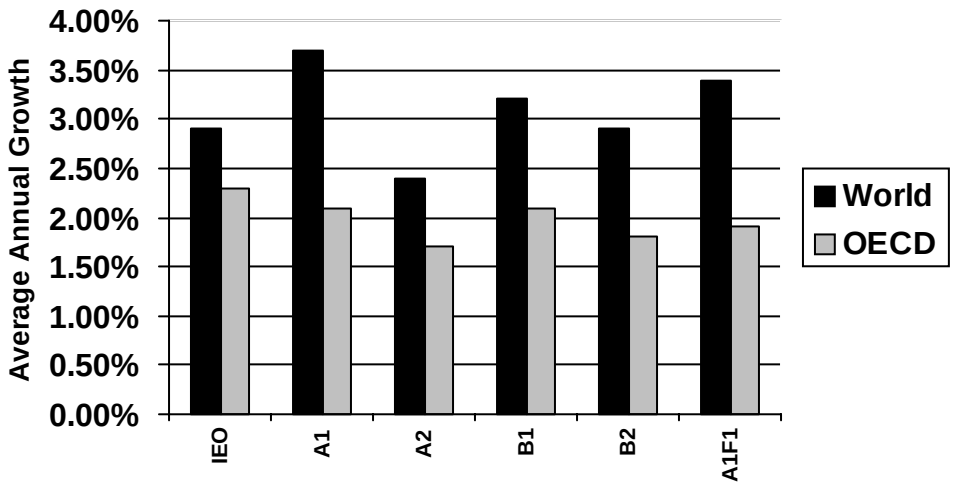


Figure 3.4-5. Global CO2 Emissions from Fossil Fuel Use

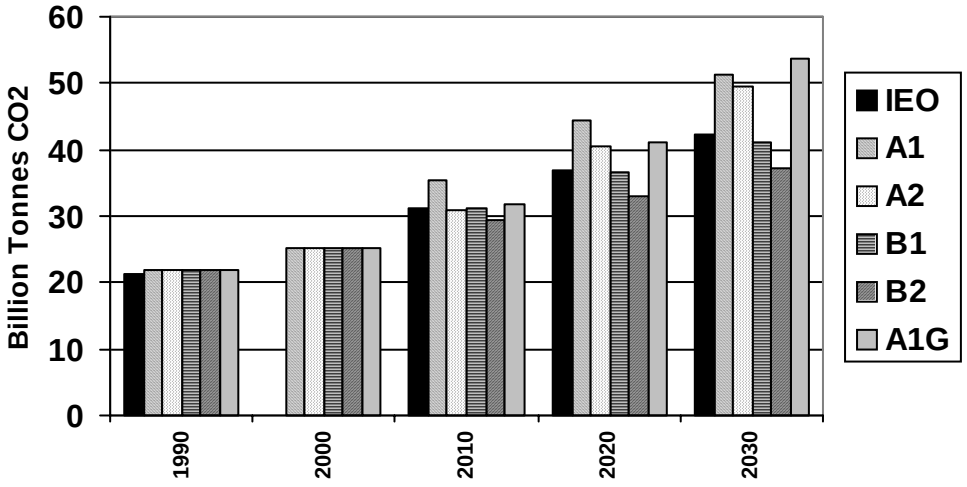


Figure 3.4-6. World Primary Energy Use Forecast

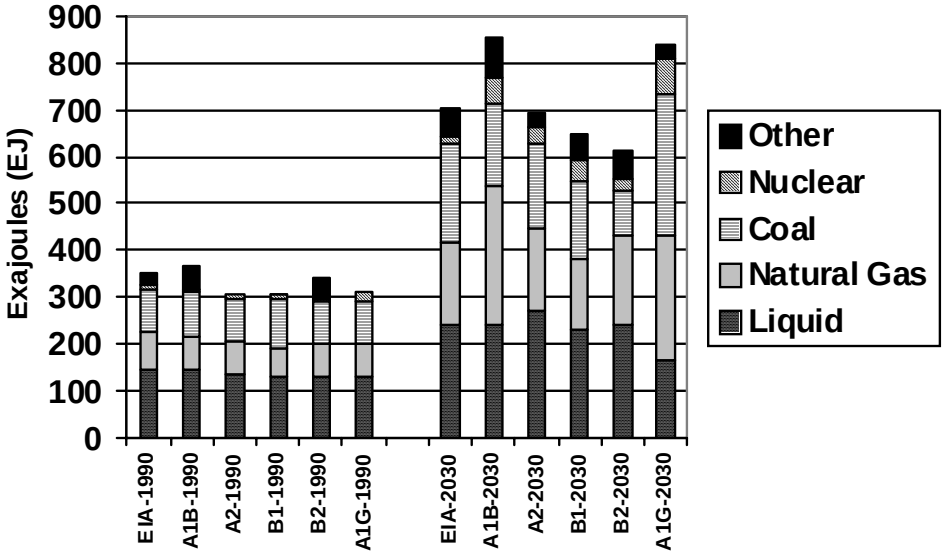
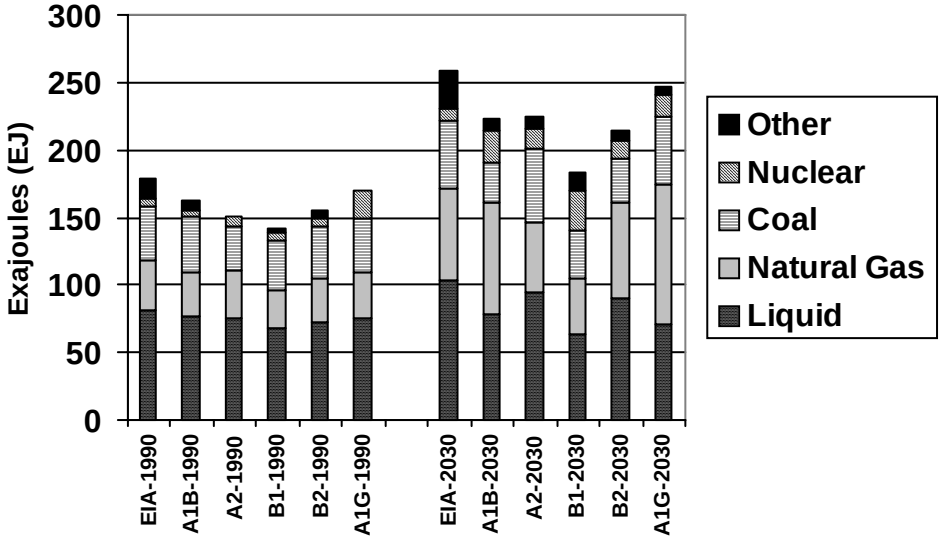


Figure 3.4-7. OECD90 Primary Energy Use Forecast[20]



Where information in the analysis included in this FEIS is incomplete or unavailable, NHTSA has relied on the CEQ regulations regarding incomplete or unavailable information (*see* 40 CFR § 1502.22(b)). In this case, despite the inconsistencies between the IPCC assumptions on global trends

[20] The SRES results provide forecasts for countries that were members of the OECD in 1990 only. The IEO 1990 and 2030 estimates are scaled to reflect only countries in the OECD in 1990.

across all GHG-emitting sectors (and the drivers that affect them) and the particularities of the Volpe model on the U.S. transportation sector, the approach used is valid for this analysis. These inconsistencies affect all alternatives equally; therefore, they do not hinder a comparison of the alternatives in terms of their relative effects on climate.

The approaches focus on marginal changes in emissions that affect climate. Thus, the approaches result in a reasonable characterization of climate change for a given set of emissions reductions, regardless of the underlying details associated with those emissions reductions. The discussion that follows characterizes projected climate change under the No Action Alternative (Alternative 1) and the action alternatives (Alternatives 2 through 7).

The climate sensitivity analysis also uses the B1 (low), B2, A2 (high), and A1F1 emissions scenarios (Nakicenovic *et al.* 2000) as "reference" scenarios. This provides a basis for determining climate responses to varying levels of global emissions and climate sensitivities under for the Optimized Alternative (Alternative 3). Some responses of the climate system are believed to be non-linear; by using a range of emissions cases and climate sensitivities, the effects of the alternatives in relation to different reference cases can be estimated.

3.4.3.2.4 Tipping Points and Abrupt Climate Change

The phrase "tipping point" is most typically used, in the context of climate change and its consequences, to describe situations in which the climate system (the atmosphere, oceans, land, cryosphere,[21] and biosphere) reaches a point at which there is a disproportionately large or singular response in a climate-affected system as a result of only a moderate additional change in the inputs to that system (such as an increase in the CO_2 concentration). Exceeding one or more tipping points, which "occur when the climate system is forced to cross some threshold, triggering a translation to a new state at a rate determined by the climate system itself and faster than the cause" (Committee on Abrupt Climate Change 2002), could result in abrupt changes in the climate or any part of the climate system. These changes would likely produce impacts at a rate and intensity far greater than the slower, steady changes currently being observed (and in some cases, planned for) in the climate system.

The phrase tipping point is also used outside the climate modeling community. In addition to climate scientists, many others – including biologists, marine chemists, engineers, and policymakers – are concerned about tipping points, because it is not just the climate that can change abruptly. The same type of non-linear responses exists in the physical, environmental, and societal systems that climate affects. For example, ocean acidity resulting from an elevated atmospheric concentration of CO_2 might reach a point at which there would be a dramatic decline in coral ecosystems. Consideration of possible tipping points could therefore encompass sharp changes in climate-affected resources and not be restricted to climate change alone.

Using the broad definition of the term tipping point to include both climate change and its consequences, the scale of spatial responses can range from global (*e.g.*, a "supergreenhouse" atmosphere with higher temperatures worldwide), to continental or subcontinental changes (such as dramatically altering the Asian monsoon), to regional (*e.g.*, drying in the southwestern United States leading to increases in the frequency of fires, to local (such as loss of the Sierra Nevada snowpack). The definition of tipping point used by Lenton *et al.* (2008) (discussed below) specifically applies only to subcontinental or larger features, whereas public policy is concerned with a wider range of scales, as the IPCC analysis (discussed below) suggests.

[21] The cryosphere describes the portion of Earth's surface that is frozen water, such as snow, permafrost, floating ice, and glaciers.

The temporal scales considered are also important. On crossing a tipping point, the evolution of the climate-affected system is no longer controlled by the time scale of the climate forcing (such as the heat absorption by GHGs), but rather is determined by its internal dynamics, which can either be much faster than the forcing, or substantially slower. The much faster case – abrupt climate change – might be said to occur when the:

- Rate of change is sharply greater than (or a different sign than) what has been prevailing over previous decades;
- State of the system exceeds the range of variations experienced in the past; or
- Rate has accelerated to a pace that exceeds the resources and ability of nations to respond to it.

Climate changes could occur in many ways as tipping points are reached. These mechanisms range from the appearance or unusual strengthening of positive feedbacks – self-reinforcing cycles – and reversible-phase transitions in climate-affected systems to irreversible-phase transitions – where a threshold has been crossed that could lead to either abrupt or unexpected changes in the rate or direction of change in climate-affected systems. Although climate models incorporate many positive (and negative, or dampening) feedback mechanisms, the magnitude of these effects and the threshold at which the feedback-related tipping points are reached are only roughly known, especially regarding global impacts. In addition, models of climate and climate-affected systems do not contain all feedback processes. Although substantial progress has been made in understanding the qualitative processes associated with tipping points, there are limits to the quantitative understanding of many of these systems.

In recent years, the concept of a tipping point – or a set of tipping points – in Earth's climate system has been attracting increased attention among climate scientists and policy makers. The following sections draw on perspectives from four key analyses of the issue and other relevant research: the IPCC, the USCCSP, paleoclimate[22] evidence, and Lenton *et al.* (2008). The section concludes with a brief comparative evaluation.

IPCC Perspectives on Tipping Points

In its Fourth Assessment Report, the IPCC addresses the issue of tipping points in the discussion of "major or abrupt climate changes" and highlights three large systems: the meridional overturning circulation (MOC) system that drives Atlantic Ocean circulation, the collapse of the West Antarctic ice sheet, and the loss of the Greenland ice sheet (Meehl *et al.* 2007). The IPCC states that there is uncertainty in the understanding of these systems but concludes that these systems are unlikely to reach their tipping points within the 21st Century (Meehl *et al.* 2007). The IPCC also mentions additional systems, as noted below, that might have tipping points, but does not include estimates for them.

The IPCC WGI report (Meehl *et al.* 2007) describes various climate and climate-affected systems that might undergo abrupt change, contribute to "climate surprises," or experience irreversible impacts. The systems that the IPCC described include:

- Atlantic MOC (AMOC) and other ocean circulation changes
- Arctic sea ice

[22] Paleoclimatology is the study of climate change through the physical evidence left on earth of historical global climate change (prior to the widespread availability of records to temperature, precipitation, and other data). *See generally* http://www.giss.nasa.gov/research/paleo/.

- Glaciers and ice caps
- Greenland and West Antarctic ice sheets
- Vegetation cover
- Atmospheric and ocean-atmosphere regimes

The IPCC Working Group II (WGII) report provides insight on the uncertainties surrounding tipping points, their systemic and impact thresholds, and the value judgments required to select a critical level of warming (Carter *et al.* 2007). The presence of these thresholds can also present their own physical and ecological limits and informational and cognitive barriers to adaptation (Adger *et al.* 2007). In the case of this FEIS, uncertainty prevents NHTSA from being able to quantify the impacts of the alternatives under consideration on specific tipping-point thresholds.

In the IPCC WG II report, certain thresholds are assumed and then used with analyses of emissions scenarios and stabilization targets to assess how certain impacts might be avoided (Schneider *et al.* 2007). For example, several authors hypothesize that a large-scale climatic event or other impacts (for example, widespread coral-reef bleaching; deglaciation of West Antarctica) would be likely if atmospheric CO_2 concentrations stabilize at levels exceeding 450 ppm, although the location of the tipping points and thresholds is uncertain (O'Neill and Oppenheimer 2002, Lowe *et al.* 2006, and Corfee-Morlot and Höhne 2003, all as cited in Schneider *et al.* 2007).

USCCSP Perspectives on Tipping Points

The USCCSP reaches similar conclusions in its report *Scientific Assessment of the Effects of Global Change on the United States* (National Science and Technology Council 2008). The USCCSP report summarizes scientific studies that suggest that there are several "triggers" of abrupt climate change and that "anthropogenic forcing *could* increase the risk of abrupt climate change;" however, "future abrupt changes cannot be predicted with confidence" because of the insufficiencies of current climate models, which reflect the limits of current understanding.[23] However, the USCCSP report does reiterate the conclusion that if it occurs, an abrupt climate change event would likely transpire over the course of many hundreds of years and that it is *"very unlikely"* that any abrupt climate change will occur "during the 21st century."

The USCCSP analysis considers the susceptibility of the same three systems to abrupt change as IPCC highlighted: the AMOC system that drives Atlantic Ocean circulation, the collapse of the West Antarctic ice sheet, and the loss of the Greenland ice sheet (National Science and Technology Council 2008). The USCCSP analysis also suggests that there are thresholds in non-climate systems influenced by CO_2 emissions, such as ocean acidification, where there could be a threshold beyond which existing coral reef ecosystems cannot survive (CCSP 2008e). The USCCSP report concludes that these impacts, including climate-related thresholds, could occur in groups as thresholds are crossed, but, due to the uncertainty, more research is needed to quantify the impacts of crossing particular thresholds and to determine when these thresholds would be reached (CCSP 2008e). A forthcoming USCCSP report, Synthesis and Assessment Product 3.4, "Abrupt Climate Change," will provide additional information on this topic, focusing on glaciers and ice sheets, hydrological change, the MOC, and methane releases.

[23] *See* U.S. Climate Change Science Program, Synthesis and Assessment Product 3.1 (Climate Models: An Assessment of Strengths and Limitations), Final Report (July 2008), *available at* http://www.climatescience.gov/Library/default.htm#sap.

Paleoclimate Evidence on Tipping Points

The paleoclimate record cited by IPCC, USCCSP, and others gives an indication of sea-level rise from previous ice-sheet melt, and the corresponding temperature for these periods. For example, geological evidence showing the presence of elevated beaches suggests that global sea level was 4 to 6 meters higher during the most recent interglacial period about 125,000 years ago (Jansen *et al.* 2007). Paleoclimatic reconstructions suggest that global average temperature then was about 1 °C (1.8 °F) warmer than during the present interglacial period (Hansen *et al.* 2007b). Corings from the ice sheets to determine their ages, supplemented by simulations of ice-sheet extent, suggest that large-scale retreat of the southern half of the Greenland ice sheet and other Arctic ice fields likely contributed roughly 2 to 4 meters of sea-level rise during the last interglacial, with most of any remainder likely coming from the Antarctic ice sheet (Jansen *et al.* 2007).

Paleoclimatic reconstructions also indicate occurrences of abrupt changes in the terrestrial, ice, and oceanic climatic records. For example, ice-core records suggest that temperatures atop the Greenland ice sheet warmed by 8 to 16 °C (14 to 29 °F) within a few decades during Dansgaard-Oeschger events,[24] which were likely caused by the North Atlantic Ocean being covered by catastrophic outflows of glacial meltwater from the North American ice sheet that was present during glacial times (Jansen *et al.* 2007). A more recent study (Steffensen *et al.* 2008) provides more detail, indicating that a there was a sharp warming over 1 to 3 years (that is, "abrupt climate change happens in [a] few years"), followed by a more gradual warming over 50 years.

Based on the IPCC estimates of temperature increases of approximately 2 to 4 °C in the next 100 years, MacCracken (2008) notes that paleoclimatic research indicates that corresponding sea-level rise could be 10 to 20 meters or more from the melting of the West Antarctic and Greenland ice sheets. The time required to melt the ice sheets is uncertain, ranging from decades to centuries or longer. MacCracken (2008) suggests that "significant sea level rise [over 1 meter] could happen relatively quickly," meaning less than a century. For example, the average rate of rise from 20 kiloannum[25] (ka) to 8 ka was about 1 meter per century, so there have been periods with high rates of rise, although the melting North American ice sheet was an order of magnitude larger than Greenland is today (MacCracken, personal communication, 2008). For the future, Hansen *et al.* (2007b) asserts that positive feedback mechanisms in the climate system have the potential to cause large and rapid shifts in climate and in factors like glacial melt and sea-level rise that are closely dependent on the climate; Rahmstorf (2007) presents a projected sea-level rise in 2100 of 0.5 to 1.4 meters above the 1990 level.

In a study utilizing model runs and paleoclimatic data,[26] Hansen *et al.* (2007b) conclude that "…a CO_2 level exceeding about 450 ppm is 'dangerous,'" where "dangerous" is defined by the authors to be global warming of more than 1 ºC (1.8 ºF) above the level in 2000, potentially leading to highly disruptive effects. Although this 450-ppm estimate has limitations and uncertainties, Hansen actually considers this estimate of dangerous CO_2 concentration to be an upper limit because it depends on several simplifying assumptions (Hansen 2008b). He warns that the limit might be lower and that a "safe" level

[24] Dansgaard-Oeschger events are very rapid climate changes—up to 7 °C in some 50 years—during the Quaternary geologic period, and especially during the most recent glacial cycle. (A Dictionary of Geography. Oxford University Press, 1992, 1997, 2004.)

[25] Kiloannum means "one thousand years ago."

[26] The authors compare the corresponding GHG concentrations and associated temperature increases to paleoclimatology research to demonstrate that abrupt changes have occurred in Earth's past, resulting from a similar range in increased temperature as those being predicted, and to argue the existence of a CO_2 concentration equivalent level (in atmospheric GHG concentration) at which the probability of abrupt, irreversible changes in climate-affected systems might occur.

of CO_2 could be 350 ppm – lower than the CO_2-equivalent concentration, including the offsetting effects of aerosols, is today (Hansen 2008b).

The range of views linking past and future sea-level rise is clearly broad, with uncertainty attributable to each view. Therefore, the forthcoming USCCSP report – Synthesis and Assessment Product 3.4, "Abrupt Climate Change" – should provide additional, more complete information on the issue.

Perspectives on Tipping Points from a Critical Review of the Literature and an Expert Elicitation as Presented by Lenton *et al.* (2008)

Building on the IPCC and USCCSP research, during a workshop titled "Tipping Points in the Earth System," experts identified several climate systems that have tipping points and conducted an expert elicitation involving 52 members of the international scientific community, many of whom participated in the IPCC. This study identified nine systems facing separate tipping points due to increased CO_2 and temperature levels that met four scientifically based criteria to be considered "policy-relevant potential future tipping elements in the climate system" (Lenton *et al.* 2008). Additional systems were identified but insufficient information precluded these systems from meeting the definition of policy relevant. The systems at risk that the researchers identified are:

- Arctic sea ice
- Greenland ice sheet
- West Antarctic ice sheet
- Atlantic thermohaline circulation (a component of the AMOC)
- El-Niño-Southern oscillation
- Indian summer monsoon
- Sahara/Sahel and West African monsoon
- Amazon rainforest
- Boreal forest

The discussion that follows is drawn primarily from the Lenton *et al.* (2008) study, including the citations therein.

Arctic sea ice. The surface of Arctic sea ice has a higher reflectivity (albedo) than the darker ocean surface. As sea ice melts from higher air and ocean temperatures, more of the ocean is exposed, which allows more radiation to be absorbed, amplifying the sea-ice melt. In summer, Arctic sea-ice loss could lead to the ice cap melting beyond a certain size/thickness, making it unstable and leading to an ice-free Arctic. Recent record ice losses and modeling studies have led some researchers to suggest that the summer Arctic will be ice free within a decade or less, that there is a critical threshold for summer Arctic sea-ice loss, and that this threshold has already been crossed (Borenstein and Joling 2008).

Greenland ice sheet. The Greenland ice sheet is also susceptible to positive feedbacks. Melting at the glacial margins lowers the edge of the ice sheet to elevations that are warmer and where more melting will occur. The IPCC estimated the Greenland ice sheet threshold for negative surface mass at 1.9 to 4.6 °C (3.4 to 8.3 °F) above pre-industrial temperature, well within the predicted temperature range for this century. Dynamic ice-melting processes, regional temperatures, warming surrounding oceans, and recent observations indicating that both Greenland and Antarctica are now losing mass have led researchers to conclude that the timescale for Greenland ice-shelf collapse is conceivably on a scale of hundreds rather than thousands of years.

West Antarctic ice sheet. The West Antarctic ice sheet is grounded below sea level and positive feedbacks could result from the loss of buttressing sea-ice shelves and the ingress of warmer ocean water. While centuries or millennia could to pass before a collapse, the thresholds for ocean and surface atmospheric warming temperature are likely to be crossed this century. A recent study of ice-core records suggests strong links between past West Antarctic climate, and potentially its ice sheet, to large-scale changes in global climate, particularly major El Niño events (Schneider and Steig 2008). It should be noted that ice-sheet loss, even over millennia, could cause the sea level to rise at a rate greater than 1 meter per century – more than five times the rate of rise during the 20th Century. The level reached would be higher than has been the case during at least the past few thousand years when coastal cities were established.

Atlantic thermohaline circulation. The term thermohaline circulation (THC) refers to the physical driving mechanism of ocean circulation, resulting from fluxes of heat and freshwater across the sea surface, subsequent interior mixing of heat and salt, and geothermal heat sources. The MOC, discussed in the IPCC and USCCSP reports, is the observed response in an ocean basin to this type of ocean circulation coupled with wind-driven currents. The Lenton *et al.* (2008) paper refers to risk to the Atlantic THC instead of the AMOC because they are discussing the influence of climate change on the underlying cooling or freshwater forcing of the Atlantic Ocean circulation, even though this in turn dramatically affects the AMOC.

If enough freshwater enters the North Atlantic (such as from melting sea ice or the Greenland ice sheet), the density-driven sinking of North Atlantic waters might be reduced or even stopped, as evidence indicated occurred happened during the last glacial cycle. This would likely reduce the northward flow of energy in the Gulf Stream and result in less heat transport to the North Atlantic. At the same time, reduced formation of very cold water would likely slow the global ocean THC, leading to impacts on global climate and ocean currents. The IPCC review of the results of model simulations suggests that an abrupt transition of the Atlantic Ocean's component of the global THC is *very unlikely* this century. However, more recent modeling that includes increased freshwater inputs suggests there could be initial changes this century, with larger and more intense reductions in the overturning circulation persisting for many centuries (Mikolajewicz *et al.* 2007).

El-Niño-Southern oscillation (ENSO). The changes that might lead to increasingly persistent (and frequent) El Niño (or La Niña) conditions are particularly uncertain. Increases in ocean heat content could have an effect on ENSO conditions, but predictive and paleoclimate modeling studies do not agree on the magnitude, frequency, and direction of these effects. However, ENSO has substantial and large-scale effects on the global climate system.

Indian summer monsoon. The Indian summer monsoon is the result of land-to-ocean pressure gradients and advection of moisture from ocean to land. By warming the land more than the ocean, climate change generally strengthens the monsoon. However, reductions in the amount of solar radiation that is absorbed by the land surface, such as land-use change, generally weaken it. An albedo greater than roughly 50 percent is necessary to simulate the collapse of the Indian summer monsoon in a simple model (Zickfield *et al.* 2005). IPCC projections do not project passing a threshold this century, although paleoclimatic reconstructions do indicate that the monsoon has changed substantially in the past.

West African monsoon. Sahara/Sahel rainfall depends on the West African monsoon circulation, which is affected by sea-surface temperature. By warming the land more than the ocean and therefore causing greater upward movement of the air, GHG forcing is expected to draw more moist oceanic air inland and thereby increase rainfall in the region, which has been shown by some models. Other models, however, project a less productive monsoon. The reasons for this inconsistency are not clear.

Amazon rainforest. The recycling of precipitation in the Amazon rainforest means that deforestation, reductions in precipitation, a longer dry season, and increased summer temperature could cause forest dieback. These conditions are thought to be linked to a more persistent El Niño and an increase of global average temperature by 3 to 4 °C (5.4 to 6.8 °F). Important additional stressors also present include forest fires and human activity (such as land clearing). A critical threshold might exist in canopy cover, which could be reached through changes in land use or regional precipitation, ENSO variability, and global forcing.

Boreal Forest. The dieback of boreal forest could result from a combination of increased heat stress and water stress, leading to decreased reproduction rates, increased disease vulnerability, and subsequent fire. Although highly uncertain, studies suggest a global warming of 3 °C (5.4 °F) could be the threshold for loss of the boreal forest.

Comparative Evaluation

The Lenton *et al.* (2008) group's list differs slightly from that of the IPCC because of differences in definition and criteria, an attempt to be more explicit than the IPCC, and the inclusion of more recent studies. The scientists defined these tipping points as "tipping elements" and attempted to estimate when the tipping element of the various systems might be reached, ranging from about 1 year (rapid) to more than 300 years (slow). As with the IPCC and USCCSP conclusions, this group also concluded that the loss of the Greenland ice sheet, the collapse of the West Antarctic ice sheet, and the disruption of the Atlantic THC systems are not expected to cross their estimated tipping elements in this century (though actions this century could create enough momentum in the climate system to cross the threshold in future centuries[27]). However, this group determined that several other systems could reach a tipping threshold within the century: loss of Arctic sea ice, Indian summer monsoon disruption, Sahara/Sahel and West African monsoon changes, drying of the Amazon rainforest, and warming of the boreal forest.

Another factor that might accelerate climate change at rates faster than those currently observed is the possible shift of soil and vegetation-carbon feedbacks, causing the soil and vegetation to become carbon sources rather than carbon sinks. Currently, soil and vegetation act as sinks, absorbing carbon from the atmosphere as plant material and storing carbon in the soil when the plants die. However, by mid-century (about the time the IPCC predicts the global average temperature reaches 2 ºC (3.6 ºF) above pre-industrial levels), increasing temperatures and precipitation could cause increased rates of transpiration, resulting in soil and vegetation becoming a potential source of carbon emissions (Cox *et al.* 2000 as cited in Meehl *et al.* 2007). Warming could also thaw frozen Arctic soils (permafrost), causing the wet soils to emit more methane, a GHG. There is evidence that this process is already taking place (Walter *et al.* 2007). This additional research clarifies the concept of tipping points by further revealing that several climate systems might have tipping points that could occur within the century, and in some systems changes are currently being observed. However, uncertainties exist, especially for timing estimates, and the uncertainties are at least partly responsible for the broad spectrum of views regarding the tipping point. Exactly where these tipping points exist, and the levels at which they occur, are still a matter in need of further scientific investigation before precise quantitative conclusions can be made.

Where information in this FEIS analysis is incomplete or unavailable, as here due to current climate modeling limitations, NHTSA has relied on the CEQ regulations regarding incomplete or unavailable information. 40 CFR § 1502.22(b). CEQ regulations state, in part, that when an agency is evaluating "reasonably foreseeable significant adverse impacts on the human environment and …information relevant to…[the] impacts cannot be obtained because the overall costs of obtaining it are exorbitant or the means to obtain it are not known, the agency shall include within the [EIS]:

[27] *See* Lenton *et al.* (2008).

(1) a statement that such information is incomplete or unavailable;

(2) a statement of the relevance of the incomplete or unavailable information to evaluating reasonably foreseeable significant adverse impacts on the human environment;

(3) a summary of existing credible scientific evidence which is relevant to evaluating the reasonably foreseeable significant adverse impacts on the human environment; and

(4) The agency's evaluation of such impacts based upon theoretical approaches or research methods generally accepted in the scientific community. For the purposes of this section, "reasonably foreseeable" includes impacts which have catastrophic consequences, even if their probability of occurrence is low, provided that the analysis of the impacts is supported by credible scientific evidence, is not based on pure conjecture, and is within the rule of reason."

40 CFR § 1502.22 (b)

This FEIS addresses the requirements of 40 CFR § 1502.22 appropriately. The above survey of the current state of climate science tipping points provides a "summary of existing credible scientific evidence which is relevant to evaluating the…adverse impacts of the CAFE standards." In *Colorado Environmental Coalition v. Dombeck,* the Tenth Circuit found that the ultimate goal of the agency is to ensure that the EIS's "form, content, and preparation foster both informed decision making and informed public participation" (185 F.3d 1162, 1172 [10th Cir. 1999] [quoting *Oregon Envtl. Council v. Kunzman*, 817 F.2d 484, 492 (9th Cir. 1987)]). The Tenth Circuit held that 40 CFR § 1502.22 could not be read as imposing a "data gathering requirement under circumstances where no such data exists." *Id.*

In this case, this FEIS acknowledges that information on tipping points or abrupt climate change is incomplete, and the state of the science does not allow for a characterization of how the CAFE alternatives influence these risks. This action alone, even as analyzed for the most stringent alternative, does not produce sufficient CO_2 emissions reductions to avert levels of abrupt and severe climate change. To the degree that the action in this rulemaking reduces the rate of CO_2 emissions, the rule contributes to the general reduction or delay of reaching these tipping-point thresholds. These conclusions are not meant to be read as expressing NHTSA's view that tipping points in climate-related systems are not areas of concern for policymakers. Under NEPA, the agency is obligated to discuss "the environmental impact[s] *of the proposed action*" (42 U.S.C. § 4332(2)(C)(i) [emphasis added]). The above discussion fulfills NHTSA's NEPA obligations regarding this issue.

3.4.4 Environmental Consequences

This section describes the consequences of the MY 2011-2015 CAFE standards in relation to GHG emissions and climate effects.

3.4.4.1 Greenhouse Gas Emissions

To estimate the emissions resulting from changes in passenger-car and light-truck CAFE standards, NHTSA uses the Volpe model (*see* Section 3.1.4 for a description of the model). The change in fuel use projected to result from each alternative CAFE standard determines the resulting impacts on total and petroleum energy use, which in turn affects the amount of CO_2 emissions. Reducing fuel use also lowers CO_2 emissions from the use of fossil carbon-based energy during crude oil extraction, transportation, and refining, and in the transportation, storage, and distribution of refined fuel. Because CO_2 accounts for such a large fraction of total GHGs emitted during fuel production and use – more than 95 percent, even after accounting for the higher global warming potentials of other GHGs – NHTSA's

consideration of GHG impacts focuses on reductions in CO_2 emissions resulting from the savings in fuel use that accompany higher fuel economy.[28]

NHTSA estimated GHG emissions for each alternative using the Reference Case assumptions. In the discussion and table that follows, emissions reductions represent the differences in total annual emissions by all cars or light trucks in use between their estimated future levels under the No Action Alternative (Alternative 1) and each action alternative (Alternatives 2 through 7). Emissions reductions resulting from the CAFE standard for MY 2011-2015 cars and light trucks were estimated from 2010 to 2100. Reductions would begin in 2010, the first year that MY 2011 vehicles would be on the road. For each alternative, all vehicles after MY 2015 were assumed to meet the MY 2015 CAFE standards. Emissions were estimated for all alternatives through 2100, and these emissions were compared against the NPRM baseline (which assumes all vehicles after MY 2010 meet MY 2010 standards) to estimate emissions reductions. The Volpe model estimates emissions through the year 2060.[29] Annual emissions reductions from 2061-2100 were held constant at 2060 levels.

Table 3.4-1 and Figure 3.4-8 show total emissions and emissions reductions resulting from applying the seven alternatives to new passenger cars and light trucks from 2010 to 2100. Emissions for the period range from 193,212 $MMTCO_2$ for the Technology Exhaustion Alternative (Alternative 7) to 221,258 $MMTCO_2$ for the No Action Alternative. Compared to the No Action Alternative, projections of emissions reductions over the period 2010 to 2100 due to the MY 2011-2015 CAFE standards ranged from 5,922 to 28,047 $MMTCO_2$.[30] Compared to global emissions of 4,850,000 $MMTCO_2$ over this period (projected by the A1B-medium scenario), this rulemaking is expected to reduce global CO_2 emissions by about 0.1 to 0.6 percent.

Table 3.4-1

Reference Case Emissions and Emissions Reductions Due to the MY 2011-2015 CAFE Standards from 2010-2100 ($MMTCO_2$)

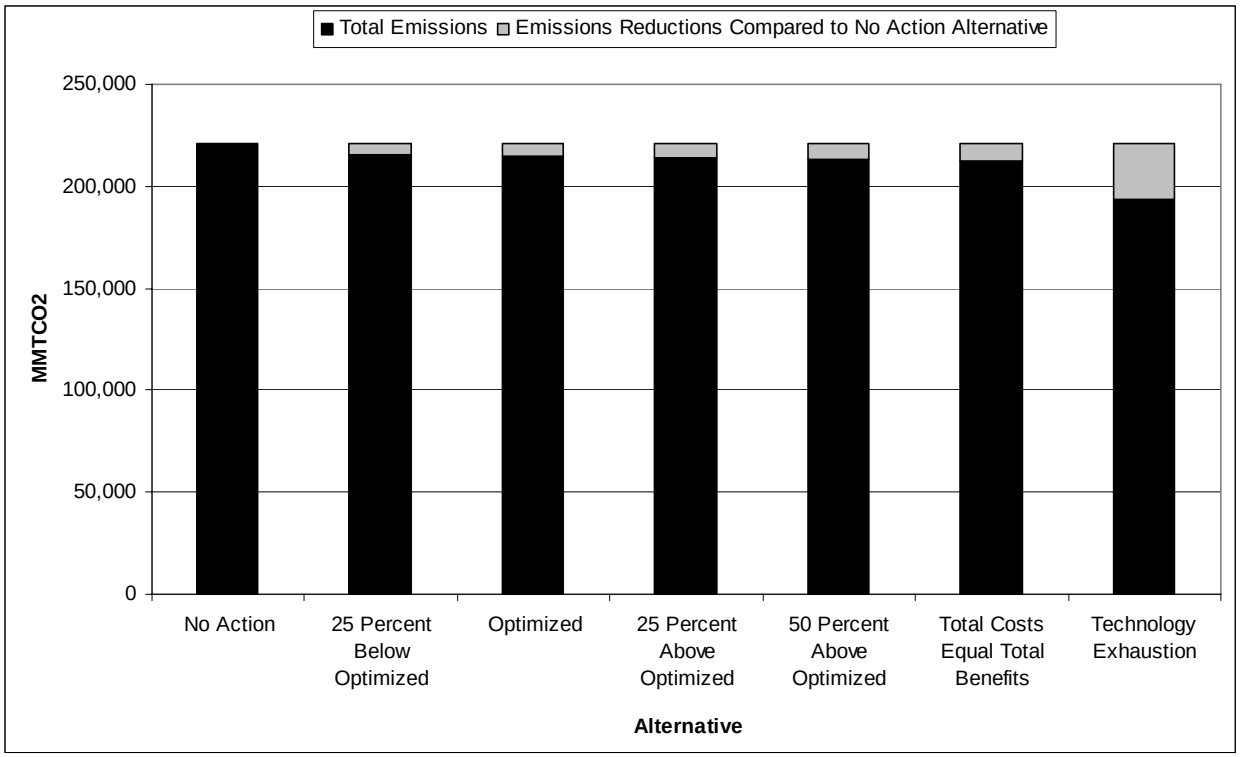
Alternative	Emissions	Emissions Reductions Compared to No Action Alternative
1 No Action	221,258	0
2 25 Percent Below Optimized	215,337	5,922
3 Optimized	214,643	6,616
4 25 Percent Above Optimized	214,144	7,114
5 50 Percent Above Optimized	213,254	8,004
6 Total Costs Equal Total Benefits	212,345	8,913
7 Technology Exhaustion	193,212	28,047

[28] Although this section includes a discussion of CO_2 emissions only, the climate modeling discussion in Section 3.4.4.4 assesses the direct and indirect effects associated with emissions reductions of multiple gases, including CO_2, CH_4, N_2O, SO_2, CO, NO_x, and VOCs.

[29] *See* Section 3.1.3 for a summary of the scope and parameters of the Volpe model.

[30] The values here are summed from 2010 through 2100, and are thus considerably higher than the value of 520 $MMTCO_2$ cited in the NPRM for the Optimized Alternative (Alternative 3). The latter value is the reduction in CO_2 emissions by only MY 2011-2015 cars and light trucks over their lifetimes resulting from the optimized CAFE standards, measured as a reduction from the NPRM baseline of extending the CAFE standards for MY 2010 to apply to MY 2011-2015.

Figure 3.4-8. Reference Case Emissions and Emissions Reductions Due to the MY 2011-2015 CAFE Standards from 2010 to 2100 ($MMTCO_2$)



To get a sense of the relative impact of these reductions, it can be helpful to consider the relative importance of emissions from cars and light trucks as a whole and to compare them against emissions projections from the transportation sector, and expected or stated goals from existing programs designed to reduce CO_2 emissions.

As mentioned earlier, U.S. cars and light trucks account for 19.2 percent of CO_2 emissions in the United States. Thus, with the action alternatives reducing U.S. car and light truck CO_2 emissions by 2.7 to 12.7 percent, this would represent a reduction of 0.5 to 2.4 percent of total U.S. CO_2 emissions (assuming the relative contribution of cars and light trucks stays the same). Figure 3.4-9 shows projected annual emissions from cars and light trucks under the MY 2011-2015 alternative CAFE standards.

As Table 3.4-2 shows, total CO_2 emissions accounted for by the U.S. car and light-truck fleets are projected to increase substantially from their level in 2010 under the No Action Alternative, which would extend passenger car and light truck CAFE standards for MY 2010 to apply to all future model years. The table also shows that each of the action alternatives would reduce total car and light-truck CO_2 emissions in future years from their projected levels under the No Action Alternative. Progressively larger reductions in CO_2 emissions from their levels under the No Action Alternative are projected to occur during each future year as the action alternatives require successively higher fuel economy levels for MY 2011-2015 and later passenger cars and light-trucks.

Figure 3.4-9. Projected Reference Case Annual Emissions Under the MY 2011-2015 Alternative CAFE Standards ($MMTCO_2$)

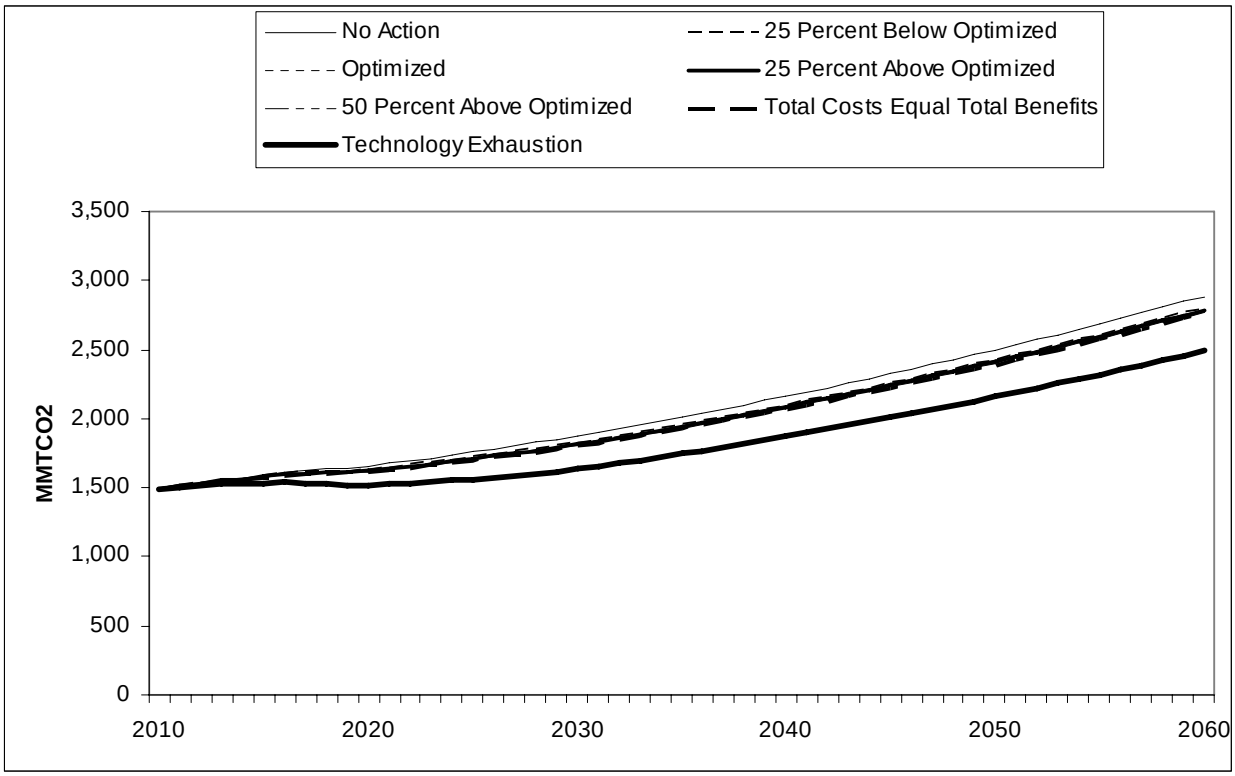


Table 3.4-2

Reference Case Nationwide Emissions of Greenhouse Gases from Passenger Cars and Light Trucks under Alternative CAFE Standards for MY 2011-2015 (MMT per Year)

	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7
GHG and Year	**No Action**	**25% Below Optimized**	**Optimized**	**25% Above Optimized**	**50% Above Optimized**	**Total Costs Equal Total Benefits**	**Technology Exhaustion**
Carbon dioxide (CO_2)							
2010	1,487	1,487	1,487	1,487	1,487	1,487	1,487
2020	1,651	1,625	1,622	1,619	1,616	1,611	1,517
2030	1,876	1,825	1,820	1,815	1,808	1,800	1,636
2040	2,161	2,099	2,092	2,087	2,077	2,068	1,869
2050	2,500	2,427	2,419	2,413	2,402	2,391	2,158
2060	2,883	2,799	2,790	2,783	2,770	2,757	2,489
Methane (CH_4)							
2010	1.75	1.75	1.75	1.75	1.75	1.75	1.75
2020	1.94	1.91	1.90	1.90	1.90	1.89	1.75
2030	2.20	2.14	2.13	2.13	2.12	2.11	1.87
2040	2.53	2.46	2.45	2.45	2.43	2.42	2.13
2050	2.93	2.85	2.84	2.83	2.81	2.80	2.46
2060	3.38	3.28	3.27	3.26	3.25	3.23	2.83

Table 3.4-2 (cont'd)

Reference Case Nationwide Emissions of Greenhouse Gases from Passenger Cars and Light Trucks under Alternative CAFE Standards for MY 2011-2015 (MMT per Year)

GHG and Year	Alt. 1 No Action	Alt. 2 25% Below Optimized	Alt. 3 Optimized	Alt. 4 25% Above Optimized	Alt. 5 50% Above Optimized	Alt. 6 Total Costs Equal Total Benefits	Alt. 7 Technology Exhaustion
Nitrous oxide (N_2O)							
2010	0.06	0.06	0.06	0.06	0.06	0.06	0.06
2020	0.05	0.05	0.05	0.04	0.04	0.04	0.03
2030	0.05	0.05	0.05	0.05	0.05	0.05	0.03
2040	0.06	0.06	0.06	0.05	0.05	0.05	0.03
2050	0.06	0.06	0.06	0.06	0.06	0.06	0.04
2060	0.07	0.07	0.07	0.07	0.07	0.07	0.04

However, Table 3.4-2 also shows that none of the action alternatives would reduce total CO_2 emissions accounted for by passenger cars and light trucks below the levels that are projected to occur in calendar year 2010. This is because forecasted growth in the number of cars and light trucks in use throughout the United States, combined with assumed increases in their average use, is projected to result in sufficiently rapid growth in total car and light truck travel to more than offset the increases in fuel economy that would result even under the Technology Exhaustion Alternative (Alternative 7). As a consequence, total fuel consumption by U.S. passenger cars and light trucks is projected to increase over the period shown in the table under each of the action alternatives. Because CO_2 emissions are a direct consequence of total fuel consumption, the same result is projected for total CO_2 emissions from passenger cars and light trucks.

Emissions of CO_2, the primary gas that drives climate effects, from the U.S. car and light-truck fleet represented about 2.5 percent of total global emissions of all GHGs in 2000 (EPA 2008a; WRI 2008). Although substantial, this source contributes a small percentage of global emissions, and the relative contribution of CO_2 emissions from the U.S. light-vehicle fleet is expected to decline in the future. This expected decline is due primarily to rapid growth of emissions from developing economies (which result in part from growth in global transportation sector emissions). In the SRES A1B (medium) scenario (Nakicenovic *et al.* 2000), the share of liquid fuel use – mostly petroleum and biofuels – from Organization for Economic Cooperation and Development (OECD) countries (including the United States) declines from 60 percent in 2000 to 17 percent in 2100.

In its Annual Energy Outlook, EIA projects U.S. transportation CO_2 emissions to increase from 2,037 $MMTCO_2$ in 2010 to 2,682 $MMTCO_2$ in 2030,[31] with total U.S. emissions from transportation over this period at 49,287 $MMTCO_2$. Over this same period, the emissions reductions over the range of the new standards are projected to be 527 to 2,656 $MMTCO_2$, which would yield a 1- to 5-percent reduction from the transportation sector. The environmental impact from increasing fuel economy standards grows as new vehicles enter the fleet and older vehicles are retired. For example, in 2030, projected emissions reductions are 50 to 239 $MMTCO_2$, a 2- to 9-percent decrease from projected U.S. transportation emissions of 2,682 $MMTCO_2$ in 2030. It is important to note that the EIA did not take into account the

[31] AEO provides projections through 2030, not through 2100 (the relevant period for climate modeling).

expected effects of this rulemaking in their forecast (EIA 2007a), thus enabling a comparison of the impact of this rulemaking to U.S. transportation emissions under the No Action Alternative.

As another measure of the relative environmental impact of this rulemaking, these emissions reductions can be compared to existing programs designed to reduce GHG emissions in the United States. In 2007, Arizona, California, New Mexico, Oregon, and Washington formed the Western Climate Initiative (WCI) to develop regional strategies to address climate change. The WCI has a stated goal of reducing 350 $MMTCO_2$ equivalent over the period from 2009 to 2020 (WCI 2007a). Emissions levels in 2020 would represent a 33-percent reduction from the No Action Alternative and a 15-percent reduction from the beginning of the action (WCI 2007b). By comparison, this rulemaking is expected to reduce CO_2 emissions by 116 to 660 $MMTCO_2$ over the same period, with emissions levels in 2020 representing a 1- to 5-percent reduction from the future baseline emissions for cars and light trucks. Nine northeast and mid-Atlantic states have formed the Regional Greenhouse Gas Initiative (RGGI) to reduce CO_2 emissions from power plants in the northeast. Emissions reductions from 2006 to 2024 are estimated at 268 $MMTCO_2$ (RGGI 2006).[32] This represents a 23-percent reduction from the future baseline, and a 10-percent reduction from the beginning of the action (RGGI 2006). By comparison, NHTSA forecasts that this rulemaking would reduce CO_2 emissions by 252 to 1,334 $MMTCO_2$ over this period, with emissions levels in 2024 representing a 3- to 9-percent reduction from the future baseline emissions for cars and light trucks.

Two points are important to emphasize. First, emissions from sources addressed in the WCI and RGGI decrease compared to the beginning of the action, while emissions from cars and trucks continue to increase under this rulemaking due to increases in VMT. Second, these projections are only estimates, and the scope of these climate programs differs from that in this rulemaking in terms of geography, sector, and purpose.

The approach, goals, and methods of reductions vary between the NHTSA action and these regional GHG reduction initiatives. However, the expected end result – reduction of tons of CO_2 – of all of these initiatives are similar. The Stabilization Wedge Theory promulgated by Pacala and Socolow (2004) for climate change mitigation includes a graphical representation of the contributions of many GHG reduction initiatives and the ability for all of these "wedges," over time, to add up to a climate-change solution. The reductions from this rulemaking could be viewed in this context as one of many actions needed to reduce U.S. transportation emissions.

Where information in the analysis included in this FEIS is incomplete or unavailable, NHTSA has relied on the CEQ regulations regarding incomplete or unavailable information. *See* 40 CFR § 1502.22(b). In this case, the comparison of emissions reductions from the alternative CAFE standards to emissions reductions associated with other programs is intended to benefit decisionmakers by providing relative benchmarks, rather than absolute metrics, for selecting among alternatives. In summary, the alternatives analyzed here deliver GHG emissions reductions that are on the same scale as many of the most progressive and ambitious GHG emissions reduction programs underway in the United States.

3.4.4.2 Sensitivity Analysis

NTHSA performed sensitivity analyses to examine how changes in key economic assumptions affect the CAFE standards under the Optimized Alternative, and the resulting fuel savings and environmental impacts. Although the sensitivity analysis did not examine the effect of variations in economic assumptions on CAFE standards and their impacts under other action alternatives, three of the

[32] Emissions reductions were estimated by determining the difference between the RGGI Cap and the Phase III RGGI reference case. These estimates do not include offsets.

remaining five action alternatives would establish fuel economy standards that are based directly on those under the Optimized Alternative. In addition, CAFE standards under the alternative equating total costs and total benefits would also vary in response to changes in CAFE standards under the Optimized Alternative. Thus, it is reasonable to assume that fuel economy levels under each of those alternatives, and the resulting fuel savings and reductions in CO_2 emissions, will vary similarly to those under the Optimized Alternative in response to changes in economic assumptions.

The specific economic assumptions NHTSA varied in these sensitivity analyses were:

- The value of economic damages caused by CO_2 emissions (the "social cost of carbon")
- The discount rate applied to future benefits
- The level of military security outlays associated with variation in U.S. petroleum imports
- The magnitude of the fuel economy rebound effect

NHTSA performed sensitivity analyses of variations in CAFE standards, fuel savings, and reductions in CO_2 emissions in response to changes in these economic variables using the Optimized CAFE standards from both the Reference Case and the Mid-2 Scenario as bases. The primary difference between the Reference Case and the Mid-2 Scenario is that the former uses the AEO 2008 reference case forecast of fuel prices, while the latter uses fuel prices from the AEO 2008 high price case. All other economic assumptions were held constant in these analyses.

Sections 3.4.4.2.1 and 3.4.4.2.2 summarize how these changes in economic assumptions would affect CAFE standards and realized fuel economy levels under the Optimized Alternative, fuel savings compared to the No Action Alternative, and reductions in CO_2 emissions from those under the No Action Alternative for passenger cars and light trucks over the period 2010-2100.

3.4.4.2.1 Range of Input Values in Sensitivity Analysis

The sensitivity analyses first examined the effect of raising the value of reducing CO_2 emissions to $80 per metric ton CO_2. This figure corresponds to an increase of one standard deviation from the mean estimate of the social cost of carbon reported in a 2008 survey of more than 200 estimates of the SCC conducted by Tol.[33] Its derivation is described in detail in Section 10.2.2.3 of this FEIS.

Like the reference values of $2 per ton for the U.S. domestic benefit and $33 per ton for the global value of reducing CO_2 emissions, the alternative value of $80 per ton is assumed to increase at 2.4 percent annually beginning in 2007. Thus, over the lifetimes of MY 2011-15 passenger cars and light trucks, the value of reducing CO_2 emissions would average nearly $160 per ton.

The sensitivity analyses also examined the effect of discounting benefits other than those from reducing CO_2 emissions at an annual rate of 3 percent, rather than at the 7-percent rate used in the Reference Case and the Mid-2 Scenario. (In all cases, future benefits from reducing CO_2 emissions were discounted at the lower 3-percent rate, because these benefits will be experienced by future generations.) The 3-percent rate is more appropriate if manufacturers are assumed to recover costs for complying with higher CAFE standards from buyers in the form of higher prices for new vehicles (OMB 2003).

[33] Richard S.J. Tol (2008), The social cost of carbon: trends, outliers, and catastrophes, *Economics -- the Open-Access, Open-Assessment E-Journal*, **2** (25), 1-24.

Recognizing the uncertainty surrounding the effect of variations in U.S. oil imports on military activities in oil-producing regions, the sensitivity analyses also tested the effect of assuming that U.S. military spending would decline by $0.05 for each gallon by which CAFE standards reduce U.S. imports of crude petroleum or refined fuel. This estimate reflects the assumption that approximately one-third of expenses to support U.S. military activities in major oil-producing regions of the world are likely to vary in proportion to the scale of those activities. It contrasts with the assumption employed in the Reference Case and the Mid-2 Scenario that U.S. military outlays would be unaffected by the level of U.S. imports of crude petroleum or refined petroleum products.

Finally, the sensitivity analyses examined the consequences for fuel economy levels, fuel savings, and reductions in CO_2 emissions of rebound effects of 10 percent and 20 percent. These compare to the 15-percent value for the rebound effect used in the Reference Case and the Mid-2 Scenario. NHTSA's detailed analysis of 66 published estimates of the long-run rebound effect concluded that nearly two-thirds of those estimates fell within the range of 10 to 20 percent.

3.4.4.2.2 Sensitivity Analysis Results

Tables 3.4-3 and 3.4-4 illustrate the effects of these alternative assumptions on fuel economy levels under the Optimized Alternative, fuel savings compared to the No Action Alternative, and the resulting reductions in CO_2 emissions. Table 3.4-3 shows the effects of alternative economic assumptions on fuel economy, fuel savings, and reductions in CO_2 emissions in the Reference Case; Table 3.4-4 reports the effects of the same changes in economic assumptions for the Mid-2 Scenario.

Table 3.4-3

Sensitivity of Reference Case Results to Changes in Economic Assumptions

Economic Assumptions	Combined Car and Light Truck MPG (2015) a/	Fuel Savings 2010-2100 (billion gallons)	Reduction in CO_2 Emissions 2010-2100 (MMt)
Reference Case	29.6	634	6,616
CO_2 Reductions Valued @ $80/ton	33.3	1,570	15,716
3% Discount Rate	30.3	898	8,954
Military Security Savings @ $0.05/gal	29.6	643	6,715
10% Rebound Effect	29.6	630	6,571
20% Rebound Effect	29.1	494	5,105

a/ Industry-wide combined MPG required by passenger car and light truck CAFE standards for MY 2015.

Table 3.4-4

Sensitivity of Mid-2 Scenario Results to Changes in Economic Assumptions

Economic Assumptions	Combined Car and Light Truck MPG (2015) a/	Fuel Savings 2010-2100 (billion gallons)	Reduction in CO_2 Emissions 2010-2100 (MMt)
Mid-2 Scenario	31.8	1,588	16,467
CO_2 Reductions Valued @ $80/ton	33.5	1,887	19,532
3% Discount Rate	33.5	1,891	19,569
Military Security Savings @ $0.05/gal	31.8	1,591	16,496
10% Rebound Effect	31.7	1,570	16,264
20% Rebound Effect	30.3	1,286	13,449

a/ Industry-wide combined MPG required by passenger car and light truck CAFE standards for MY 2015.

As these tables illustrate, increasing the benefits from of reducing CO_2 emissions to $80 per ton would substantially increase fuel economy, fuel savings, and reductions in CO_2 emissions in both the Reference Case and the Mid-2 Scenario.

Table 3.4-3 shows that reducing the discount rate applied to future benefits (other than those from reducing CO_2 emissions, which are already discounted at 3 percent) from the 7 percent used in the Reference Case to 3 percent would result in modest increases in required fuel economy, fuel savings, and reductions in CO_2 emissions in the Reference Case. In the Mid-2 Scenario, however, Table 3.4-4 shows that lowering the discount rate to 3 percent would lead to a pronounced increase in required car and light truck fuel economy, and in the resulting fuel savings and reductions in CO_2 emissions.

In contrast, assuming that U.S. military outlays would decline by $0.05 for each gallon that CAFE standards reduce U.S. petroleum imports has almost no effect on fuel economy, fuel savings, or reductions in CO_2 emissions under either the Reference Case or the Mid-2 Scenario. Although the effects of this change on required fuel economy, fuel savings, and emissions reductions do have the expected direction, they are extremely small, and certainly well within the range of uncertainty in estimating them.

Finally, the tables show that reducing the rebound effect from the 15 percent assumed in both the Reference Case and the Mid-2 Scenario to 10 percent would have only a slight effect on fuel savings and reductions in CO_2 emissions. Although the reported effects of reducing the rebound effect to 10% are in the opposite direction from those expected, they are so small as to be well within the range of uncertainty in estimating these effects. In contrast, increasing the rebound effect from the 15 percent value used in the Reference Case and the Mid-2 Scenario to 20 percent would lower fuel savings and emissions reductions somewhat in both cases, as Tables 3.4-3 and 3.4-4 report.

3.4.4.3 Effect of Credit Flexibility on Emissions

Consistent with the Energy Independence and Security Act (EISA), NHTSA's NPRM not only proposed new CAFE standards for passenger cars and light trucks, but also revised provisions regarding the creation and application of CAFE credits. In this context, CAFE credits refer to flexibilities allowed under the Energy Policy and Conservation Act (EPCA) provisions governing use of Alternative Motor Fuels Act (AMFA) credits, allowable banked credits, and transfers of credits between the car and truck fleets allowed under EISA. The additional flexibility to transfer credits between manufacturing companies is addressed separately below. Because EPCA prohibits NHTSA from considering these flexibilities when determining the stringency of CAFE standards, NHTSA did not attempt to do so when it developed standards by using the Volpe model to estimate the stringency at which net benefits to society would be maximized.

Under the EISA, AMFA credits are being phased out. The allowable credits are reduced so that by 2020 such credits will no longer be allowed under law.

However, responding to the *Federal Register* notice regarding the scope of analysis required by NEPA, EPA and the California Attorney General have indicated that, notwithstanding EPCA's constraints regarding the context for the establishment of CAFE standards, NHTSA should attempt to account for the creation and application of CAFE credits when evaluating the effects of new CAFE standards.

As we explained in the NPRM, NHTSA believes that manufacturers are likely to take advantage of these flexibility mechanisms, thereby reducing benefits and costs. Regarding AMFA credits, for example, manufacturer product plans identify the models and quantities of flex-fuel vehicles they intend to build. While individual product plans are protected as confidential commercial information, in the

aggregate they reveal that manufacturers could use AMFA credits to assist in compliance with the standards. Manufacturers building dual-fuel vehicles are entitled to a CAFE benefit of up to 1.2 mpg in 2011 to 2014 and 1.0 mpg in 2015 for each fleet. NHTSA tentatively estimates that the impact of the use of AMFA credits could result in an average reduction of approximately 0.9 mpg in each year for model years 2011 through 2015, and a related increase in CO_2 emissions. Regarding other than AMFA credits (*e.g.*, CAFE credits earned through over-compliance, credits transferred between fleets, and credits acquired from other manufacturers), we do not have a sound basis to predict the extent to which manufacturers might use them, particularly since the credit transfer and credit trading programs have been only recently authorized.

3.4.4.3.1 Difficulties in Quantifying Emissions Implications of Credits

Questions NHTSA might need to address in performing an analysis of potential credit use and the resulting emissions include the following:

- Would manufacturers that have never used CAFE flexibilities do so in the future?
- Would flexibility-induced increases in the sale of flexible-fuel vehicles (FFVs) lead to increases in the use of alternative fuels?
- Having earned CAFE credits in a given model year, in what model year would a given manufacturer most likely apply those credits?
- Having earned CAFE credits in one fleet (*i.e.*, passenger or nonpassenger), to which fleet would a given manufacturer most likely apply those credits?

Such questions are similar to, though possibly less tractable than the behavioral and strategic questions that would be entailed in attempting to represent manufacturers' ability to "pull ahead" the implementation of some technologies, and in attempting to estimate CAFE-induced changes in market shares. As discussed on pp. 24393 to 24394 of the NPRM, data and approaches are lacking on how to analyze manufacturers' ability to develop and strategically time the application of new technologies. Substantial concerns remain about how to develop a credible market share model for integration into the modeling system NHTSA has used to analyze the costs and effects of CAFE standards.

3.4.4.3.2 Market Behavior

Some manufacturers make substantial use of current flexibilities. Other manufacturers regularly exceed CAFE standards applicable to one or both fleets, and allow the corresponding excess CAFE credits to expire. Some manufacturers transfer earned CAFE credits to future (or past) model years, but do not produce FFVs and create corresponding CAFE credits. Finally, still other manufacturers regularly pay civil penalties for noncompliance, even when producing FFVs would substantially reduce the magnitude of those penalties.

Notwithstanding these uncertainties, NHTSA anticipates that manufacturers would make varied use of the flexibilities provided by EPCA, as amended by EISA. These flexibilities could result in somewhat lower benefits (that is, CO_2 emissions reductions) than estimated here, as manufacturers' actions would cause VMT levels, fuel consumption, and emissions to be higher than reported here. We expect that all of the seven alternatives reported here—including the No Action Alternative in relation to which the effects of the six action alternatives are measured—would be affected. Insofar as the No Action Alternative would be affected, it is even less certain how the net effects of each of the six action alternatives would change.

NHTSA expects that use of flexibilities would tend to be greater under more stringent standards. As stringency increases, the potential for manufacturers to face greater cost increases, and for some, depending on its level of technological implementation, costs could rise substantially. The economic advantage of employing allowed flexibilities increases and could affect manufacturer behavior in this regard. A critical factor in addressing the fuel and emissions impacts of such flexibilities is that the likely extent of utilization cannot be assumed constant across the alternatives.

3.4.4.3.3 Trading Between Companies

The allowable trading between manufacturers is categorically different from the case discussed above. The provisions in Section 104 of Title I of the EISA require that fuel savings, and thus, GHG emissions, be conserved in any trades between manufacturers. Therefore, there would not be an environmental impact of any such trades because any increases in fuel use or emissions would have to be offset by the manufacturer buying the credits.

3.4.4.4 Direct and Indirect Effects on Climate Change

Sections 3.4.4.3.1 through 3.4.4.3.4 describe the direct and indirect effects of the alternatives on climate change in relation to atmospheric CO_2 concentrations, temperature, precipitation, and sea-level rise.

3.4.4.4.1 Atmospheric CO_2 Concentrations

MAGICC is a simple climate model that is well calibrated to the mean of the multi-model ensemble results for three of the most commonly used emissions scenarios – B1 (low), A1B (medium), and A2 (high) from the IPCC SRES series – as shown in Table 3.4-5.[34] As the table indicates, the results of the model runs developed for this analysis agree relatively well with IPCC estimates for both CO_2 concentrations and surface temperature.

Table 3.4-5

Comparison of MAGICC Modeling Results and Reported IPCC Results (IPCC 2007a)

	CO_2 Concentration (ppm)		Global Mean Increase in Surface Temperature (°C)		Sea-level Rise (cm)	
Scenario	**IPCC WGI (2100)**	**MAGICC (2100)**	**IPCC WGI (2080-2099)**	**MAGICC (2090)**	**IPCC WGI (2090-2099) a/**	**MAGICC (2095)**
B1 (low)	550	538.3	1.79	1.81	28	26
A1B (medium)	715	717.2	2.65	2.76	35	35
A2 (high)	836	866.8	3.13	3.31	37	38

a/ The IPCC values represent the average of the 5- to 95-percent range of the rise of sea level between 1980 to 1989 and 2090 to 2099.

A comparison of sea-level rise from MAGICC 5.3 and the IPCC Fourth Assessment Report is presented in the release documentation for MAGICC 5.3 (Wigley 2003 to 2008). In Table 3 of the documentation, Wigley (2008) presents the results for six SRES scenarios, which show that the

[34] NHTSA used the default climate sensitivity in MAGICC of 3.0 °C.

comparable value for sea-level rise from MAGICC 5.3 (total sea-level rise minus estimates for contributions from non-melt sources such as warming of the permafrost) within 0.01 centimeter in 2095.

As discussed in Section 3.4.2, NHTSA used the SRES A1B (medium) scenario to represent the No Action Alternative in the MAGICC modeling runs. Table 3.4-6 and Figures 3.4-10 through 3.4.13 present the results of MAGICC simulations for the No Action Alternative and the six action alternatives, in terms of CO_2 concentrations and increases in global mean surface temperature in 2030, 2060, and 2100. As Figures 3.4-10 and 3.4-11 show, the reduction in the amount of increases in CO_2 concentrations and temperature from each of the action alternatives is just a fraction of the total increases in CO_2 concentrations and global mean surface temperature. However, the relative impact of the action alternatives is shown by the reduction in increase of both CO_2 concentrations and temperature under Alternative 7. As shown in Figures 3.3-12 and 3.4-13, the reduction in increase of CO_2 concentrations under Alternative 7 is nearly four times that of Alternative 2. Similarly, the reduction in increase of temperature under Alternative 7 is more than five times that of Alternative 2.

As shown in the table and figures, estimated CO_2 concentrations for 2100 range from 714.6 ppm under the most stringent alternative (Technology Exhaustion) to 717.2 ppm under the No Action Alternative. For 2030 and 2060, the range is even smaller. Because CO_2 concentrations are the key driver of other climate effects (which in turn act as drivers on the resource impacts discussed in Chapter 4), this leads to small differences in these effects.

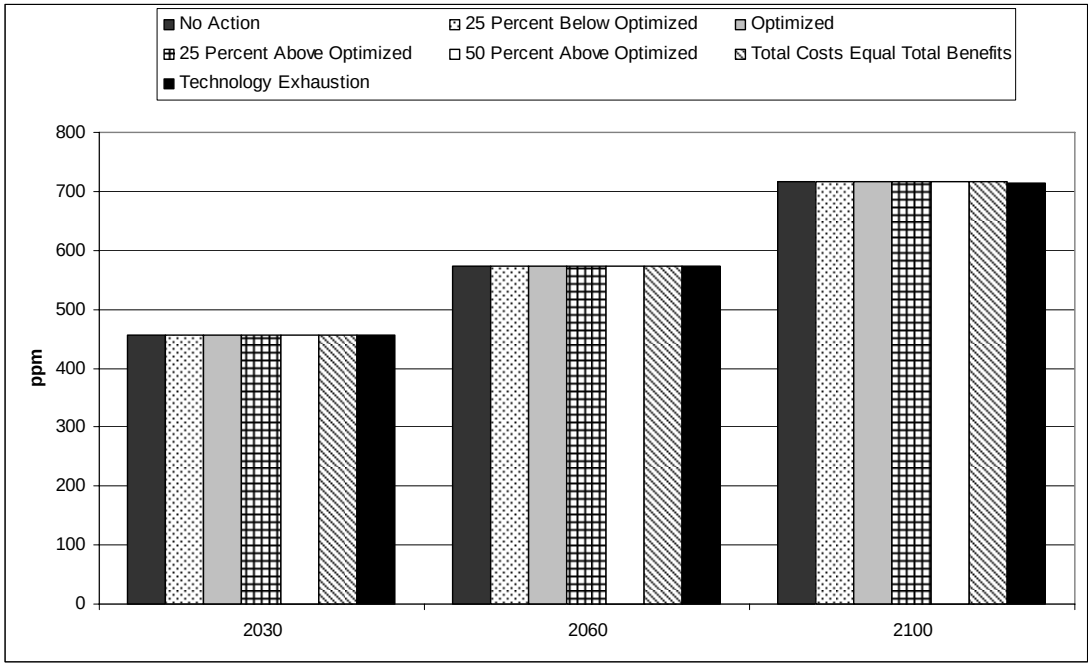
Table 3.4-6

Reference Case MY 2011-2015 Standards Impact on CO_2 Concentrations, Global Mean Surface Temperature Increase, and Sea-level Rise in 2100 Using MAGICC (A1B a/)

Totals by Alternative	CO_2 Concentration (ppm)			Global Mean Surface Temperature Increase (°C)			Sea-level Rise (cm)		
	2030	2060	2100	2030	2060	2100	2030	2060	2100
1 No Action (A1B-AIM)	455.5	573.7	717.2	0.874	1.944	2.959	7.99	19.30	37.10
2 25 Percent Below Optimized	455.5	573.4	716.7	0.873	1.943	2.957	7.99	19.29	37.08
3 Optimized	455.5	573.4	716.6	0.873	1.943	2.956	7.99	19.29	37.08
4 25 Percent Above Optimized	455.5	573.4	716.6	0.873	1.943	2.956	7.99	19.29	37.08
5 50 Percent Above Optimized	455.5	573.4	716.5	0.873	1.943	2.956	7.99	19.29	37.08
6 Total Costs Equal Total Benefits	455.4	573.3	716.4	0.873	1.943	2.956	7.99	19.28	37.07
7 Technology Exhaustion	455.3	572.5	714.6	0.872	1.938	2.946	7.99	19.25	36.99
Reductions Under Alternative CAFE Standards									
2 25 Percent Below Optimized	0.0	0.3	0.5	0.000	0.001	0.002	0.00	0.01	0.02
3 Optimized	0.0	0.3	0.6	0.000	0.001	0.002	0.00	0.01	0.02
4 25 Percent Above Optimized	0.0	0.3	0.6	0.000	0.001	0.003	0.00	0.01	0.02
5 50 Percent Above Optimized	0.0	0.3	0.7	0.000	0.001	0.003	0.00	0.01	0.02
6 Total Costs Equal Total Benefits	0.1	0.4	0.8	0.000	0.002	0.003	0.00	0.02	0.03
7 Technology Exhaustion	0.2	1.2	2.6	0.002	0.007	0.013	0.00	0.05	0.11

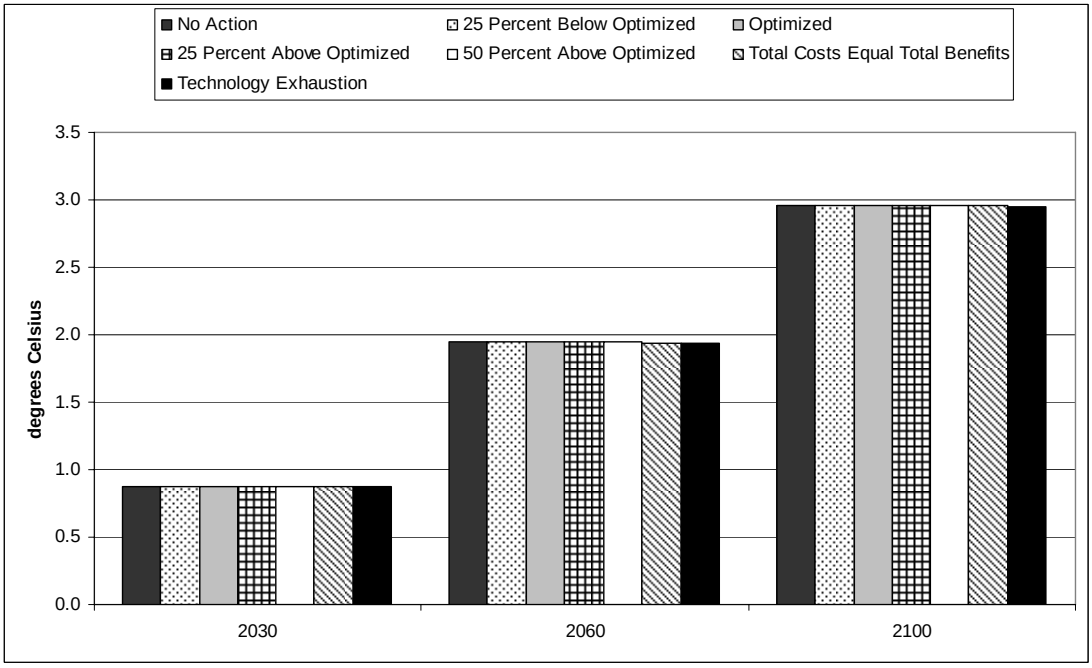
a/ The A1B scenario is the SRES marker scenario used by the IPCC WGI to represent the SRES A1B (medium) storyline.

Figure 3.4-10. Reference Case MY 2011-2015 Standards Impact on CO_2 Concentrations (ppm) Using MAGICC (A1B a/)



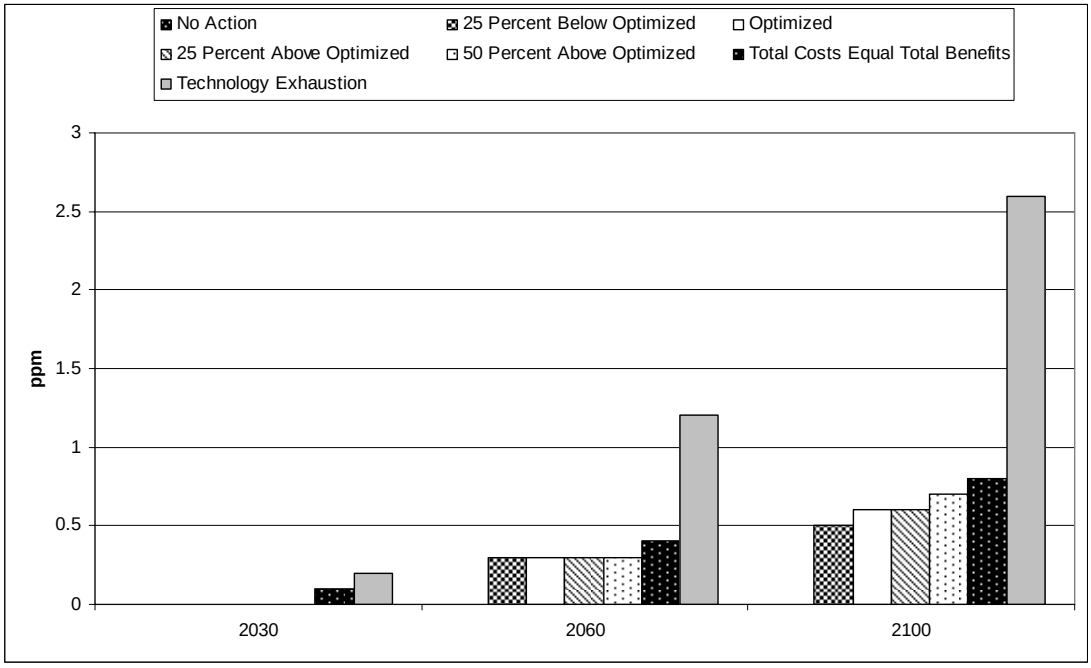
a/ The A1B scenario is the SRES marker scenario used by the IPCC WGI to represent the SRES A1B (medium) storyline.

Figure 3.4-11. Reference Case MY 2011-2015 Standards Impact on Global Mean Surface Temperature Increase (°C) Using MAGICC (A1B a/)



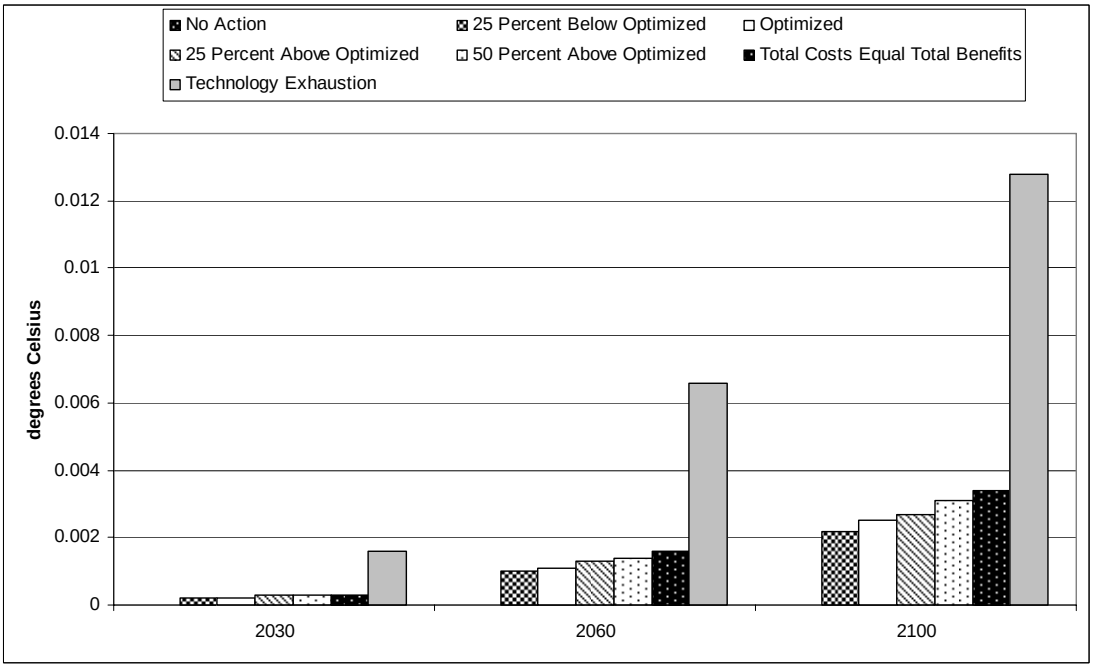
a/ The A1B scenario is the SRES marker scenario used by the IPCC WGI to represent the SRES A1B (medium) storyline.

Figure 3.4-12. Reference Case MY 2011-2015 Standards Impact on the Reduction in the Increase of CO_2 Concentrations (ppm) Using MAGICC (A1B a/)



a/ The A1B scenario is the SRES marker scenario used by the IPCC WGI to represent the SRES A1B (medium) storyline.

Figure 3.4-13. Reference Case MY 2011-2015 Standards Impact on the Reduction in the Increase of Global Mean Temperature Using MAGICC (A1B a/)



a/ The A1B scenario is the SRES marker scenario used by the IPCC WGI to represent the SRES A1B (medium) storyline.

3.4.4.4.2 Temperature

The MAGICC model simulations of mean global surface air temperature increases are shown in Table 3.4-6. For all alternatives, the temperature increase is about 0.87 °C for 2030, 1.94 °C for 2060, and 2.95 °C for 2100. The differences among alternatives are small. For 2100, the reduction in temperature increase, in relation to the No Action Alternative, ranges from 0.002 °C to 0.013 °C.

Table 3.4-7 summarizes the regional changes in warming and seasonal temperatures presented in the IPCC Fourth Assessment Report. At this time, quantifying the changes to regional climate from the CAFE alternatives is not possible, but the alternatives would be expected to reduce the impacts in proportion to the amount of reduction in global mean surface temperature.

Table 3.4-7

Summary of Regional Changes to Warming and Seasonal Temperatures Extracted from the IPCC Fourth Assessment Report (Christensen *et al.* 2007)

Land Area	Sub-region	Mean Warming	Maximum Summer Temperatures
Africa	Mediterranean area and northern Sahara	*Likely* larger than global mean throughout continent and in all seasons	
	Southern Africa and western margins		
	East Africa		
Mediterranean and Europe	Northern Europe	*Likely* to increase more than the global mean with largest warming in winter	Maximum summer temperatures *likely* to increase more than the average
	Southern and Central Europe		
	Mediterranean area		
Asia	Central Asia	*Likely* to be well above the global mean	
	Tibetan Plateau	*Likely* to be well above the global mean	
	Northern Asia	*Likely* to be well above the global mean	
	Eastern Asia	*Likely* to be above the global mean	*Very likely* that heat waves/hot spells in summer will be longer, more intense, and more frequent *Very likely* fewer very cold days
	South Asia	*Likely* to be above the global mean	*Very likely* fewer very cold days
	Southeast Asia	*Likely* to be similar to the global mean	
North America	Northern regions/Northern North America	*Likely* to exceed the global mean warming	Warming is *likely* to be greatest in winter. Minimum winter temperatures are *likely* to increase more than the average
	Southwest		Warming is *likely* to be greatest in summer Maximum summer temperatures are *likely* to increase more than the average
	Northeast USA		
	Southern Canada		
	Canada		

Table 3.4-7 (cont'd)

Summary of Regional Changes to Warming and Seasonal Temperatures Extracted from the IPCC Fourth Assessment Report (Christensen *et al.* 2007)

Land Area	Sub-region	Mean Warming	Maximum Summer Temperatures
	Northernmost part of Canada		
Central and South America	Southern South America	*Likely* to be similar to the global mean warming	
	Central America	*Likely* to be larger than global mean warming	
	Southern Andes		
	Tierra del Fuego		
	Southeastern South America		
	Northern South America		
Australia and New Zealand	Southern Australia	*Likely* comparable to the global mean but less than in the rest of Australia	Increased frequency of extreme high daily temperatures and decreased frequency of cold extremes are *very likely*
	Southwestern Australia	*Likely* comparable to the global mean	
	Rest of Australia	*Likely* comparable to the global mean	
	New Zealand, South Island	*Likely* less than the global mean	
	Rest of New Zealand	*Likely* comparable to the global mean	
Polar Regions	Arctic	*Very likely* to warm during this century more than the global mean	Warming greatest in winter and smallest in summer
	Antarctic	*Likely* to warm	
Small Islands		*Likely* to be smaller than the global annual mean	

MAGICC 5.3 estimates radiative forcing from black carbon, a primary aerosol emitted through the incomplete combustion of fossil fuel and biomass burning. However, emissions trends for black carbon are "hard-wired" in the model to follow emissions of SO_2 and cannot be specified as separate inputs to the model.[35] The radiative forcing of black carbon is difficult to accurately quantify because it is a function of microphysical properties of the geographic and vertical placement, and lifetime of the aerosol; however, that black carbon contributes substantially to global warming is clear (Jacobson 2001). Total global black carbon emissions are estimated to be approximately 8 teragrams of carbon per year (Tg C/yr) (Bond *et al.* 2004 as cited in Forster *et al.* 2007) with estimates of fossil fuel contributions

[35] Accurately determining the magnitude of mobile source emissions of black carbon is difficult because the emissions vary with fuel properties and fluctuations in the combustion environment. MOBILE6.2 outputs particulate matter mass that is then incorporated in the Volpe model. This particulate matter is based on tailpipe emissions and thus includes carbon emissions from the combustion process. Because the carbon emissions are included as part of the particular matter and are not treated independently, the Volpe model does not provide direct results of the impact of the carbon emissions.

ranging from 2.8 Tg C/yr (Ito and Penner 2005 as cited in Forster *et al.* 2007) to 8.0 Tg C/yr (Haywood and Boucher as cited in Forster *et al.* 2007). The United States contributes an estimated 6.1 percent of the global soot emissions, with major sources including off-road vehicles, on-road vehicles, stack emissions, and fugitive sources (Jacobson Testimony 2007). In summary, the climate modeling accounts for the effects of black carbon on climate variables.

3.4.4.4.3 Precipitation

According to IPCC (Meehl *et al.* 2007), global mean precipitation is expected to increase under all scenarios. Generally, precipitation increases occur in the tropical regions and high latitudes, with decreases in the sub-tropics. The results from the AOGCMs suggest considerable uncertainty in future precipitation for the five SRES scenarios.

Where information in the analysis included in this FEIS is incomplete or unavailable, NHTSA has relied on the CEQ regulations regarding incomplete or unavailable information. *See* 40 CFR § 1502.22(b). In this case, the IPCC (Meehl *et al.* 2007) summary of precipitation represents the most thoroughly reviewed, credible assessment of this highly uncertain factor. NHTSA expects that the alternative CAFE standards would reduce the changes in proportion to their effects on temperature.

The global mean change in precipitation provided by the IPCC for the A2 (high), A1B (medium), and B1 (low) scenarios (Meehl *et al.* 2007) is given as the scaled change in precipitation (as a percentage change from 1980 to 1999 averages) divided by the increase in global mean surface warming for the same period (per °C) as shown in Table 3.4-8. The IPCC provides scaling factors in the year ranges of 2011 to 2030, 2046 to 2065, 2080 to 2099, and 2180 to 2199. NHTSA used the scaling factors for the A1B (medium) scenario in our analysis because MAGICC does not directly estimate changes in global mean precipitation.

Table 3.4-8

Global Mean Precipitation Change (scaled, % per °C) (Meehl *et al.* 2007)

Scenario	2011-2030	2046-2065	2080-2099	2180-2199
A2 (high)	1.38	1.33	1.45	NA
A1B (medium	1.45	1.51	1.63	1.68
B1 (low)	1.62	1.65	1.88	1.89

Applying these scaling factors to the reductions in global mean surface warming provides estimates of changes in global mean precipitation. Given that the CAFE standards action alternatives reduce temperature increases slightly in relation to the No Action Alternative, they also slightly reduce predicted increases in precipitation, as shown in Table 3.4-9 (again based on the A1B [medium] scenario).

In addition to changes in mean annual precipitation, climate change is anticipated to affect the intensity of precipitation, as described below (Meehl *et al.* 2007):

> Intensity of precipitation events is projected to increase, particularly in tropical and high latitude areas that experience increases in mean precipitation. Even in areas where mean precipitation decreases (most subtropical and mid-latitude regions), precipitation intensity is projected to increase but there would be longer periods between rainfall events. There is a tendency for drying of the mid-continental areas during summer, indicating a greater risk of droughts in those regions. Precipitation extremes increase more than does the mean in most tropical and mid- and high-latitude areas.

Table 3.4-9

Reference Case MY 2011-2015 Alternative CAFE Standards: Impact on Reductions in Global Mean Precipitation Based on A1B a/ SRES Scenario (percent change), Using Increases in Global Mean Surface Temperature Simulated by MAGICC

Scenario	2020	2055	2090
Global Mean Precipitation Change (scaled, % K-1)	1.45	1.51	1.63
Global Temperature Above Average 1980-1999 Levels (°K) for the A1B Scenario and Alternative CAFE Standards, Mid-level Results			
1 No Action	0.560	1.764	2.765
2 25 Percent Below Optimized	0.560	1.763	2.763
3 Optimized	0.560	1.763	2.763
4 25 Percent Above Optimized	0.560	1.763	2.762
5 50 Percent Above Optimized	0.560	1.763	2.762
6 Total Costs Equal Total Benefits	0.560	1.763	2.762
7 Technology Exhaustion	0.560	1.758	2.753
Reduction in Global Temperature (°K) for Alternative CAFE Standards, Mid-level Results (Compared to No Action Alternative)			
2 25 Percent Below Optimized	0.000	0.001	0.002
3 Optimized	0.000	0.001	0.002
4 25 Percent Above Optimized	0.000	0.001	0.002
5 50 Percent Above Optimized	0.000	0.001	0.003
6 Total Costs Equal Total Benefits	0.000	0.001	0.003
7 Technology Exhaustion	0.000	0.006	0.011
Mid-level Global Mean Precipitation Change (%)			
1 No Action	0.81	2.66	4.51
2 25 Percent Below Optimized	0.81	2.66	4.50
3 Optimized	0.81	2.66	4.50
4 25 Percent Above Optimized	0.81	2.66	4.50
5 50 Percent Above Optimized	0.81	2.66	4.50
6 Total Costs Equal Total Benefits	0.81	2.66	4.50
7 Technology Exhaustion	0.81	2.65	4.49
Reduction in Global Mean Precipitation Change for Alternative CAFE Standards (% Compared to No Action Alternative)			
2 25 Percent Below Optimized	0.00	0.00	0.00
3 Optimized	0.00	0.00	0.00
4 25 Percent Above Optimized	0.00	0.00	0.00
5 50 Percent Above Optimized	0.00	0.00	0.00
6 Total Costs Equal Total Benefits	0.00	0.00	0.00
7 Technology Exhaustion	0.00	0.01	0.02

a/ The A1B scenario is the SRES marker scenario used by the IPCC WGI to represent the SRES A1B (medium) storyline.

Regional variations and changes in the intensity of precipitation events cannot be quantified further, primarily due to the unavailability of AOGCMs required to estimate these changes. These models are typically used to provide results among scenarios with very large changes in emissions such as the SRES B1 (low), A1B (medium), and A2 (high) scenarios; very small changes in emissions profiles would produce results that would be difficult to resolve among scenarios with small changes in emissions. Also, the multiple AOGCMs produce results that are regionally consistent in some cases but inconsistent for other areas.

Table 3.4-10 summarizes the regional changes in precipitation from the IPCC Fourth Assessment Report. Quantifying the changes in regional climate from the alternative CAFE standards is not possible at present, but they would be expected to reduce the changes in relation to the reduction in global mean surface temperature.

Table 3.4-10

Summary of Regional Changes to Precipitation Extracted from the IPCC Fourth Assessment Report (Christensen *et al.* 2007)

Land Area	Sub-region	Precipitation	Snow Season and Snow Depth
Africa	Mediterranean area and northern Sahara	*Very likely* to decrease	
	Southern Africa and western margins	Winter rainfall *likely* to decrease in southern parts	
	East Africa	*Likely* to be an increase in annual mean rainfall	
Mediterranean and Europe	Northern Europe	*Very likely* to increase and extremes are *likely* to increase	*Likely* to decrease.
	Southern and Central Europe		
	Mediterranean area	*Very likely* to decrease and precipitation days are *very likely* to decrease	
Asia	Central Asia	Precipitation in summer is *likely* to decrease	
	Tibetan Plateau	Precipitation in boreal winter is *very likely* to increase	
	Northern Asia	Precipitation in boreal winter is *very likely* to increase Precipitation in summer is *likely* to increase	
	Eastern Asia	Precipitation in boreal winter is *likely* to increase Precipitation in summer is *likely* to increase *Very likely* to be an increase in the frequency of intense precipitation Extreme rainfall and winds associated with tropical cyclones are *likely* to increase	
	South Asia	Precipitation in summer is *likely* to increase *Very likely* to be an increase in the frequency of intense precipitation Extreme rainfall and winds associated with tropical cyclones are *likely* to increase	
	Southeast Asia	Precipitation in boreal winter is *likely* to increase in southern parts Precipitation in summer is *likely* to increase in most parts Extreme rainfall and winds associated with tropical cyclones are *likely* to increase	
North America	Northern regions/Northern North America		Snow season length and snow depth are *very likely* to decrease
	Southwest	Annual mean precipitation is *likely* to decrease	
	Northeast USA	Annual mean precipitation is *very likely* to increase	
	Southern Canada		
	Canada	Annual mean precipitation is *very likely* to increase	

Table 3.4-10 (cont'd)

Summary of Regional Changes to Precipitation Extracted from the IPCC Fourth Assessment Report (Christensen *et al.* 2007)

Land Area	Sub-region	Precipitation	Snow Season and Snow Depth
North America (cont'd)	Northernmost part of Canada		Snow season length and snow depth are *likely* to increase
Central and South America	Southern South America		
	Central America	Annual precipitation is *likely* to decrease	
	Southern Andes	Annual precipitation is *likely* to decrease	
	Tierra del Fuego	Winter precipitation is *likely* to increase	
	Southeastern South America	Summer precipitation is *likely* to increase	
	Northern South America	Uncertain how rainfall would change	
Australia and New Zealand	Southern Australia	Precipitation is *likely* to decrease in winter and spring	
	Southwestern Australia Rest of Australia	Precipitation is *very likely* to decrease in winter	
	New Zealand, South Island Rest of New Zealand	Precipitation is *likely* to increase in the west	
Polar Regions	Arctic	Annual precipitation is *very likely* to increase. *Very likely* that the relative precipitation increase would be largest in winter and smallest in summer	
	Antarctic	Precipitation *likely* to increase	
Small Islands		Mixed, depending on the region	

3.4.4.4.4 Sea-level Rise

IPCC identifies four primary components to sea-level rise: (1) thermal expansion of ocean water, (2) melting of glaciers and ice caps, (3) loss of land-based ice in Antarctica, (4) and loss of land-based ice in Greenland (IPCC 2007c). Ice-sheet discharge is an additional factor that could influence sea level over the long term. MAGICC calculates the oceanic thermal expansion component of global-mean sea level rise using a nonlinear temperature- and pressure-dependent expansion coefficient (Wigley 2003 to 2008). It also addresses the other three primary components through ice-melt models for small glaciers and the Greenland and Antarctic ice sheets, and excludes non-melt sources, which the IPCC Fourth Assessment Report also excluded. Neither MAGICC 5.3 nor the IPCC Fourth Assessment Report includes more recent information, suggesting that ice flow from Greenland and Antarctica will be accelerated. The Fourth Assessment Report estimates the ice flow to be between 9 and 17 centimeters by 2100 (Wigley 2003 to 2008).

The state of the science reflected as of the publication of the IPCC Fourth Assessment Report projects a sea-level rise of 18 to 59 centimeters by 2090 to 2099 (Parry *et al.* 2007 as cited by National Science and Technology Council 2008). This projection does not include all changes in ice-sheet flow or the potential for rapid acceleration in ice loss (Alley *et al.* 2005, Gregory and Huybrechts 2006, and Hansen 2005, all as cited by Pew Center on Global Climate Change 2007). Several recent studies have

found the IPCC estimates of potential sea-level rise might be underestimated regarding ice loss from the Greenland and Antarctic ice sheets (Shepherd and Wignham 2007, Csatho *et al.* 2008) and ice loss from mountain glaciers (Meier *et al.* 2007). Further, IPCC results for sea-level projections might underestimate sea level rise due to changes in global precipitation (Wentz *et al.* 2007 and Zhang *et al.* 2007). Rahmstorf (2007) used a semi-empirical approach to project future sea-level rise. The approach yielded a proportionality coefficient of 3.4 millimeters per year per degree Centigrade of warming, and a projected sea-level rise of 0.5 to 1.4 meters above 1990 levels in 2100 when applying IPCC Third Assessment Report warming scenarios. Rahmstorf (2007) concludes that "[a] rise over 1 meter by 2100 for strong warming scenarios cannot be ruled out." Section 3.5.5, Coastal Ecosystems, discusses sea-level rise in more detail.

Table 3.4-6 lists the impacts on sea-level rise under the scenarios and shows sea-level rise in 2100 ranging from 37.10 centimeters under the No Action Alternative to 36.99 centimeters under the Technology Exhaustion Alternative, for a maximum reduction of 0.11 centimeter by 2100 from the CAFE alternatives.

In summary, the impacts of the MY 2011-2015 alternative CAFE alternatives on global mean surface temperature, precipitation, or sea-level rise are small in relation to the expected changes associated with the emissions trajectories in the SRES scenarios. This is due primarily to the global and multi-sectoral nature of the climate problem.

3.4.5 Input Scenarios

In response to public comments, and to test how different economic assumptions might affect estimates of emissions reductions and resulting climate effects, NHTSA modeled three additional scenarios—High, Mid-1, and Mid-2—and compared the results to the results for the Reference Case described in Section 3.4.4. Variables NHTSA altered include fuel price, SCC, oil import externalities, and the discount rate for other benefits.

For the High Scenario, NHTSA used the AEO 2008 high fuel prices, an SCC of $33 per ton (2007 dollars), and a 3-percent discount rate for other benefits. Table 3.4-11 shows the emissions and emissions reductions resulting from the High Scenario.

Table 3.4-11

High Scenario Emissions and Emissions Reductions Due to the MY 2011-2015 CAFE Standards from 2010-2100 ($MMTCO_2$)

Alternative	Emissions	Emissions Reductions Compared to No Action Alternative
1 No Action	195,501	0
2 25 Percent Below Optimized	182,890	12,611
3 Optimized	180,591	14,910
4 25 Percent Above Optimized	179,079	16,422
5 50 Percent Above Optimized	177,669	17,832
6 Total Costs Equal Total Benefits	176,736	18,765
7 Technology Exhaustion	170,829	24,672

Compared to the Reference Case, total emissions under the High Scenario were lower for all alternatives (*see* Figure 3.4-13). The primary reason for this difference is the lower VMT forecast under the High Scenario. Emissions reductions for all alternatives compared to the No Action Alternative were higher under the High Scenario than under the Reference Case, except for the emissions reduction resulting from the Technology Exhaustion Alternative (*see* Figure 3.4-14). Emissions reductions would be greater for the Technology Exhaustion Alternative under the Reference Case than under the High Scenario.

Table 3.4-12 shows the resulting effects on CO_2 concentration, global mean surface temperature, and sea-level rise. Under the High Scenario, the resulting CO_2 concentration, global mean surface temperature, and sea-level rise were lower than under the Reference Case for all action alternatives except the Technology Exhaustion Alternative. Thus, the differences between the action alternatives and the No Action Alternative are greater under the High Scenario than under the Reference Case, except for the Technology Exhaustion Alternative.[36]

To further assess how different economic assumptions could affect estimates of fuel consumption, NHTSA ran two additional scenarios in the Volpe model: the Mid-1 Scenario and the Mid-2 Scenario. For the Mid-1 Scenario, NHTSA used the AEO 2008 high fuel prices, an SCC of $33 per ton (2007 dollars), and a 7-percent discount rate for other benefits. Compared to the Reference Case, total emissions under the Mid-1 Scenario were lower for all alternatives. Emissions reductions compared to the No Action Alternative were higher for all alternatives under the Mid-1 Scenario, except for the Technology Exhaustion Alternative. The primary reason for this difference is the lower VMT forecasted under the Mid-1 Scenario. The resulting CO_2 concentrations, global mean surface temperature, and sea-level rise were lower for all alternatives under the Mid-1 Scenario, except for the Technology Exhaustion Alternative. Thus, the differences between the action alternatives and the No Action Alternative are greater under the Mid-1 Scenario than under the Reference Case except for the Technology Exhaustion Alternative.

For the Mid-2 Scenario, NHTSA used the AEO 2008 high fuel prices, an SCC of $2 per ton (2007 dollars), and a 7-percent discount rate for other benefits. Compared to the Reference Case, total emissions under the Mid-2 Scenario were lower for all alternatives. Emissions reductions compared to the No Action Alternative were higher for all alternatives under the Mid-2 Scenario, except the Technology Exhaustion Alternative. The primary reason for this difference is the lower VMT forecast under the Mid-2 Scenario. The resulting CO_2 concentrations, global mean surface temperature, and sea-level rise were lower for all alternatives under the Mid-2 Scenario, except for the Technology Exhaustion Alternative. Thus, the differences between the action alternatives and the No Action Alternative are greater under the Mid-2 Scenario than under the Reference Case, except for the Technology Exhaustion Alternative.

Tables in Appendix B list the results for the Mid-1 and Mid-2 Scenarios.

[36] Note that in both the Reference Case and the High Scenario, the No Action Alternative is modeled to have the same emissions, *viz.* emissions set to the A1B scenario. This is the case even though, in absolute terms, U.S. passenger-vehicle and light-truck emissions are lower under the High Scenario than the Reference Case. In other words, the MAGICC model runs are intended to show relative differences in relation to a no action case; they are not intended to show absolute differences between Volpe model assumptions.

Figure 3.4-14. Comparison of Emissions under the Reference Case and High Scenario Due to the MY 2011-2015 CAFE Standards from 2010-2100 ($MMTCO_2$)

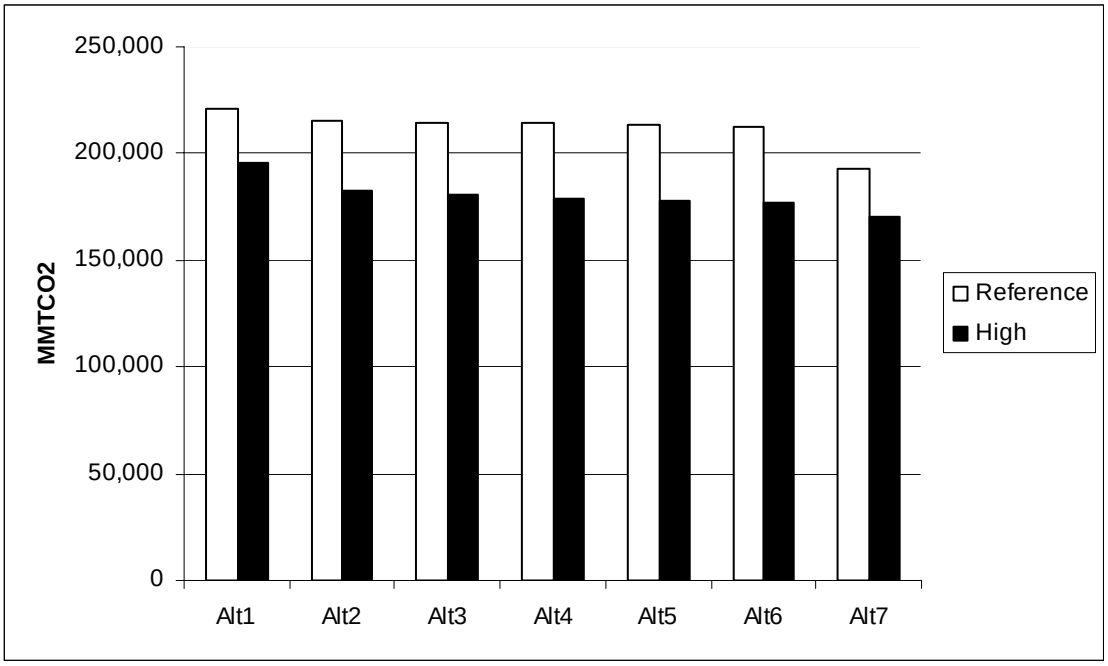


Figure 3.4-15. Comparison of Emissions Reductions under the Reference Case and High Scenario Due to the MY 2011-2015 CAFE Standards from 2010-2100 ($MMTCO_2$)

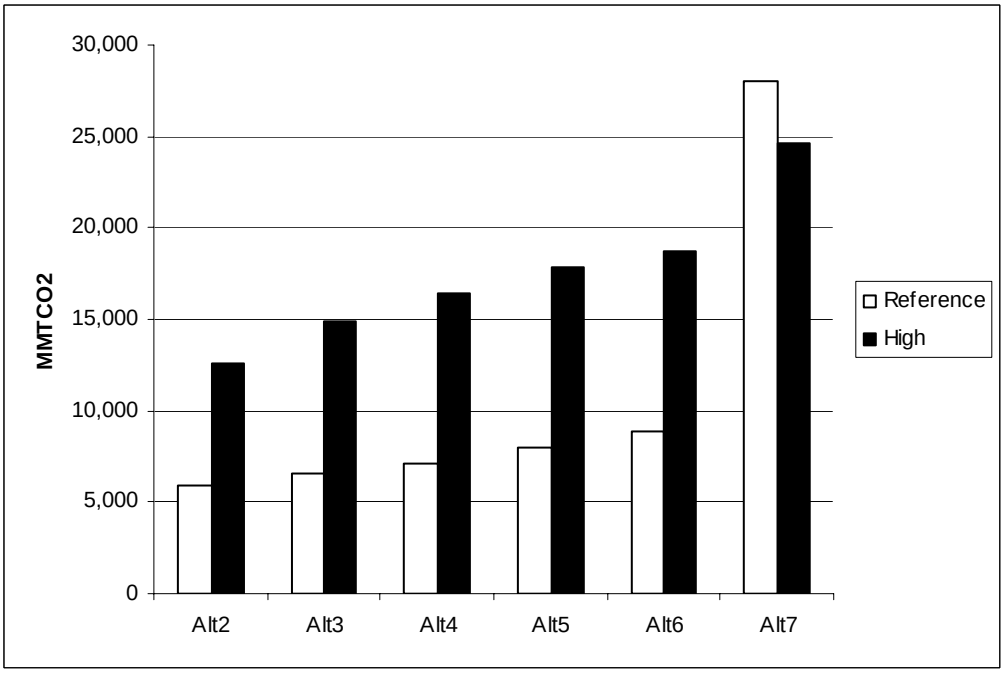


Table 3.4-12

High Scenario MY 2011-2015 Impacts of Alternative CAFE Standards on CO_2 Concentrations, Global Mean Surface Temperature Increase, and Sea-level Rise in 2100 Using MAGICC (A1B a/)

Totals by Alternative	CO_2 Concentration (ppm)			Global Mean Surface Temperature Increase (°C)			Sea-level Rise (centimeters)		
	2030	2060	2100	2030	2060	2100	2030	2060	2100
1 No Action (A1B-AIM)	455.5	573.7	717.2	0.874	1.944	2.959	7.99	19.30	37.10
2 25 Percent Below Optimized	455.4	573.2	716.1	0.873	1.942	2.954	7.99	19.28	37.06
3 Optimized	455.4	573.1	715.8	0.873	1.942	2.953	7.99	19.28	37.05
4 25 Percent Above Optimized	455.4	573.0	715.7	0.873	1.941	2.953	7.99	19.28	37.04
5 50 Percent Above Optimized	455.4	572.9	715.6	0.873	1.941	2.952	7.99	19.27	37.04
6 Total Costs Equal Total Benefits	455.3	572.9	715.5	0.873	1.940	2.951	7.99	19.27	37.03
7 Technology Exhaustion	455.3	572.6	714.9	0.872	1.938	2.948	7.99	19.26	37.00
Reductions Compared to the No Action Alternative									
2 25 Percent Below Optimized	0.1	0.5	1.1	0.001	0.002	0.005	0.00	0.02	0.04
3 Optimized	0.1	0.6	1.4	0.001	0.003	0.006	0.00	0.02	0.05
4 25 Percent Above Optimized	0.1	0.7	1.5	0.001	0.003	0.006	0.00	0.02	0.06
5 50 Percent Above Optimized	0.1	0.8	1.6	0.001	0.004	0.007	0.00	0.03	0.06
6 Total Costs Equal Total Benefits	0.2	0.8	1.7	0.001	0.004	0.008	0.00	0.03	0.07
7 Technology Exhaustion	0.2	1.1	2.3	0.002	0.006	0.011	0.00	0.04	0.10

a/ The A1B scenario is the SRES marker scenario used by the IPCC WGI to represent the SRES A1B (medium) storyline.

3.5 OTHER POTENTIALLY AFFECTED RESOURCE AREAS

This section describes the affected environment and environmental consequences of the alternative CAFE standards on water resources (3.5.1), biological resources (3.5.2), land use and development (3.5.3), safety (3.5.4), hazardous materials and regulated wastes (3.5.5), land uses protected under Section 4(f) (3.5.6), historic and cultural resources (3.5.7), noise (3.5.8), and environmental justice (3.5.9). These sections describe the current and projected future threats to these resources from non-global climate change impacts relevant to the alternatives and provide primarily qualitative assessments of any potential consequences of the alternatives—either positive or negative—on these resources.

This section does not describe the affected environment in relation to, or address potential environmental consequences resulting from, global climate change. For a description of potential impacts of global climate change, *see* Chapter 4.

3.5.1 Water Resources

3.5.1.1 Affected Environment

Water resources include surface water and groundwater. Surface waters are water bodies open to the atmosphere, such as rivers, streams, lakes, oceans, and wetlands; surface waters can contain either fresh or salt water. Groundwater is found in natural reservoirs or aquifers below Earth's surface. Sources of groundwater include rainfall and surface water, which penetrate the ground and recharge the water table. Sections 3.5.1.1.1 through 3.5.1.1.3 describe the current and projected future threats to these resources from non-global climate change impacts related to the proposed action. The production and combustion of fossil fuels, the production of biofuels, and shifts in the location of mining activities are the identified relevant sources of impact. Section 3.5.2 describes relevant aspects of surface water resources from a habitat perspective. For a discussion of the effects of global climate change on freshwater and coastal systems, see Sections 4.5.3 and 4.5.5.

Impacts to water resources during recent decades have come from a number of different sources. These impacts include increased water demand for human and agricultural use, pollution from point and non-point sources, and climatic changes. One of the major human-caused impacts on water quality has been the extraction, refining, and combustion of petroleum products, or oil.

3.5.1.1.1 Oil Extraction and Refining

Oil refineries, which produce gasoline and diesel fuel, and the motor vehicles that combust petroleum-based fuels, are major sources of VOCs, SO_2, NO_x, CO, and other air pollutants (EPA 1995a, EPA 1997b). In the atmosphere, SO_2 and NO_x contribute to the formation of acid rain (the wet, dry, or fog deposition of SO_2 and NO_x), which enters water bodies either directly or as runoff from terrestrial systems (*see* Section 3.3 for more information on air quality). Once in surface waters, these pollutants can cause acidification of the water body, changing the acidity or alkalinity (commonly called pH) of the system and affecting the function of freshwater ecosystems (Van Dam 1996, Baum 2001, EPA 2007b). An EPA survey of sensitive freshwater lakes and streams (those with a low capacity to neutralize or buffer against decreases in pH) found that 75 percent of the lakes and 50 percent of the streams had experienced acidification as a result of acid rain (EPA 2007b). EPA has identified the areas of the United States most sensitive to acid rain as the Adirondacks and Catskill Mountains in New York State, the mid-Appalachian highlands along the east coast, the upper Midwest, and mountainous areas of the western United States (EPA 2007b).

Water quality might also be affected by petroleum products released during the refining and distribution process. Oil spills can lead to contamination of surface and groundwater and can result in impacts to drinking water and marine and freshwater ecosystems (*see* Section 3.5.2.1.1). EPA estimates that, of the volume of oil spilled in "harmful quantities," as defined under the Clean Water Act, 83.8 percent was deposited in internal/headland waters and within 3 miles of shore, with 17.5 percent spilled from pipelines, often in inland areas (EPA 2004a). The environmental impacts on and recovery time for individual waterbodies vary based on several factors (*e.g.*, salinity, water movement, wind, temperature), with faster-moving and warm water locations recovering more quickly (EPA 2008f).

During oil extraction, the primary waste product is highly saline liquid called "produced water," which can contain metals and other potentially toxic components (*see* Section 3.5.5.1.1 for more on produced water). Produced water and other oil extraction wastes are most commonly disposed of by reinjecting them to the well, which increases pressure and can force out more oil. Potential impacts from these wastes generally occur when large amounts are spilled and they enter surface waters, when decommissioned wells are improperly sealed, or when saline water from the wells intrudes into fresh surface water or groundwater (Kharaka and Otton 2005).

Water quality impacts also occur as a result of contamination by VOCs. A nationwide study of groundwater aquifers conducted by United States Geological Survey (USGS) found VOCs in 90 of 98 major aquifers sampled (Zogorski *et al.* 2006). The study concluded that "…[t]he widespread occurrence of VOCs indicates the ubiquitous nature of VOC sources and the vulnerability of many of the Nation's aquifers to low-level VOC contamination." Several of the most commonly identified VOCs were a gasoline additive (gasoline oxygenate – methyl tertiary butyl ether [MTBE]) and a gasoline hydrocarbon (toluene). USGS notes, however, that only 1 to 2 percent of the well samples had concentrations of VOCs at levels that would be of potential concern to human health; none of the VOCs found in potentially hazardous quantities were primarily used in the manufacture of fuels or as fuel additives (Zogorski *et al.* 2006). Section 3.5.5 describes toxic chemicals released during fuel production and combustion.

3.5.1.1.2 CO_2 Emissions

Oceanic concentrations of CO_2 from anthropogenic (human-made) sources, primarily the combustion of fossil fuels, have increased since the Industrial Revolution and likely will continue to increase. In addition to its role as a GHG, atmospheric CO_2 plays a key role in the biogeochemical cycle of carbon. Atmospheric CO_2 concentrations influence the chemistry of natural waters.

Atmospheric concentrations of CO_2 are in equilibrium with aqueous (dissolved in water) carbonic acid (H_2CO_3), which in turn influences the aqueous concentrations of bicarbonate ion (HCO_3^-) and carbonate ion (CO_3^2). In natural waters, the carbonate system controls pH, which in turn controls the availability of some nutrients and toxic materials in freshwater and marine systems.

One of the large-scale non-climatic effects of an increase in CO_2 emissions is the potential for ocean acidification. The ocean exchanges huge quantities of CO_2 with the atmosphere, and when atmospheric concentrations rise (due to anthropogenic emissions), there is a net flux from the atmosphere into the oceans. This decreases the pH of the oceans, reducing the availability of calcium. According to Richardson and Poloczanska (2008), "declines in ocean pH may impact calcifying organisms, from corals in the tropics to pteropods (winged snails) in polar ecosystems, and will take tens of thousands of years to reequilibrate to preindustrial conditions." Section 4.7 provides more information on the non-climate effects of CO_2 on plant and animal communities.

3.5.1.1.3 Biofuel Cultivation and Mining Activity

The need to supply agricultural products for a growing population will continue to affect water resources; future irrigation needs are likely to include increased production of both food and biofuel crops (Simpson 2008). Global demand for water is increasing as a result of population growth and economic development and irrigation currently accounts for around 70 percent of global water withdrawals (Shiklomanov and Rodda 2003 as cited in Kundzewicz *et al.* 2007). EPA states that "[d]emand for biofuels is also likely to have impacts on water including increasing land in agricultural production, resulting in increased risk of runoff of sediments, nutrients, and pesticides … [p]roduction of biofuels also uses significant amounts of water" (EPA 2008d). Runoff from agricultural sources often contains nitrogen, phosphorus, and other fertilizers and chemicals that harm water quality and can lead to euthrophication (the enrichment of a water body with plant-essential nutrients that can ultimately lead to oxygen depletion) (Vitousek *et al.* 1997, as cited in Fischlin *et al.* 2007). If biofuel production in the United States continues to be based on input-intensive crops like corn and soybeans, projected expansions to meet demand likely will result in significantly increased runoff of fertilizer and sediment (Simpson 2008).

Shifts toward fuel-saving lighter vehicles, either as a result of consumer preference for fuel-efficient vehicles or down-weighting design decisions by manufacturers, might result in changes in mining land use patterns with resulting impacts to water quality (*see* Section 3.5.3.1.1). Metal mining results in impacts to water resources via run-off sedimentation from cleared mining sites and degradation of groundwater quality or quantity due to excavation and extraction activities (EPA 1995a). Shifts in demand for lighter vehicles could mean that areas with iron deposits would experience less mining activity, while areas where commonly used light weight metals (such as aluminum or magnesium) might experience an increase in mining and related water impacts.

3.5.1.2 Environmental Consequences

As discussed in Section 3.3, each action alternative is generally expected to decrease the amount of VOCs, SO_2, NO_x, and other air pollutants in relation to No Action Alternative (Alternative 1) levels. Reductions in these pollutant levels would be the result of lower petroleum fuel consumption by cars and light trucks, and a potential for reduced extraction, transportation, and refining of crude oil. NHTSA expects that lower pollutant emissions would decrease the formation of acid rain in the atmosphere as compared to the No Action Alternative, which in turn would have a beneficial impact on the quality of freshwater standards by decreasing eutrophication and acidification. As discussed in Section 3.4, the impact of the alternative CAFE standards on CO_2 is relatively small compared to global emissions of CO_2. The U.S. car and light-truck fleet represents less than 4 percent of the global emissions of CO_2 from cars and light trucks, and this contribution is projected to decline in the future, due primarily to rapid growth of emissions from developing countries.

Each alternative could lead to an indirect increase in the production of biofuels and the use of more lightweight materials in vehicles, depending on the mix of tools manufacturers use to meet the increased CAFE standards, economic demand, and technological capabilities. If biofuel production were to increase, agricultural runoff could increase. If manufacturers opted for increased production of down-weighted vehicles, shifts in the location of metal extraction could alternatively benefit water quality in locations of decreased activity, while negatively affecting it in areas of increased activity. However, due to uncertainty about how manufacturers would meet the new requirements, and the fact that none of the alternative CAFE standards prescribe increased biofuel use or vehicle down-weighting, these potential impacts are not quantifiable. Section 3.5.4 provides additional information on vehicle down-weighting.

3.5.2 Biological Resources

3.5.2.1 Affected Environment

Biological resources include vegetation, wildlife, and special status species (those classified as "threatened" or "endangered" under the Endangered Species Act). The U.S. Fish and Wildlife Service has jurisdiction over terrestrial and freshwater special status species and the National Marine Fisheries Service has jurisdiction over marine special status species. States and other federal agencies, such as the Department of the Interior's Bureau of Land Management, also have species of concern to which they have assigned additional protections. Sections 3.5.2.1.1 through 3.5.2.1.3 describe the current and projected future threats to these biological resources from non-global climate change impacts related to the proposed action. As discussed below, the production and combustion of fossil fuels, the cultivation and production of biofuels from agricultural crops, and shifts in the location of mining activities are the identified relevant sources of impacts on biological resources. Section 4.5 describes the effects of global climate change on ecosystems.

3.5.2.1.1 Petroleum Extraction and Refining

Oil extraction activities could impact biological resources through habitat destruction and encroachment, raising concerns about their effects on the preservation of animal and plant populations and their habitats. Oil exploration and extraction result in intrusions into onshore and offshore natural habitats and can involve construction within natural habitats. "The general environmental effects of encroachment into natural habitats and the chronic effects of drilling and generating mud and discharge water on benthic (bottom-dwelling) populations, migratory bird populations, and marine mammals constitute serious environmental concerns for these ecosystems" (Borasin *et al.* 2002 as cited in O'Rourke and Connolly 2003).

Oil extraction and transportation can also result in spills of oil and hazardous materials. Oil contamination of aquatic and coastal habitats can directly smother small species and is dangerous to animals and fish if ingested or coated on their fur, skin, or scales. Oil refining and related activities result in chemical and thermal pollution of water, both of which can be harmful to animal and plant populations (Borasin *et al.* 2002). Offshore and onshore drilling and oil transport can lead to spills, vessel or pipeline breakage, and other accidents that release petroleum, toxic chemicals, and highly saline water into the environment and affect plant and animal communities.

Oil extraction, refining and transport activities, and the combustion of fuel during motor-vehicle operation, result in air emissions that affect air quality and can contribute to the production of acid rain; these effects can have negative impacts on plants and animals. Once present in surface waters, air pollutants can cause acidification of waterbodies, changing the pH of the system and affecting the function of freshwater ecosystems. EPA states:

> …plants and animals living within an ecosystem are highly interdependent…Because of the connections between the many fish, plants, and other organisms living in an aquatic ecosystem, changes in pH or aluminum levels affect biodiversity as well. Thus, as lakes and streams become more acidic, the numbers and types of fish and other aquatic plants and animals that live in these waters decrease (EPA 2008b).

Acid rain has also been shown to affect forest ecosystems negatively, both directly and indirectly. These impacts include stunted tree growth and increased mortality, primarily as a result of the leaching of calcium and other soil nutrients (Driscoll *et al.* 2001, DeHayes *et al.* 1999, Baum 2001). Declines in

biodiversity of aquatic species and changes in terrestrial habitats likely have ripple effects on other wildlife that depend on these resources.

The combustion of fossil fuels and certain agricultural practices have lead to a disruption in the nitrogen cycle (the process by which gaseous nitrogen from the atmosphere is used and recycled by organisms) with serious repercussions for biological resources. Nitrogen-cycle disruption has occurred through the introduction of large amounts of anthropogenic nitrogen in the form of ammonium and nitrogen oxides to aquatic and terrestrial systems (Vitousek 1994). Increased availability of nitrogen in these systems is a major cause of eutrophication in freshwater and marine waterbodies. Eutrophic systems typically contain communities dominated by phytoplankton (free-floating microscopic plants). Eutrophication can ultimately result in fish and other aquatic animal kills and harmful algal blooms. Acid rain enhances eutrophication of aquatic systems through the deposition of additional nitrogen (Lindberg n.d.). Introduction of large quantities of nitrogen to certain terrestrial systems has also been predicted to lead to an increase in decomposing soil bacteria and subsequent increase in the release of CO_2 into the atmosphere as these bacteria consume organic matter (Black 2008).

3.5.2.1.2 CO_2 Emissions

Ocean acidification as a result of increasing concentrations of atmospheric CO_2, primarily from the combustion of fossil fuels, is expected to affect calciferous marine organisms. In conjunction with rapid climate change, ocean acidification could pose severe threats to coral reef ecosystems. Hoegh-Guldberg *et al.* (2007) state that "[u]nder conditions expected in the 21st century, global warming and ocean acidification will compromise carbonate accretion, with corals becoming increasingly rare on reef systems. The result will be less diverse reef communities and carbonate reef structures that fail to be maintained."

In contrast to its potential adverse effect on the productivity of marine ecosystems, higher CO_2 concentrations in the atmosphere could increase the productivity of terrestrial systems, because plants use CO_2 as an input to photosynthesis. The IPCC Fourth Assessment Report states that "[o]n physiological grounds, almost all models predict stimulation of carbon assimilation and sequestration in response to rising CO_2, called CO_2 fertilization" (Denman *et al.* 2007).

Under bench-scale and field-scale experimental conditions, several investigators have found that higher concentrations have a "fertilizer" effect on plant growth (*e.g.*, Long *et al.* 2006, Schimel *et al.* 2000). IPCC reviewed and synthesized field and chamber studies, finding that:

> There is a large range of responses, with woody plants consistently showing NPP [net primary productivity] increases of 23 to 25 percent (Norby *et al.*, 2005), but much smaller increases for grain crops (Ainsworth and Long 2005) … Overall, about two-thirds of the experiments show positive response to increased CO_2 (Ainsworth and Long 2005, Luo *et al.* 2005, as cited in Denman *et al.* 2007). Since saturation of CO_2 stimulation due to nutrient or other limitations is common (Dukes *et al.* 2005, Körner *et al.* 2005, both as cited in Denman *et al.* 2007), it is not yet clear how strong the CO_2 fertilization effect actually is.

The CO_2 fertilization effect could mitigate some of the increase in atmospheric CO_2 concentrations by resulting in more storage of carbon in vegetation.

Increased atmospheric CO_2, in conjunction with other environmental factors and changes in plant communities, could alter growth, abundance, and respiration rates of some soil microbes (Lipson *et al.* 2005, Chung *et al.* 2007, Lesaulnier *et al.* 2008).

3.5.2.1.3 Land Disturbances Due to Biofuel Production and Mining

Future demands for biofuel production are predicted to require increased commitments of land to agricultural production (EPA 2008d). Placing additional land into agricultural production or returning marginal agricultural land to production to grow perennial grass or trees for use in cellulosic ethanol production would decrease the area available as natural habitat. A decrease in habitat and potential habitat for plants and animal species would likely result in negative impacts to certain species. Increased agriculture production would also likely result in increased surface runoff of sediments and fertilizers. Additional fertilizer inputs to water could increase eutrophication and associated impacts. Sediment runoff can settle to the bottom of waterbodies and degrade essential habitat for some species of aquatic organisms, bury food sources and areas used for spawning, and kill benthic organisms (EPA 2000b).

As stated in section 3.5.1.1.3, a shift toward lighter vehicles would likely result in changes to mining land use patterns and impacts to water quality; such changes could affect aquatic and terrestrial ecosystems. EPA notes that mining activities could result in the destruction of terrestrial habitat, loss of fish populations due to water-quality impacts, and a loss of plants due to increased dust (EPA 1995a). As previously stated, such a shift would likely be beneficial in areas of decreased activity and detrimental in areas of increased activity.

3.5.2.1.4 Endangered Species

Off-shore drilling, on-shore oil and gas drilling, and roads created to access remote extraction sites through habitats used by threatened or endangered species might also affect these plants and animals both directly, through loss of individual animals or habitat, and indirectly, through water-quality degradation or cumulative impacts with other projects. Loss of potential habitat to the production of biofuels could also result in negative impacts to some species (*e.g.*, diminished potential for habitat expansion, increased runoff-related impacts).

Increased anthropogenic inputs of nitrogen to terrestrial, aquatic, and microbial communities containing rare plants and animals could also affect threatened and endangered species. In ecosystems with certain vegetation and soil types, this increased nitrogen availability can result in reduced biodiversity or the exclusion of certain endemic species in favor of those adapted to make use of these nutrients to their competitive advantage (Bobbink *et al.* 1998, Fenn *et al.* 2003, Weiss 1999). For example, the decline of certain nutrient-poor native grasslands in California, which serve as critical habitat for the Bay checkerspot butterfly, is likely partially due to an increase in invasive grass species made possible by such nutrient inputs (Weiss 1999).

3.5.2.2 Environmental Consequences

The decrease in overall fuel consumption by cars and light trucks, anticipated under all of the alternatives except the No Action Alternative, could lead to reductions in oil exploration, extraction, transportation, and refining. NHTSA expects that a reduction in these activities would result in decreased impacts to on- and off-shore habitat and plant and animal species. This decrease could have a small overall benefit to plants and animals primarily through decreased levels of direct ground disturbance and releases of oil and hazardous materials. Reductions in the rate of fuel consumption increase under all of the alternatives compared to the No Action Alternative would lead to overall decreases in the release of SO_2 and NOx. Reductions in acid rain and anthropogenic nutrient deposition could lower levels of eutrophication in surface waters and could slow direct impacts to ecosystems and to soil leaching.

Reductions in the rate of fuel consumption increase would also lead to a decrease in the release of CO_2 compared to the No Action Alternative.. Lower levels of atmospheric CO_2 could slow projected

effects to terrestrial plant growth, calciferous marine organisms, and microorganisms. However, as discussed in Section 3.5.1.2, the reduction in CO_2 as a result of the proposed action would be relatively small compared to current and projected global CO_2 releases (*see* Chapter 2 and Section 3.3).

The alternatives could lead to an increase in the production of biofuels and mining for lightweight raw materials, depending on the mix of tools manufacturers use to meet the new CAFE standards, economic demands from consumers and manufacturers, and technological developments. Depending on these factors, increased production of biofuels could result in the conversion of existing food-agricultural lands and non-agricultural areas to biofuel crop production. This change in land use would have implications for environmental issues associated with fertilizer runoff, water body eutrophication, and sediment runoff effects to aquatic organism food and spawning habitat. Similarly, increased mining land-disturbance activities could affect aquatic health due to increased sedimentation. However, due to the uncertainty surrounding how manufacturers would meet the new requirements and the fact that none of the analyzed standards prescribe increased biofuel use or vehicle downweighting, these potential effects are not quantifiable.

NHTSA has not been able to identify or quantify the impacts to endangered or threatened species or critical habitat as a result of this rulemaking. Therefore, NHTSA will not perform a Section 7 Consultation.

3.5.3 Land Use and Development

3.5.3.1 Affected Environment

Land use and development refers to human activities that alter land (*e.g.*, industrial and residential construction in urban and rural settings, clearing of natural habitat for agricultural or industrial use) and may affect the amount of carbon or biomass in existing forest or soil stocks in the affected areas. For the purposes of this analysis, shifts in agricultural and mining production and changes to manufacturing plants that produce cars and light trucks are the identified relevant sources of impact.

3.5.3.1.1 Changes in Agricultural Production and Mining

Biofuel production is predicted to require increased devotion of land to agricultural production (EPA 2008d, Keeney and Hertel 2008). Converting areas into cropland would decrease the overall land area kept in a natural state as well as the potential area available for other uses (such as commercial development or pastureland) (Keeney and Hertel 2008). Uncertainty exists regarding how much additional land could be required to meet projected biofuel needs in the United States, as well as how an increase in biofuel production could affect other land uses (Keeney and Hertel 2008).

Shifts toward fuel-saving lighter vehicles, either as a result of consumer preference for fuel-efficient vehicles or downweighting design decisions by manufacturers, might result in changes in mining land use patterns. Mining for the minerals needed to construct these lighter vehicles (primarily aluminum and magnesium) could shift some metal extraction activities to areas rich in these resources. Schexnayder *et al.* (2001) noted that such a shift in materials "could reduce mining for iron ore in the United States, but increase the mining of bauxite for aluminum, magnesium, titanium, and other materials in such major countries as Canada, China, and Russia and in many small, developing countries, such as Guinea, Jamaica, and Sierra Leone."

3.5.3.1.2 Manufacturing Changes

Recent shifts in consumer demand in the United States away from less fuel-efficient vehicles have begun to change the types of vehicles produced and the manufacturing plants where they are made. Sharp decreases in demand for trucks and SUVs have recently resulted in plant closures and production shifts to plants where small cars and gas-electric hybrid vehicles are made (WWJ News Radio 2008, Keenan and Mckenna 2008, Bunkley 2008).

3.5.3.2 Environmental Consequences

The alternatives could lead to an increase in the production of biofuels and the use of more lightweight materials in vehicles, depending on the mix of tools manufacturers use to meet the new CAFE standards, economic demands from consumers and manufacturers, and technological developments. Depending on these factors, increased production of biofuels could result in the conversion of existing food-agricultural lands and natural areas to the production of these fuel crops. Downweighted vehicles could result in shifts in mining from areas containing iron to those containing aluminum and magnesium. These changes would have implications for environmental issues associated with land use and development. However, due to the uncertainty surrounding how manufacturers would meet the new requirements and the fact that none of the analyzed standards prescribe increased biofuel use or vehicle downweighting, these potential impacts are not quantifiable. *See* Section 3.5.4 for more information on vehicle downweighting.

Major changes to manufacturing facilities, such as those occurring with the apparent shift in consumer demand toward more fuel-efficient vehicles, might have implications for environmental issues associated with land use and development. However, NHTSA's review of existing and available technologies and capabilities shows that the CAFE standards under all the alternatives can be met by existing and planned manufacturing facilities. Because of the availability of sufficient existing and planned capacity, and because none of the alternatives prescribe particular technologies for meeting these standards, the various alternatives are not projected to force changes in product mixes that would result in plant changes.

3.5.4 Safety and Other Impacts to Human Health

This section addresses how future improvements in fuel economy might affect human health and welfare through vehicle safety performance, particularly crashworthiness and the rate of traffic fatalities. It also addresses how the new standards might affect energy concerns, which could have ramifications for family health and welfare.

3.5.4.1 Affected Environment

Multiple factors influence traffic fatality rates, including driver demographics (age, gender, etc); driver behavior (*e.g.*, driving under the influence, seat belt use, observance of speed limits and other traffic laws, miles driven); and vehicle characteristics such as size, weight, and various technologies designed to increase vehicle safety performance (*e.g.*, air bags, anti-lock braking systems, structural reinforcement, impact crumple zones). Several studies have attempted to define the relationship between vehicle crashworthiness (specifically as it relates to traffic fatalities) and fuel economy standards; however, different methodologies have yielded different conclusions. Although much of the research identifies a link between vehicle downsizing and decreased crashworthiness, studies have reached various conclusions.

The 2002 National Academy of Sciences report (NAS 2002) made explicit links between weight and vehicle safety. The NAS study conclusions were divided, with 11 of 13 committee members representing the majority view and 2 of 13 the minority view. The findings of the majority state, "the majority of the committee finds that the downsizing and weight reduction that occurred in the late 1970s and early 1980s most likely produced between 1,300 and 2,600 crash fatalities and between 13,000 and 26,000 serious injuries in 1993. The proportion of these casualties attributable to CAFE standards is uncertain." Two members provided a minority view: "The relationships between vehicle weight and safety are complex and not measurable with any reasonable degree of certainty at present. The relationship of fuel economy to safety is even more tenuous. … it appears that in certain kinds of accidents, reducing weight will increase safety risk, while in others it may reduce it. Reducing the weights of light-duty vehicles will neither benefit nor harm all highway users, there will be winners and losers…"

The Kahane study (2003) estimates the effect of 100-pound reductions in heavy (more than 3,900 pounds curb weight) light trucks and vans (LTVs), light LTVs, heavy passenger cars, and light passenger cars. It compares the fatality rates of LTVs and cars to quantify differences among vehicle types, given drivers of the same age, gender, etc. The study found that annual fatalities increased with a reduction in weight in all groups of passenger vehicles except light trucks with a curb weight greater than 3,900 pounds. The net safety effect of removing 100 pounds from a light truck is close to zero for the group of all light trucks with a curb weight greater than 3,900 pounds.

Honda has cited several reports, which it asserts demonstrate that limited weight reductions would not reduce safety and could possibly decrease overall fatalities. Honda stated that the 2003 study by Dynamic Research Inc. (DRI) found that reducing weight without reducing size slightly decreased fatalities, and that this was confirmed in a 2004 study by DRI[37] that assessed new data and methodology changes in the 2003 Kahane study. DRI submitted an additional study, *Supplemental Results on the Independent Effects of Curb Weight, Wheelbase, and Track Width on Fatality Risk in 1985-1998 Model Year Passenger Cars and 1985-1997 Model Year LTVs* (van Auken and Zellner 2005). This DRI study concluded that reductions in "footprint" (the product of multiplying a vehicle's wheelbase by its track width) are harmful to safety, whereas reductions in mass while holding footprint constant would benefit safety.

NHTSA analyses of the relationships between fatality risk and mass, track width, and wheelbase in four-door 1991 to 1999 passenger cars (Docket No. 2003-16318-0016) found a strong relationship between track width and the rollover fatality rate, but only a modest (although substantial) relationship between track width and fatality rate in non-rollover crashes. Even controlling for track width and wheelbase – for example, by holding footprint constant – weight reduction in the lighter cars is strongly associated with higher non-rollover fatality rates in the NHTSA analysis.

While further scientific examination continues, EISA included an important reform that requires NHTSA to issue attribute-based standards, which eliminates or reduces the incentive to decrease the size (weight) of the vehicle to comply with the fuel economy standards because smaller-footprint (size) vehicles have to achieve higher fuel economy targets. The attribute-based approach was originally recommended by the NAS to remove the apparent incentive to reduce size and/or the weight of vehicles as a means of meeting the standards.

NHTSA adopted an attribute-based approach for light trucks in 2006. NHTSA continues to examine this important safety issue and has tentatively concluded in its current NPRM that use of the

[37] *See* Docket Nos. 2003-16318-2, 2003-16318-3, and 2003-16318-7.

footprint-attribute will achieve greater fuel economy/emissions reductions without creating an incentive to downsize vehicles.

Another way that the new standards could affect human health and welfare is by increasing the amount of VMT. NHTSA tracks very closely the rate of traffic fatalities as a function of VMT, even while recognizing that many other factors are critical in determining fatality risks. In February 2008, NHTSA reported that the fatality rate in 2006 was 1.41 per million VMT, a decline from 2005 rates (Subramanian 2008). These effects are not limited to vehicle occupants (bicyclists and pedestrians could also have an increased risk as a result of increased VMT). However, as with vehicle occupant fatalities, many other factors are important in determining the overall risk associated with vehicle, pedestrian, and bicycle fatalities.

Finally, there is scientific literature that posits a relationship between petroleum scarcity and human health. Frumkin *et al.* (2007) argues that increased oil prices could result in increased use of other fuels for power generation and increase costs to hospitals for providing back-up power via diesel generators. Petroleum scarcity could also result in more expensive food (due to transportation and agricultural costs), which could be intensified by several factors, including climate change, market demand for biofuels (which would inflate some food prices), and degradation of agricultural land. These effects could threaten the health of low-income people and others who do not have secure access to food. Other effects of peak petroleum prices on health are more speculative, but concerns remain for issues such as (1) higher petroleum prices triggering a persistent economic downturn, which could increase the ranks of the uninsured, (2) social disruptions that could create a substantial burden of anxiety, depression, and other psychological ailments, and (3) resource scarcity, including petroleum scarcity, that could trigger armed conflict, which poses multiple risks to public health. To the extent that the CAFE standards affect petroleum supply or price, they might have an effect on human welfare.

3.5.4.2 Environmental Consequences

Because of the attribute-based approach recommended by NAS and adopted by NHTSA, the incentive to meet the new standards by making more smaller vehicles and fewer larger vehicles should be reduced or eliminated. Further, NHTSA chose fuel-economy levels that could be achieved without reductions in weight for vehicles less than 5,000 pounds. Because the alternatives do not mandate the methods by which the CAFE standards are achieved, vehicle manufacturers could achieve increased fleet fuel economy by reducing vehicle weight. To the extent that manufacturers choose this approach, there could be some additional traffic fatalities and more serious injuries resulting from vehicle accidents. The extent of these effects cannot be estimated without knowing the extent to which manufacturers choose to meet the new CAFE standards by making lighter vehicles with similar footprints.

The PRIA for the CAFE standards of MY 2011-2015 passenger cars and light trucks concluded that increases in fleet fuel economy are likely to lead to more miles being driven by the U.S. population (NHTSA 2008a). Known as the rebound effect, higher CAFE standards would lead to the perception of a lower cost of driving, which is typically the largest component of the cost of operating a vehicle. In response to the perception of lowered costs, consumers would increase the number of miles they drive. By one estimate, a 10-percent increase in fuel economy would ultimately result in a 2.4-percent increase in total miles traveled (Small and Dender 2005a). The recent and unprecedented decline in miles driven – a 4.3 percent drop in the total miles driven in March of 2008 as compared to March of 2007, equating to a decrease of 11 billion miles (FHWA 2008) – in response to recent surges in the price of gasoline, underscores the relationship between the cost of operating a passenger vehicle and driver behavior as it relates to miles driven. Because increased average fuel economy would lead to vehicles that cost less to operate, it can be expected that individuals would drive more miles, and traffic accidents and fatalities of vehicle occupants, bicyclists, and pedestrians would increase on the whole. However, an estimate of

increased fatalities based on miles driven is influenced, in part, by unpredictable market forces, and is uncertain to predict.

The alternatives would reduce petroleum use. To the extent that petroleum scarcity would be reduced by higher fuel economy standards, any adverse health impacts as described by Frumkin *et al.* (2007) would also be reduced.

3.5.5 Hazardous Materials and Regulated Wastes

3.5.5.1 Affected Environment

Hazardous wastes are defined here as solid wastes, which also include certain liquid or gaseous materials, that because of their quantity and concentration, or their physical, chemical, or infectious characteristics could cause or contribute to an increase in mortality or an increase in serious irreversible or incapacitating reversible illness or could pose a substantial hazard to human health or the environment when improperly treated, stored, used, transported, disposed of, or otherwise managed. Hazardous wastes are generally designated as such by individual states or EPA under the Resource Conservation and Recovery Act of 1976. Additional federal and state legislation and regulations, such as the Federal Insecticide, Fungicide, and Rodenticide Act, determine handling and notification standards for other potentially toxic substances. For the purposes of this analysis, hazardous materials and wastes generated during the oil extraction and refining processes and by agricultural production and mining activities are the identified relevant sources of impact.

3.5.5.1.1 Wastes Produced during the Extraction Phase of Oil Production

The primary waste created during the extraction of oil is “produced water,” highly saline water pumped from oil and gas wells during mining (American Petroleum Institute 2000, EPA 2000c). In 1995, the onshore oil and gas industry produced approximately 15 billion barrels of produced water (American Petroleum Institute 2000). Produced waters are generally “highly saline (total dissolved solids may exceed 350,000 milligrams per liter [mg/L]), may contain toxic metals, organic and inorganic components, and radium-226/228 and other naturally occurring radioactive materials” (Kharaka and Otton 2005). Drilling wastes, primarily mud and rock cuttings, account for 149 million barrels of extraction wastes. “Associated wastes,” generally the most hazardous wastes produced during extraction (often containing benzenes, arsenic, and toxic metals), account for another 22 million barrels (The American Petroleum Institute 2000, EPA 2000c).

Wastes produced during oil and gas extraction have been known to have serious environmental effects on soil, water, and ecosystems (Kharaka and Otton 2005, O’Rourke and Connolly 2003). Onshore environmental effects result “primarily from the improper disposal of large volumes of saline water produced with oil and gas, from accidental hydrocarbon and produced water releases, and from abandoned oil wells that were not correctly sealed” (Kharaka and Otton 2005). Offshore effects result from improperly treated produced water released into the waters surrounding the oil platform (EPA 2000c).

3.5.5.1.2 Wastes Produced during the Refining Phase of Oil Production

Wastes produced during the petroleum-refining process are primarily released to the air and water, accounting for 75 percent (air emissions) and 24 percent (wastewater discharges) of the total (EPA 1995a). EPA defines a release as the “on-site discharge of a toxic chemical to the environment…emissions to the air, discharges to bodies of water, releases at the facility to land, as well as contained disposal into underground injection wells” (EPA 1995a). EPA reports that 9 of the 10 most

common toxic substances released by the petroleum-refining industry are volatile chemicals, highly reactive substances prone to state changes or combustion, that include benzene, toluene, ethylbenzene, xylene, cyclohexane, 1,2,4-trimethylbenzene and ethylbenze (EPA 1995a). These substances are present in crude oil and in finished petroleum products. Other potentially dangerous substances commonly released during the refining process include ammonia, asoline additives (methanol, ethanol, and MTBE), and chemical feedstocks (propylene, ethylene, and napthalene) (EPA 1995a). Spent sulfuric acid is by far the most commonly produced toxic substance; however, it is generally reclaimed instead of released or transferred for disposal (EPA 1995a).

Wastes released during the oil-refining process can cause environmental impacts to water quality, air quality, and human health. The volatile chemicals released during the refining process are known to react in the atmosphere and contribute to ground-level ozone and smog (EPA 1995a). Several of the produced volatile chemicals are also known or suspected carcinogens, and many others are known to cause respiratory problems and impair internal-organ functions, particularly in the liver and kidneys (EPA 1995a). Ammonia is a form of nitrogen and can contribute to eutrophication in surface waters.

3.5.5.1.3 Agricultural Materials

Agricultural production, especially of the type required to grow the corn and soy beans most commonly used to produce biofuels in the United States, also results in the release of potentially hazardous materials and wastes. Wastes from agricultural production can include pesticide (insecticides, rodenticides, fungicides, and herbicides) and fertilizer runoff and leaching, wastes used in the maintenance and operation of agricultural machinery (used oil, fuel spills, organic solvents, metal machining wastes, spent batteries), and other assorted process wastes (EPA 2000d).

Agricultural wastes in the form of runoff from agricultural fields can cause environmental impacts to water and human health. Fertilizers can run off into surface waters and cause eutrophication, while pesticides can directly affect beneficial insects and wildlife (EPA 2000d). A National Renewable Energy Lab report concludes that the negative environmental impacts on soil and water due to impacts of increased biofuel production are likely to occur disproportionately in the Midwest, where most of these crops are grown (Powers 2005). Human health can also be affected by improperly handled or applied pesticides, with potential effects ranging from minor respiratory or skin inflammation to death (EPA 2000d). Nitrogen fertilizer runoff to drinking-water sources can lead to methemogloanemia, the potentially fatal binding of a form of nitrogen to hemoglobin in infants (Powers 2005).

Ethanol, as a biofuel additive to gasoline, is suspected of enhancing the plume size after a gasoline-blended ethanol spill and might decrease degradation of the spilled hydrocarbon and related compounds, such as benzene (Powers *et al.* 2001, Deeb *et al.* 2002, Williams *et al.* 2003).

3.5.5.1.4 Automobile Production and Assembly

Hazardous materials and toxic substances are produced by motor vehicles and the motor vehicle equipment industry, businesses engaged in the manufacture and assembly of cars, trucks, and busses. EPA reports that solvents (xylene, methyl ethyl ketone, acetone, etc.) are the most commonly released toxic substances it tracks for this industry (EPA 1995a). These solvents are used to clean metal and in the vehicle-finishing process during assembly and painting (EPA 1995a). Other industry wastes include metal paint and component-part scrap.

In addition, studies have suggested that the substitution of lighter weight materials (such as aluminum, magnesium, titanium, or plastic) for steel and iron to increase fuel efficiency could increase the total waste stream resulting from automobile manufacturing (Schexnayder *et al.* 2001). Mining

wastes generated during the extraction of these lighter raw materials would likely increase substantially, primarily due to aluminum mining, and other production wastes (e.g., from refining of aluminum and plastic manufacturing) could also increase (Schexnayder *et al.* 2001, Dhingra 1999). The extraction and processing of these metals and the production of manmade fibers and plastics also generate various hazardous wastes (EPA 1995b, EPA 1997c). An assessment of the solid and hazardous wastes generated during the production of three lightweight concept cars concluded the net generation of waste would increase versus conventional vehicles; however, the study also noted that the generation of most hazardous materials of particular concern to human health (*e.g.*, cadmium, chlorine, lead) emitted during the production of vehicles appeared to decrease in the vehicle models analyzed (Schexnayder *et al.* 2001). Recycling of vehicles at the end of the vehicle life could help to offset some of the projected net increase in waste production versus primarily steel/iron construction vehicles.

3.5.5.1.5 CO_2 Emissions

CO_2 is not currently classified as a hazardous material or regulated waste. For a discussion of the release of CO_2 relevant to the proposed action and its impacts on climate change, *see* Section 3.4. For a discussion of the impacts of CO_2 on water resources, *see* Section 3.5.1.1.2. For a discussion of the impacts of CO_2 on biological resources, *see* Section 3.5.2.1.2.

3.5.5.2 Environmental Consequences

The projected reduction in fuel production and consumption as a result of the proposed action could lead to a reduction in the amount of hazardous materials and wastes created by the oil extraction and refining industries. NHTSA expects corresponding decreases in the associated environmental and health impacts of these substances. However, these effects would likely be small if they occurred because of the limited overall effect of the proposed action on these areas.

All of the alternatives could lead to an increase in the production of biofuels and the use of more lightweight materials in vehicles, depending on the mix of tools manufacturers use to meet the new CAFE standards, economic demands from consumers and manufacturers, and technological developments. If biofuel production increased, these could be additional runoff of agricultural fertilizers and pesticides; if manufacturers pursued vehicle downweighting, these could be a net increase in the waste stream. However, due to the uncertainty surrounding how manufacturers would meet the new requirements and the fact that none of the analyzed standards prescribes increased biofuel use or vehicle downweighting, these potential impacts are not quantifiable. *See* Section 3.5.4 for additional information on vehicle downweighting.

3.5.6 Land Uses Protected under Section 4(f)

3.5.6.1 Affected Environment

Section 4(f) resources are publicly owned parks, recreational areas, wildlife and waterfowl refuges, or public and private historical sites, which are given special consideration by the DOT. Originally included as part of the Department of Transportation Act of 1966, Section 4(f) stipulates that DOT agencies cannot approve the use of land from publicly owned parks, recreational areas, wildlife and waterfowl refuges, or public and private historical sites unless: "(1) there is no feasible and prudent alternative to the use of such land, and (2) such program includes all possible planning to minimize harm to such park, recreational area, wildlife and waterfowl refuge, or historic site resulting from such use" (49 U.S.C. 303).

3.5.6.2 Environmental Consequences

"Section 4(f) only applies where land is permanently incorporated into a transportation facility and when the primary purpose of the activity on the 4(f) resource is for transportation" (FHWA 2005). Therefore, these resources are not affected by the types of environmental issues under consideration as part of the proposed action.

3.5.7 Historic and Cultural Resources

3.5.7.1 Affected Environment

The National Historic Preservation Act of 1966, Section 106 states that agencies of the Federal Government must take into account the impacts of their action to historic properties; the regulations to meet this requirement can be found at 36 CFR Part 800. This process, known as the "Section 106 process," is intended to support historic preservation and mitigate impacts to significant historical or archeological properties through the coordination of federal agencies, states, and other affected parties. Historic properties are generally identified through the *National Register of Historic Places*, which lists properties of significance to the United States or a particular locale because of their setting or location, contribution to or association with history, or unique craftsmanship or materials. National Register-eligible properties must also be sites: "A. That are associated with events that have made a significant contribution to the broad patterns of our history; or B. That are associated with the lives of persons significant in our past; or C. That embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or D. That have yielded, or may be likely to yield, information important in prehistory or history" (NPS n.d.). Acid rain as a result of the processing of petroleum products and the combustion of petroleum-based fuels is the identified relevant source of impact to historic and cultural resources for this analysis.

Acid rain, the primary source of which is the combustion of fossil fuels, is one cause of degradation to exposed cultural resources and historic sites. EPA states that "[a]cid rain and the dry deposition of acidic particles contribute to the corrosion of metals (such as bronze) and the deterioration of paint and stone (such as marble and limestone). These effects substantially reduce the societal value of buildings, bridges, cultural objects (such as statues, monuments, and tombstones), and cars" (EPA 2007b).

3.5.7.2 Environmental Consequences

The projected reduction in fuel production and combustion as a result of the proposed action could lead to a minor reduction in the amount of pollutants that cause acid rain. A decrease in the production of such pollutants could result in a corresponding decrease in the amount of damage to historic and other structures caused by acid rain. However, such effects are not quantifiable.

3.5.8 Noise

3.5.8.1 Affected Environment

Excessive amounts of noise, which is measured in decibels, can present a disturbance and a hazard to human health at certain levels. Potential health hazards from noise range from annoyance (sleep disturbance, lack of concentration, and stress) to hearing loss at high levels (Delucchi and Hsu 1998, Geary 1998, Fleming *et al.* 2005). Motor-vehicle noise also affects property value. A study of the impacts of roadway noise on property value estimated this cost to be roughly 3 billion dollars in 1991

dollars (Delucchi and Hsu 1998). The noise from motor vehicles has been shown to be one of the primary causes of noise disturbance in homes (OECD 1988, as cited in Delucchi and Hsu 1998 and Geary 1998). 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.

3.5.8.2 Environmental Consequences

As a result of the rebound effect (the increase in VMT as the cost per mile for fuel decreases), NHTSA predicts that there will be increased vehicle use under all of the alternatives; higher overall VMTs would result in increases in vehicle road noise. However, determining if there will be noise impacts is not possible based on the available data. Noise levels are location specific, meaning factors such as the time of day at which increases in traffic occur, existing ambient noise levels, the presence or absence of noise abatement structures, and the location of school, residences, and other sensitive noise receptors all influence whether there will be noise impacts.

All of the alternatives could lead to an increase in use of hybrid vehicles, depending on the mix of tools manufacturers use to meet the new CAFE standards, economic demands from consumers and manufacturers, and technological developments. An increased percentage of hybrid vehicles could result in reduced road noise, potentially offsetting some of the increase in road noise predicted to result from increased VMT. However, due to the uncertainty surrounding how manufacturers would meet the new requirements, the fact that none of the alternatives prescribes increased production of hybrid vehicles, and the location-specific nature of noise impacts, these potential impacts are not quantifiable.

3.5.9 Environmental Justice

3.5.9.1 Affected Environment

Federal agencies must identify and address disproportionably high and adverse impacts to minority and low-income populations in the United States (Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*). DOT Order 5610.2 establishes the process the Department uses to "incorporate environmental justice principles (as embodied in the Executive Order) into existing programs, policies, and activities." The production and use of fossil fuels and the production of biofuels are the identified relevant sources of impact to environmental populations for this analysis. For a discussion of the effects of changes in climate on environmental justice populations, *see* Section 4.6.

Numerous studies have noted that there appears to be a historic and ongoing relationship between the environmental impacts of petroleum extraction, processing, and use and environmental justice populations (Pastor *et al.* 2001, O'Rourke and Connolly 2003, Lynch *et al.* 2004, Hymel 2007, Srinivasan *et al.* 2003).

Potential impacts of the oil exploration and extraction process on environmental justice communities include "human health and safety risks for neighboring communities and oil industry workers, and displacement of indigenous communities" (O'Rourke and Connolly 2003). Subsistence-use activities (collecting plants or animals to fulfill basic needs for food, clothing, or shelter) can also be affected by extraction and exploration through the direct loss of subsistence-use areas or impacts to culturally/economically important plants and animals as a result of a spill or hazardous material release (O'Rourke and Connolly 2003, Kharaka and Otton 2005).

It has been shown that minority and low income populations often disproportionately reside near high-risk polluting facilities, such as oil refineries (Pastor *et al.* 2001, Graham *et al.* 1999, O'Rourke and Connolly 2003), and "mobile" sources of air toxins and pollutants, such as highways (Morello-Frosch 2002, Jerrett *et al.* 2001, O'Neill *et al.* 2003c). Populations near refineries could be disproportionately affected by exposure to potentially dangerous petroleum and by-products of the refining process, such as benzene (Borasin et. al 2002). Exposure to the toxic chemicals associated with refineries, primarily by refinery workers, has been shown to be related to increases in certain diseases and types of cancer (Pukkala 1998, Chan *et al.* 2005); the precise nature and severity of these health impacts are still under debate. Pollutants from transportation sources, such as NO_2 and CO from roadway traffic, are often unevenly distributed and tend to remain near their release locations (O'Neill *et al.* 2003c). A correlation between this uneven distribution of some pollutants and minority and low income populations has been documented, demonstrating the potential for a disproportionate allocation of the health impacts of these air pollutants to environmental justice populations (Jerret *et al.* 2001, Morello-Frosch 2002). Recent reviews by health and medical researchers indicate a general consensus that proximity to high-traffic roadways could result in health effects in the areas of cardiovascular health (Adar and Kaufman 2007), and asthma and respiratory health (Heinrich and Wichmann 2004, Salam *et al.* 2008). The exact nature of the relationship between these health impacts, traffic-related emissions, and the influence of confounding factors such as traffic noise are not known at this time (Samet 2007).

The production of biofuels could, depending on the mix of agricultural crops or crop residues used in its production, affect food prices. The International Food Policy Research Institute states, "An aggressive biofuel scenario that assumes that current plans for expansion of the sector in Africa, Asia, Europe, and North and South America are actually realized could lead to substantial price increases for some food crops by 2020 – about 80 percent for oilseeds and about 40 percent for maize – unless new technologies are developed that increase efficiency and productivity in both crop production and biofuel processing" (von Braun and Pachauri 2006). Such an increase in food prices would disproportionately affect low income and minority populations, because these groups are less likely to be capable of absorbing the impacts of higher prices.

3.5.9.2 Environmental Consequences

The projected reduction in fuel production and consumption as a result of the action alternatives could lead to a minor reduction in the amount of direct land disturbance as a result of oil exploration and extraction, and the amount of air pollution produced by the oil refineries. There could be corresponding decreases in impacts on environmental justice populations as a result of the alternatives, but the effects of any such decreases are not quantifiable and would likely be minor, if they occurred.

As discussed in Section 3.3, the overall decrease in emissions predicted to occur as a result of the new CAFE standards is not evenly distributed due to the increase in VMT from the rebound effect and regional changes in upstream emissions. As a result, some criteria and toxic air pollutants are predicted to increase in some air quality nonattainment areas. The large size of each nonattainment area, the uniform distribution of increases in VMT, and the minor emissions increases in affected nonattainment and other areas make it unlikely that there would be disproportionate effects to environmental justice populations.

All of the alternatives could lead to an increase in the production of biofuels, depending on the mix of tools manufacturers use to meet the increased CAFE standards, economic demands from consumers and manufacturers, and technological developments. If grain-based biofuel production increases, there could be effects on food prices. However, because of the uncertainty surrounding how manufacturers would meet the new requirements, and the fact that none of the alternatives prescribes increased biofuel use, these potential impacts are not quantifiable.