Phase 2 Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles

Final EIS Summary

August 2016

Docket No. NHTSA-2014-0074

U.S. Department of Transportation
National Highway Traffic Safety Administration

NHTSA

SUMMARY

Foreword

The National Highway Traffic Safety Administration (NHTSA) prepared this Environmental Impact Statement (EIS) to analyze and disclose the potential environmental impacts of the Phase 2 fuel efficiency standards for commercial medium-duty and heavy-duty on-highway engines, vehicles, and trailers (hereinafter referred to collectively as "HD vehicles") for model years (MYs) 2018 and beyond (the Final Action).[1] NHTSA prepared this document pursuant to Council on Environmental Quality (CEQ) National Environmental Policy Act (NEPA) implementing regulations, U.S. Department of Transportation (DOT) Order 5610.1C, and NHTSA regulations.

This EIS compares the potential environmental impacts of five alternatives to regulating HD vehicle fuel efficiency for MYs 2018 and beyond, including Alternative 3 (the Preferred Alternative/Final Action), three other action alternatives, and Alternative 1 (the No Action Alternative), and analyzes the direct, indirect, and cumulative impacts of each action alternative relative to the No Action Alternative. The action alternatives NHTSA selected for evaluation encompass a reasonable range of alternatives to evaluate the potential environmental impacts of the Final Action and alternatives under NEPA. The EIS chapters and appendices provide or reference all relevant supporting information.

Background

The Energy Policy and Conservation Act of 1975 (EPCA) mandated that NHTSA establish and implement a regulatory program for motor vehicle fuel economy. As codified in Chapter 329 of Title 49 of the U.S. Code (U.S.C.), and as amended by the Energy Independence and Security Act of 2007 (EISA), EPCA sets forth specific requirements concerning the establishment of average fuel economy standards for passenger cars and light trucks, which are motor vehicles with a gross vehicle weight rating (GVWR) less than 8,500 pounds and medium-duty passenger vehicles with a GVWR less than 10,000 pounds. This regulatory program, known as the Corporate Average Fuel Economy Program (CAFE), was established to reduce national energy consumption by increasing the fuel economy of these vehicles.

EISA provided DOT—and NHTSA, by delegation—new authority to implement, through rulemaking and regulations, "a commercial medium- and heavy-duty on-highway vehicle and work truck fuel efficiency improvement program designed to achieve the maximum feasible improvement" for motor vehicles with a GVWR of 8,500 pounds or greater, except for medium-duty passenger vehicles that are already covered under CAFE. This broad sector (HD vehicles, as described above)—ranging from large pickups to sleeper-cab tractors—represents the second-largest contributor to oil consumption and greenhouse gas (GHG) emissions from the transportation sector, after passenger cars and light trucks. EISA directs NHTSA to "adopt and implement appropriate test methods, measurement metrics, fuel economy standards, and compliance and enforcement protocols that are appropriate, cost-effective, and

[1] The Final Action establishes new standards beginning with MY 2018 for trailers and MY 2021 for all of the other heavy-duty vehicle and engine categories, with stringency increases through MY 2027 for some segments. Standards will remain at the final stringency levels until amended by a future rulemaking.

technologically feasible for commercial medium- and heavy-duty on-highway vehicles and work trucks." This new authority permits NHTSA to set "separate standards for different classes of vehicles."

Consistent with these requirements and in consultation with the U.S. Environmental Protection Agency (EPA) and Department of Energy (DOE), NHTSA established the first fuel efficiency standards for HD engines and vehicles in September 2011, as part of a comprehensive HD National Program to reduce GHG emissions and fuel consumption for HD vehicles (trailers were not included in that phase). Those fuel-efficiency standards constitute the first phase (Phase 1) of the NHTSA HD Fuel Efficiency Improvement Program. They were established to begin in MY 2016 and remain stable through MY 2018, consistent with EISA's requirements. Although EISA prevented NHTSA from enacting mandatory standards before MY 2016, NHTSA established voluntary compliance standards for MYs 2014–2015 prior to mandatory regulation in MY 2016. Throughout this EIS, NHTSA refers to the rulemaking and EIS associated with the MY 2014–2018 HD vehicle fuel efficiency standards described in this paragraph as "Phase 1" or the "Phase 1 HD National Program."

In February 2014, the president directed NHTSA and EPA to develop and issue the next phase of HD vehicle fuel efficiency and GHG standards by March 2016, as stated in the White House's 2014 report *Improving the Fuel Efficiency of American Trucks – Bolstering Energy Security, Cutting Carbon Pollution, Saving Money and Supporting Manufacturing Innovation*. Consistent with this directive, NHTSA is establishing fuel efficiency standards for HD vehicles for MYs 2018 and beyond as part of a joint rulemaking with EPA to establish what is referred to as the Phase 2 HD National Program (also referred to as "Phase 2"). As with Phase 1 and as directed by EISA, NHTSA conducted the Phase 2 rulemaking in consultation with EPA and DOE.

Pursuant to NEPA, federal agencies proposing "major federal actions significantly affecting the quality of the human environment" must, "to the fullest extent possible," prepare "a detailed statement" on the environmental impacts of the proposed action, including alternatives to the proposed action. To inform its development of the Phase 2 standards, NHTSA prepared this EIS, which analyzes, discloses, and compares the potential environmental impacts of a reasonable range of action alternatives including the No Action Alternative. This EIS also identifies a Preferred Alternative, pursuant to CEQ NEPA implementing regulations, DOT Order 5610.1C, and NHTSA regulations. The Draft EIS was issued together with the Phase 2 Notice of Proposed Rulemaking (NPRM) on June 19, 2015. NHTSA is issuing this Final EIS concurrently with the Final Rule (Record of Decision), pursuant to 49 U.S.C. 304a (Pub. L. 114-94, 129 Stat. 1312, Section 1311(a)) and U.S. Department of Transportation *Final Guidance on MAP-21 Section 1319 Accelerated Decisionmaking in Environmental Reviews*.

Purpose and Need for the Action

NEPA requires that agencies develop alternatives to a proposed action based on the action's purpose and need. The purpose of this rulemaking is to continue to promote EPCA's goals of energy independence and security, as well as to improve environmental outcomes and national security, by continuing to implement an HD Fuel Efficiency Improvement Program that is "designed to achieve the maximum feasible improvement." Congress specified that, as part of the HD Fuel Efficiency Improvement Program, NHTSA must adopt and implement appropriate test methods, measurement metrics, fuel economy standards, and compliance and enforcement protocols. These required aspects of the program must be appropriate, cost effective, and technologically feasible for HD vehicles. In developing Phase 2, NHTSA has continued to consider these EISA requirements as well as relevant environmental and safety considerations.

Although the standards established under the Phase 1 HD National Program have locked in long-lasting gains in fuel efficiency, HD vehicle fuel consumption is still projected to grow as more trucks are driven more miles. For this reason, new standards extending beyond Phase 1 are needed to further improve energy security, save money for consumers and businesses, reduce harmful air pollution, and lower costs for transporting goods. The Final Action and alternatives analyzed in this EIS have, therefore, been developed to reflect the purpose and need specified by EPCA, EISA, the Phase 1 HD National Program, and the president's 2014 directive on developing Phase 2 HD vehicle fuel efficiency and GHG standards.

Final Action and Alternatives and Analysis Methodologies

NEPA requires an agency to compare the potential environmental impacts of its proposed action and a reasonable range of alternatives. NHTSA's Action is to set HD vehicle fuel efficiency standards for MYs 2018 and beyond as part of joint rulemaking with EPA to establish what is referred to as the Phase 2 HD National Program, in accordance with EPCA, as amended by EISA. The specific alternatives NHTSA selected, described below and in Section 2.2 of this EIS, encompass a reasonable range within which to set HD vehicle fuel efficiency standards and evaluate potential environmental impacts under NEPA. Pursuant to CEQ regulations, the agency has included a No Action Alternative (Alternative 1), which assumes that NHTSA would not issue a rule regarding HD vehicle fuel efficiency standards beyond Phase 1, and assumes that NHTSA's Phase 1 HD standards and EPA's Phase 1 HD vehicle GHG standards would continue indefinitely. This alternative provides an analytical baseline against which to compare the environmental impacts of the four action alternatives.

Alternatives

The specific alternatives selected by NHTSA encompass a reasonable range of alternatives by which to evaluate the potential environmental impacts of Phase 2 of the HD Fuel Efficiency Improvement Program under NEPA. At one end of this range is the No Action Alternative, which assumes that no action would occur under the HD National Program. In addition to the No Action Alternative, NHTSA examined four action alternatives, each of which would regulate the separate segments of the HD vehicle fleet differently. Each of these action alternatives would include fuel consumption standards for engines used in Classes 2b–8 vocational vehicles and tractors (specified as gallons of fuel per horsepower-hour [gal/100 bhp-hr]); overall vehicle standards for HD pickups and vans (specified as gal/100 miles), Classes 2b–8 vocational vehicles, and Classes 7–8 tractors (specified as gallons of fuel per 1,000 ton payload miles [gal/1,000 ton-miles]); and standards for certain trailers pulled by Classes 7–8 tractors (specified as gal/1,000 ton-miles associated with "standard" reference tractors).

In the Proposed Rule and Draft EIS, the Preferred Alternative and Alternative 4 were designed to achieve similar fuel efficiency and GHG emissions levels in the long term, but with Alternative 4 being accelerated in its implementation timeline. In practice, this meant that Alternative 4 was more stringent than the Preferred Alternative in the Draft EIS. In response to comments received on the Proposed Rule and

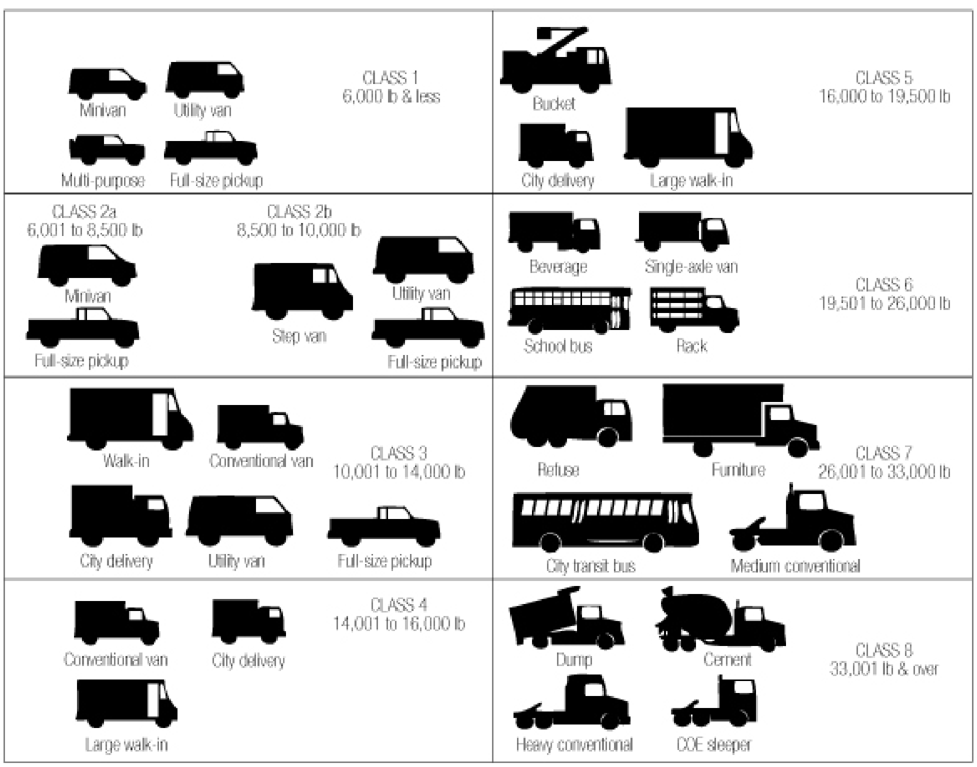
Draft EIS, the agencies revised the Preferred Alternative. As a result, the Final EIS standards for the Preferred Alternative are more stringent than the Draft EIS proposed standards for the Preferred Alternative. Standards for Alternative 4 in this Final EIS are the same as the Alternative 4 standards in the Draft EIS in order to provide a benchmark for comparison of the revised Preferred Alternative. Now, the Preferred Alternative is more stringent than Alternative 4 in this Final EIS for some vehicle categories. Under Alternative 2, standards are less stringent than the Preferred Alternative or Alternative 4. Alternative 5 represents more stringent standards compared to Alternatives 3 and 4. Alternatives 2 through 5 would regulate the same vehicle categories, with Alternative 2 being the least stringent alternative and Alternative 5 being the most stringent.

Table S-1 and Figure S-1 show the vehicle categories that are the subject of the Final Rule. Section I of the Final Rule and Section 2.2 provide more details about these vehicle categories and the specific standards for the Preferred Alternative and other action alternatives.

Table S-1. HD Vehicle Categories by Gross Vehicle Class Weight Rating (pounds)

Class 2b	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8
8,501–10,000	10,001–14,000	14,001–16,000	16,001–19,500	19,501–26,000	26,001–33,000	>33,000
HD Pickups and Vans (work trucks)						
Vocational Vehicles (*e.g.,* van trucks, utility “bucket” trucks, tank trucks, refuse trucks, buses, fire trucks, flat-bed trucks, and dump trucks)						
						Tractors (for combination tractor-trailers)

Figure S-1. HD Vehicle Categories



Potential Environmental Consequences

This section describes how the Final Action and alternatives could affect energy use, air quality, and climate (including non-climate impacts of carbon dioxide [CO_2]), as reported in Chapters 3, 4, and 5 of the EIS, respectively. The EIS also provides a life-cycle impact assessment of vehicle energy, materials, and technologies, as reported in Chapter 6 of the EIS. This EIS also qualitatively describes potential additional impacts on hazardous materials and regulated wastes, historic and cultural resources, safety impacts on human health, noise, and environmental justice, as reported in Chapter 7 of the EIS.

The impacts on energy use, air quality, and climate described in the EIS include *direct*, *indirect*, and *cumulative impacts*. Direct impacts occur at the same time and place as the action. Indirect impacts occur later in time and/or are farther removed in distance. Cumulative impacts are the incremental direct and indirect impacts resulting from the action added to those of other past, present, and reasonably foreseeable future actions.

To derive the impacts of the action alternatives, NHTSA compares the action alternatives to the No Action Alternative. The action alternatives in the direct and indirect impacts analysis and the cumulative impacts analysis are the same, but the No Action Alternative under each analysis reflects different assumptions to distinguish between direct and indirect impacts versus cumulative impacts.

- The analysis of direct and indirect impacts compares action alternatives with a No Action Alternative that generally reflects a small forecast improvement in the average fuel efficiency of new HD vehicles after 2018 due to market-based incentives for improving fuel efficiency. In this way, the analysis of direct and indirect impacts isolates the portion of the fleet-wide fuel efficiency improvement attributable directly and indirectly to the rule, and not attributable to reasonably foreseeable future actions by manufacturers after 2018 to improve new HD vehicle fuel efficiency even in the absence of new regulatory requirements.
- The analysis of cumulative impacts compares action alternatives with a No Action Alternative that generally reflects no forecast improvement in the average fuel efficiency of new HD vehicles after 2018. As a result, the difference between the environmental impacts of the action alternatives and the cumulative impacts baseline reflects the combined impacts of market-based incentives for improving fuel efficiency after 2018 (i.e., reasonably foreseeable future changes in HD vehicle fuel efficiency) and the direct and indirect impacts of the Phase 2 standards associated with each action alternative. Therefore, this analysis reflects the cumulative impacts of reasonably foreseeable improvements in fuel efficiency after 2018 due to market-based incentives in addition to the direct and indirect impacts of the Phase 2 HD standards associated with each action alternative.

Energy

NHTSA’s Phase 2 standards regulate HD vehicle fuel efficiency and, therefore, affect U.S. transportation fuel consumption. Transportation fuel comprises a large portion of total U.S. energy consumption and energy imports and has a significant impact on the functioning of the energy sector as a whole. Because transportation fuel consumption will account for most U.S. net energy imports through 2040 (as explained in Chapter 3 of the EIS), the United States has the potential to achieve large reductions in imported oil use and, consequently, in net energy imports during this time by improving the fuel efficiency of HD vehicles. Reducing dependence on energy imports is a key component of President

Obama's May 29, 2014, *All-of-the-Above Energy Strategy*, which states that the development of HD Phase 2 standards "will lead to large savings in fuel, lower carbon dioxide (CO_2) emissions, and health benefits from reduced particulate matter and ozone."

Energy intensity measures the efficiency at which energy is converted to Gross Domestic Product (GDP), with a high value indicating an inefficient conversion of energy to GDP and a lower value indicating a more efficient conversion. From 2000 to 2011, the United States recorded substantial GDP growth with almost no increase in energy consumption because of reductions in energy intensity. The Annual Energy Outlook (AEO) 2015 forecasts ongoing declines in U.S. energy intensity, with average 2013–2040 GDP growth of 2.4 percent per year resulting in average annual energy consumption growth of just 0.3 percent.

Although U.S. energy efficiency has been increasing and the U.S. share of global energy consumption has been declining in recent decades, total U.S. energy consumption has been increasing over that same period. Most of the increase in U.S. energy consumption over the past decades has not come from increased domestic energy production but instead from the increase in imports, largely for use in the transportation sector. Transportation fuel consumption has grown steadily on an annual basis. Transportation is now the largest consumer of petroleum in the U.S. economy and a major contributor to U.S. net imports.

Petroleum is by far the largest source of energy used in the transportation sector. In 2012, petroleum supplied 92 percent of transportation energy demand, and in 2040, petroleum is expected to supply 87 percent of transportation energy demand. Consequently, transportation accounts for the largest share of total U.S. petroleum consumption. In 2012, the transportation sector accounted for 79 percent of total U.S. petroleum consumption. In 2040, transportation is expected to account for 75 percent of total U.S. petroleum consumption.

With petroleum expected to account for all U.S. net energy imports in 2040 and transportation expected to account for 75 percent of total petroleum consumption, U.S. net energy imports in 2040 are expected to result primarily from fuel consumption by light-duty and HD vehicles. The United States is poised to reverse the trend of the last 4 decades and achieve large reductions in net energy imports through 2040 due to continuing increases in U.S. energy efficiency and recent developments in U.S. energy production. Stronger fuel efficiency standards for HD vehicles have the potential to increase U.S. energy efficiency in the transportation sector further and reduce U.S. dependence on petroleum.

In the future, the transportation sector will continue to be the largest component of U.S. petroleum consumption and the second-largest component of total U.S. energy consumption, after the industrial sector. NHTSA's analysis of fuel consumption in this EIS assumes that fuel consumed by HD vehicles will consist predominantly of gasoline and diesel fuel derived from petroleum for the foreseeable future.

Key Findings for Energy Use

To calculate fuel savings for each action alternative, NHTSA subtracted projected fuel consumption under each action alternative from the level under the No Action Alternative. The fuel consumption and savings figures presented below are for 2019–2050 (2050 is the year by which nearly the entire U.S. HD vehicle fleet will most likely be composed of vehicles that are subject to the Phase 2 standards).

Direct and Indirect Impacts

As the alternatives increase in stringency, total fuel consumption decreases. Table S-2 shows total 2019–2050 fuel consumption for each alternative and the direct and indirect fuel savings for each action alternative compared with the No Action Alternative through 2050. This table reports total 2019–2050 fuel consumption in diesel gallon equivalents (DGE) for diesel, gasoline, natural gas (NG), and E85 fuel for HD pickups and vans (Classes 2b–3), vocational vehicles (Classes 2b–8), and tractor-trailers (Classes 7–8) for each alternative. Gasoline accounts for approximately 56 percent of HD pickup and van fuel use, 21 percent of vocational vehicle fuel use, and just 0.0001 percent of tractor-trailer fuel use. E85 accounts for less than 0.4 percent of HD pickup and van fuel use, and NG accounts for less than 1 percent of vocational vehicle and HD pickup and van fuel use. Diesel accounts for approximately 43 percent of HD pickup and van fuel use, 78 percent of vocational vehicle fuel use, and 100 percent of tractor trailer fuel use.

Table S-2. Direct and Indirect HD Vehicle Fuel Consumption and Fuel Savings Impacts by Alternative, 2019–2050

	Billion Diesel Gallon Equivalents (DGE)				
	Alt. 1 – No Action	**Alt. 2**	**Alt. 3 – Preferred**	**Alt. 4**	**Alt. 5**
Fuel Consumption					
HD Pickups and Vans	296.5	282.7	272.1	271.2	267.5
Vocational Vehicles	364.1	344.8	324.3	330.3	316.5
Tractor Trucks and Trailers	1,182.9	1,130.1	1,015.9	1,041.7	972.4
All HD Vehicles	**1,843.6**	**1,757.6**	**1,612.4**	**1,643.3**	**1,556.4**
Fuel Savings Compared to Alt. 1 – No Action					
HD Pickups and Vans	--	13.8	24.4	25.3	29.0
Vocational Vehicles	--	19.3	39.8	33.8	47.6
Tractor Trucks and Trailers	--	52.8	167.0	141.2	210.6
All HD Vehicles	**--**	**85.9**	**231.2**	**200.3**	**287.1**

Total fuel consumption from 2019 through 2050 across all HD vehicle classes under the No Action Alternative is projected to amount to 1,843.6 billion DGE. Total projected 2019–2050 fuel consumption across the action alternatives ranges from 1,757.6 billion DGE under Alternative 2 to 1,556.4 billion DGE under Alternative 5. Less fuel would be consumed under each of the action alternatives than under the No Action Alternative, with total 2019–2050 direct and indirect fuel savings ranging from 85.9 billion DGE under Alternative 2 to 287.1 billion DGE under Alternative 5. Under the Preferred Alternative, total projected fuel consumption from 2019–2050 would be 1,612.4 billion DGE, and direct and indirect fuel savings compared with the No Action Alternative would be 231.2 billion DGE.

Cumulative Impacts

As with direct and indirect impacts, fuel consumption under each action alternative would decrease with increasing stringency under the cumulative impacts analysis, which incorporates other past, present, and reasonably foreseeable future actions that would lead to improvements in HD vehicle fuel efficiency. Table S-3 shows total 2019–2050 fuel consumption for each alternative and the cumulative fuel savings for each action alternative compared with the No Action Alternative through 2050. Total 2019–2050 fuel consumption for each action alternative in this table is the same as shown for the corresponding action alternative in Table S-2. The No Action Alternative's fuel consumption is higher in Table S-3 than in Table S-2 because the No Action Alternative's fuel consumption in Table S-3 generally does not reflect forecast improvements in the average fuel efficiency of new HD vehicles MYs 2018 and beyond due to market forces. The cumulative impact fuel savings resulting from each action alternative are higher in Table S-3 than the direct and indirect impact fuel savings reported in Table S-2 because the fuel savings in Table S-3 reflect the cumulative impact of market-based incentives for improving fuel efficiency after 2018, plus the direct and indirect impacts of the Phase 2 HD standards associated with each action alternative.

Table S-3. Cumulative HD Vehicle Fuel Consumption and Fuel Savings Impacts by Alternative, 2019–2050

	Billion Diesel Gallon Equivalents (DGE)				
	Alt. 1 – No Action	**Alt. 2**	**Alt. 3 – Preferred**	**Alt. 4**	**Alt. 5**
Fuel Consumption					
HD Pickups and Vans	298.6	282.7	272.1	271.2	267.5
Vocational Vehicles	364.1	344.8	324.3	330.3	316.5
Tractor Trucks and Trailers	1,203.2	1,130.1	1,015.9	1,041.7	972.4
All HD Vehicles	**1,865.9**	**1,757.6**	**1,612.4**	**1,643.3**	**1,556.4**
Fuel Savings Compared to Alt. 1 – No Action					
HD Pickups and Vans	--	15.9	26.5	27.4	31.1
Vocational Vehicles	--	19.3	39.8	33.8	47.6
Tractor Trucks and Trailers	--	73.0	187.3	161.4	230.8
All HD Trucks	**--**	**108.3**	**253.5**	**222.6**	**309.4**

Total fuel consumption from 2019 through 2050 across all HD vehicle classes under the No Action Alternative in Table S-3 is projected to amount to 1,865.9 billion DGE. Total 2019–2050 projected fuel consumption across alternatives ranges from 1,757.6 billion DGE under Alternative 2 to 1,556.4 billion DGE under Alternative 5. Less fuel would be consumed under each of the action alternatives than under the No Action Alternative, with total 2019–2050 cumulative fuel savings ranging from 108.3 billion DGE under Alternative 2 to 309.4 billion DGE under Alternative 5. Under the Preferred Alternative, total projected fuel consumption from 2019–2050 would be 1,612.4 billion DGE, and cumulative fuel savings compared with the No Action Alternative would be 253.5 billion DGE.

Air Quality

Air pollution and air quality can affect public health, public welfare, and the environment. The Final Action and alternatives under consideration would affect air pollutant emissions and air quality. The EIS air quality analysis assesses the impacts of the alternatives in relation to emissions of pollutants of concern from mobile sources, the resulting impacts on human health, and the monetized health benefits of emissions reductions. Although air pollutant emissions generally decline under the action alternatives compared with the No Action Alternative, the magnitudes of the declines are not consistent across all pollutants (and some air pollutant emissions might increase). This inconsistency reflects the complex interactions between tailpipe emissions rates of the various vehicle types, the technologies NHTSA assumes manufacturers will incorporate to comply with the standards, upstream emissions rates, the relative proportions of gasoline and diesel in total fuel consumption reductions, and increases in vehicle miles traveled (VMT).

Under the authority of the Clean Air Act and its amendments, EPA has established National Ambient Air Quality Standards (NAAQS) for six relatively common air pollutants, known as “criteria” pollutants because EPA regulates them by developing human health-based or environmentally based criteria for setting permissible levels. The criteria pollutants are carbon monoxide (CO), nitrogen dioxide (NO_2), ozone, sulfur dioxide (SO_2), lead, and particulate matter (PM) with an aerodynamic diameter equal to or less than 10 microns (PM10) and 2.5 microns (PM2.5, or fine particles). Ozone is not emitted directly from vehicles but is formed from emissions of ozone precursor pollutants such as nitrogen oxides (NO_X) and volatile organic compounds (VOCs).

In addition to criteria pollutants, motor vehicles emit some substances defined by the 1990 Clean Air Act amendments as hazardous air pollutants. Hazardous air pollutants include certain VOCs, compounds in PM, pesticides, herbicides, and radionuclides that present tangible hazards based on scientific studies of human (and other mammal) exposure. Hazardous air pollutants 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 have identified these air toxics as the MSATs that typically are of greatest concern when analyzing impacts of highway vehicles. DPM is a component of exhaust from diesel-fueled vehicles and falls almost entirely within the PM2.5 particle-size class.

Health Effects of the Pollutants

The criteria pollutants assessed in the EIS have been shown to cause a range of adverse health effects at various concentrations and exposures, including:

- Damage to lung tissue
- Reduced lung function
- Exacerbation of existing respiratory and cardiovascular diseases
- Difficulty breathing
- Irritation of the upper respiratory tract
- Bronchitis and pneumonia
- Reduced resistance to respiratory infections
- Alterations to the body’s defense systems against foreign materials
- Reduced delivery of oxygen to the body’s organs and tissues
- Impairment of the brain’s ability to function properly
- Cancer and premature death

MSATs are also associated with adverse health effects. For example, EPA classifies acetaldehyde, benzene, 1,3-butadiene, formaldehyde, and certain components of DPM as either known or probable human carcinogens. Many MSATs are also associated with non-cancer health effects, such as respiratory irritation.

Contribution of U.S. Transportation Sector to Air Pollutant Emissions

The U.S. transportation sector is a major source of emissions of certain criteria pollutants or their chemical precursors. Emissions of these pollutants from on-road mobile sources have declined dramatically since 1970 as a result of pollution controls on vehicles and regulation of the chemical content of fuels. Nevertheless, the U.S. transportation sector remains a major source of emissions of certain criteria pollutants or their chemical precursors. On-road mobile sources (i.e., highway vehicles, including vehicles covered by the Final Rule) are responsible for 24,796,000 tons per year of CO (34 percent of total U.S. emissions), 185,000 tons per year (3 percent) of PM2.5 emissions, and 268,000 tons per year (1 percent) of PM10 emissions. HD vehicles contribute 6 percent of U.S. highway emissions of CO, 66 percent of highway emissions of PM2.5, and 55 percent of highway emissions of PM10. Almost all of the PM in motor vehicle exhaust is PM2.5; therefore, this analysis focuses on PM2.5 rather than PM10. On-road mobile sources also contribute 2,161,000 tons per year (12 percent of total nationwide emissions) of VOCs and 5,010,000 tons per year (38 percent) of NO_X emissions, which are chemical precursors of ozone. HD vehicles contribute 8 percent of U.S. highway emissions of VOCs and 50 percent of NO_X. In addition, NO_X is a PM2.5 precursor, and VOCs can be PM2.5 precursors. SO_2 and other oxides of sulfur (SO_X) are important because they contribute to the formation of PM2.5 in the atmosphere; however, on-road mobile sources account for less than 0.56 percent of U.S. SO_2 emissions. With the elimination of lead in automotive gasoline, lead is no longer emitted from motor vehicles in more than negligible quantities and is therefore not assessed in this analysis.

Methodology

To analyze air quality and human health impacts, NHTSA calculated the emissions of criteria pollutants and MSATs from HD vehicles that would occur under each alternative. NHTSA then estimated the resulting changes in emissions under each action alternative by comparing emissions under that alternative to those under the No Action Alternative. The resulting changes in air quality and effects on human health were assumed to be proportional to the changes in emissions projected to occur under each action alternative.

The air quality results, including impacts on human health, are based on a number of assumptions about the type and rate of emissions from the combustion of fossil fuels. In addition to tailpipe emissions, this analysis accounts for upstream emissions from the production and distribution of fuels. To estimate Classes 2b–3 upstream emissions changes resulting from the decreased downstream fuel consumption, the analysis uses the Volpe HD model, which incorporates emissions factors from the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation model (GREET) model (2013 version developed by the U.S. Department of Energy Argonne National Laboratory). The Volpe HD model uses the decreased volumes of the fuels along with the emissions factors from GREET for the various fuel production and transport processes to estimate the net changes in upstream emissions as a result of fuel consumption changes. To estimate Classes 4–8 upstream emissions, the analysis uses a spreadsheet model developed by EPA that uses an identical methodology based on GREET emissions factors.

Key Findings for Air Quality

The findings for air quality effects are shown for 2040 in this summary, a mid-term forecast year by which time a large proportion of HD vehicle miles traveled would be accounted for by vehicles that meet the Phase 2 standards. The EIS provides findings for air quality effects for 2018, 2025, 2040, and 2050. In general, emissions of criteria air pollutants decrease with increased stringency across alternatives, with few exceptions. The changes in emissions reflect the complex interactions among the tailpipe emissions rates of the various vehicle types, the technologies assumed to be incorporated by manufacturers in response to the Phase 2 standards, upstream emissions rates, the relative proportions of gasoline and diesel in total fuel consumption reductions, and increases in VMT. To estimate the reduced incidence of PM2.5-related adverse health effects and the associated monetized health benefits from the emissions reductions, NHTSA multiplied direct PM2.5 and PM2.5 precursor (NO_X, SO_2, and VOCs) emissions reductions by EPA-provided pollutant-specific benefit-per-ton estimates. Reductions in adverse health outcomes include reduced incidences of premature mortality, acute bronchitis, respiratory emergency room visits, and work-loss days.

Direct and Indirect Impacts

Criteria Pollutants

- Emissions of criteria pollutants are highest under the No Action Alternative; they decline as fuel consumption decreases from the least stringent action alternative (Alternative 2) to the most stringent alternative (Alternative 5), with the exception of Alternative 4 for some pollutants and years, and CO emissions which increase slightly under all action alternatives in 2018 (Figure S-2). Many of the emissions changes are relatively small, especially for CO and PM2.5, which were reduced by less than 13 percent in 2040 under all alternatives.
- Emissions reductions were greatest under Alternative 5 for all criteria pollutants (except CO in 2018). By 2050 these reductions ranged from 7 percent for CO to 22 percent for SO_2.
- Under the Preferred Alternative, emissions of all criteria pollutants in 2040 are reduced compared to emissions under the No Action Alternative. By 2050 these reductions ranged from 4 percent for CO to 19 percent for SO_2.

Hazardous Air Pollutants

- Emissions of MSATs are highest under the No Action Alternative; they decline as fuel consumption decreases from the least stringent action alternative (Alternative 2) to the most stringent alternative (Alternative 5), with the exception of Alternatives 2, 4, and 5 for acrolein and 1,3-butadiene (Figure S-3). The emissions changes are relatively small, less than 8 percent for all MSATs under all alternatives and years.
- Emissions changes were greatest under Alternatives 4 and 5 for all MSATs, with the exception that changes in acetaldehyde and acrolein emissions were greatest under the Preferred Alternative in some years. By 2050 these changes ranged from a reduction of 8 percent for benzene (under Alternative 5) to an increase of 5 percent for 1,3-butadiene (under Alternative 4).

Figure S-2. Nationwide Criteria Pollutant Emissions (tons/year) from U.S. HD Vehicles for 2040 by Alternative, Direct and Indirect Impacts

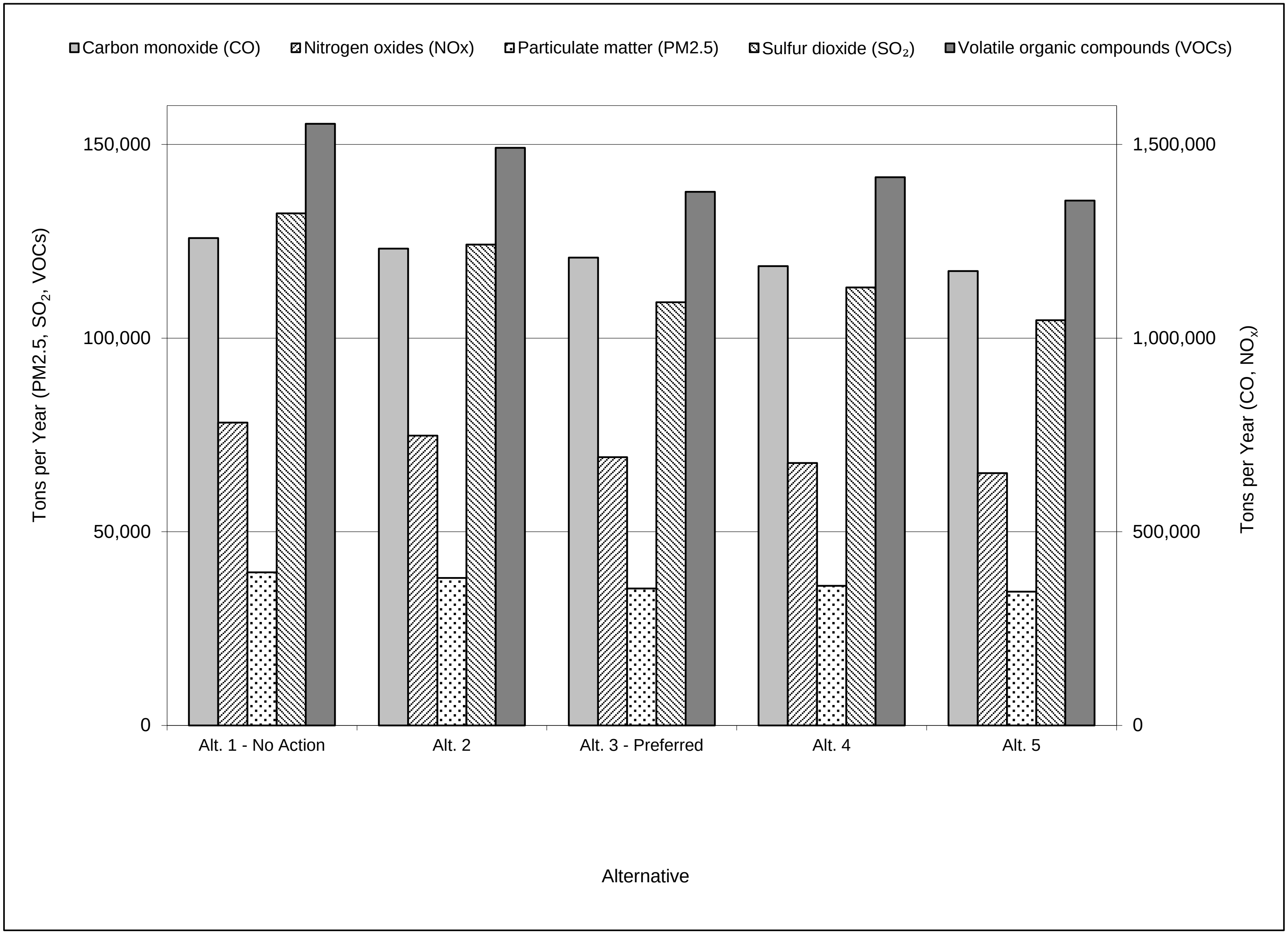
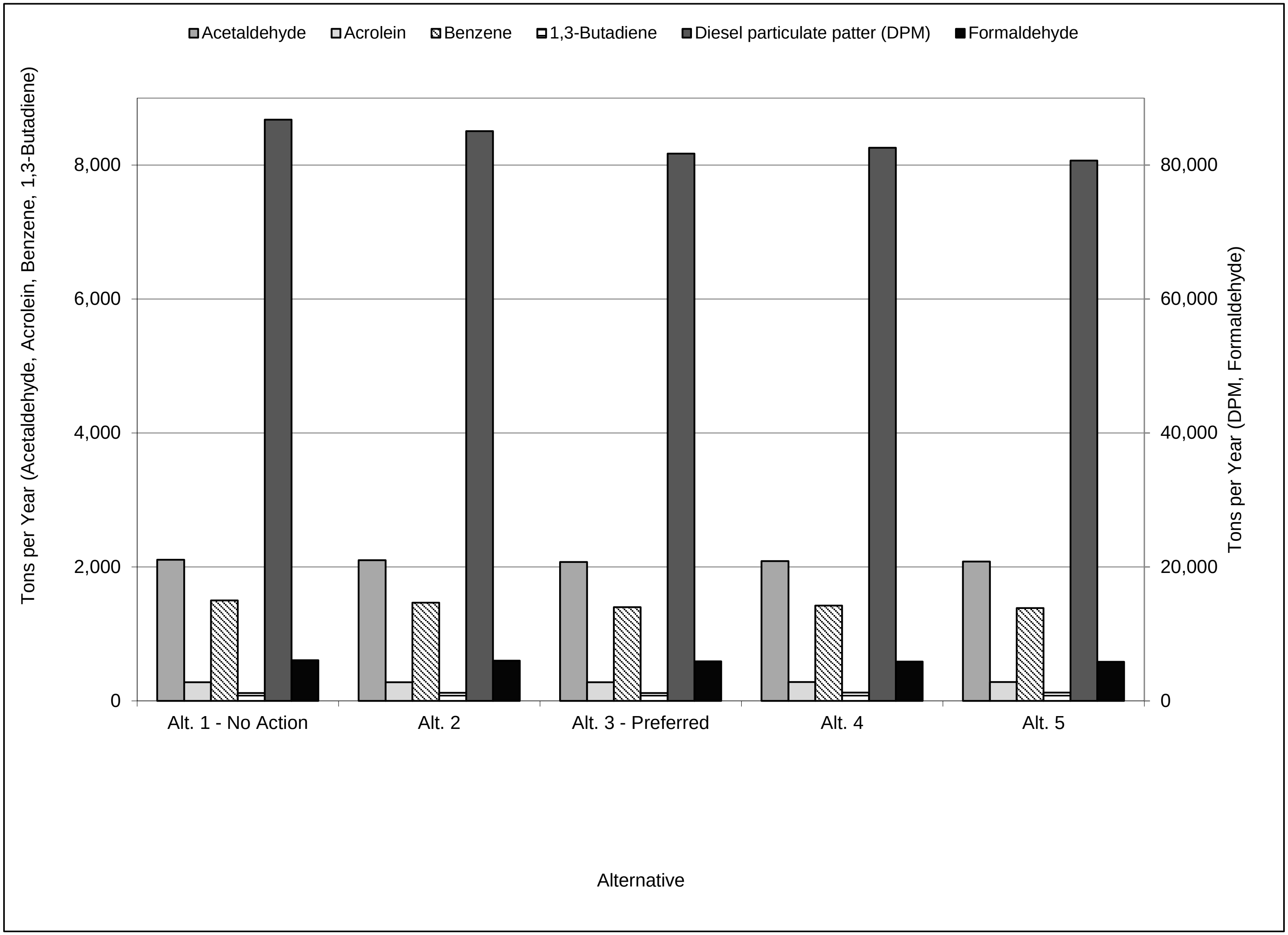


Figure S-3. Nationwide Toxic Air Pollutant Emissions (tons/year) from U.S. HD Vehicles for 2040 by Alternative, Direct and Indirect Impacts



- Under the Preferred Alternative, emissions of all MSATs in 2040 are reduced compared to emissions under the No Action Alternative. Under the Preferred Alternative by 2050, emissions of 1,3-butadiene were reduced by less than 1 percent, emissions of acrolein by 1 percent, emissions of acetaldehyde by 2 percent, emissions of formaldehyde by 3 percent, emissions of DPM by 6 percent, and emissions of benzene by 7 percent.

Health and Monetized Health Benefits

- All action alternatives would generally result in reduced adverse health effects (mortality, acute bronchitis, respiratory emergency room visits, and work-loss days) nationwide compared with the No Action Alternative, with increasing reductions from the least stringent (Alternative 2) to the most stringent (Alternative 5) alternatives, with the exception of Alternative 4 in some analysis years.
- Because monetized health benefits increase with reductions in adverse health effects, monetized benefits increase across alternatives along with increasing HD vehicle fuel efficiency standards, again with the exception of Alternative 4 in some analysis years. When estimating quantified and monetized health impacts, EPA relies on results from two PM2.5-related premature mortality studies it considers equivalent: Krewski et al. (2009) and Lepeule et al. (2012). EPA recommends that monetized benefits be shown by using incidence estimates derived from each of these studies and valued using a 3 percent and a 7 percent discount rate to account for an assumed lag in the occurrence of mortality after exposure, for a total of four separate calculations of monetized health benefits. Using these four calculations, estimated monetized health benefits in 2040 range from $1.8 billion to $15.5 billion under all action alternatives.
- Estimated monetized health benefits in 2040 range from $1.8 to $4.4 billion under Alternative 2, $5.0 to $12.4 billion under the Preferred Alternative, $4.5 to $11.2 billion under Alternative 4, and $6.2 to $15.5 billion under Alternative 5.

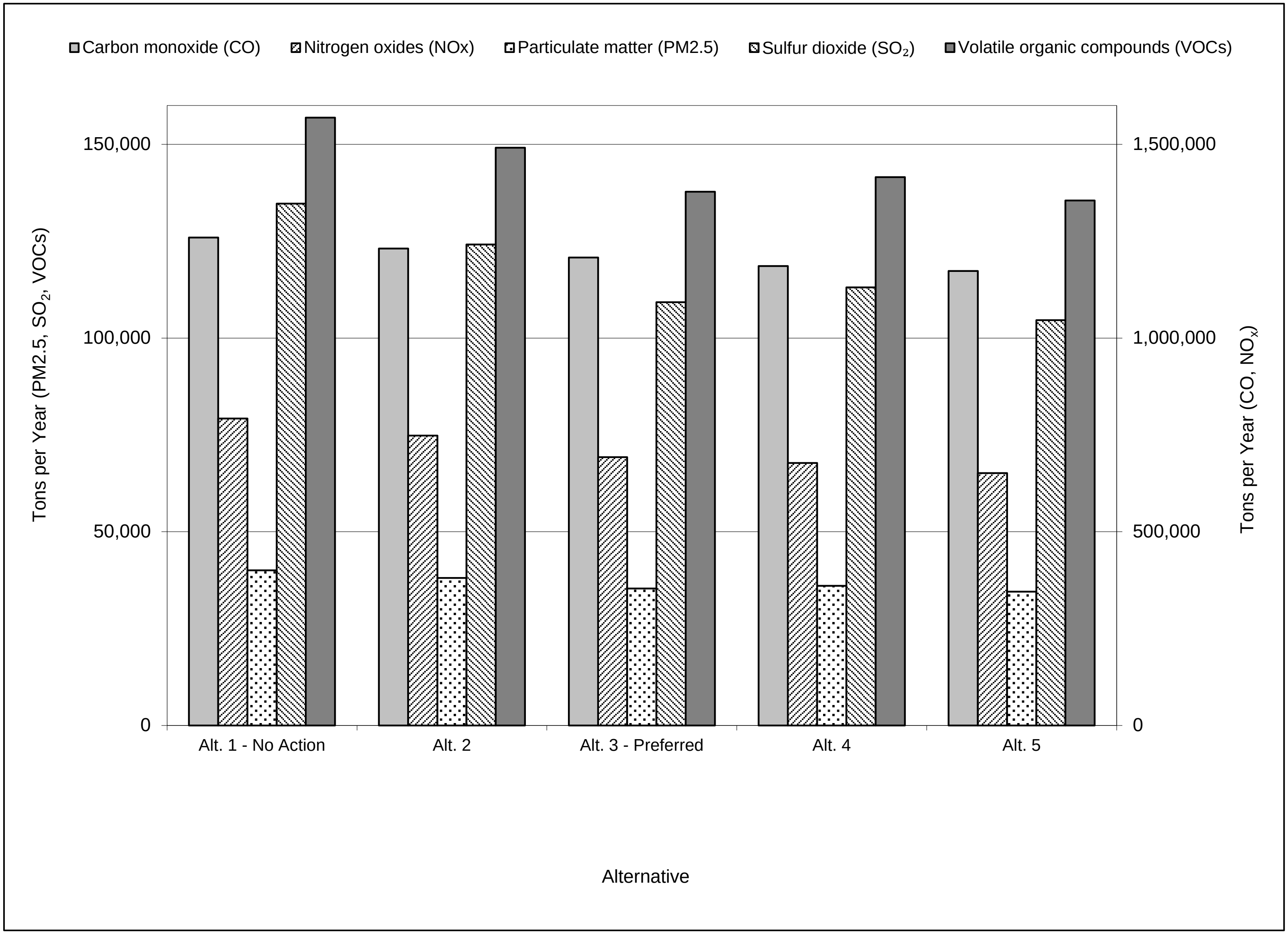
See Section 4.2.1 of this EIS for data on the direct effects of criteria and hazardous air pollutant emissions and the monetized health benefits for the alternatives.

Cumulative Impacts

Criteria Pollutants

- Cumulative emissions of criteria pollutants are highest under the No Action Alternative; they decline as fuel consumption decreases across the action alternatives, with the exception of Alternative 4 for some pollutants and years, and CO emissions which increase slightly under all action alternatives in 2018. Many of the emissions changes are relatively small, especially for CO and PM2.5, which were reduced by 14 percent or less in 2040 under all alternatives (Figure S-4).
- Emissions reductions were greatest under Alternative 5 for all criteria pollutants (except CO in 2018). By 2050 these reductions ranged from 7 percent for CO to 24 percent for SO_2.
- Under the Preferred Alternative, emissions of all criteria pollutants in 2040 are reduced compared to emissions under the No Action Alternative. By 2050 these reductions ranged from 4 percent for CO to 17 percent for SO_2**.**

Figure S-4. Nationwide Criteria Pollutant Emissions (tons/year) from U.S. HD Vehicles for 2040 by Alternative, Cumulative Impacts



Hazardous Air Pollutants

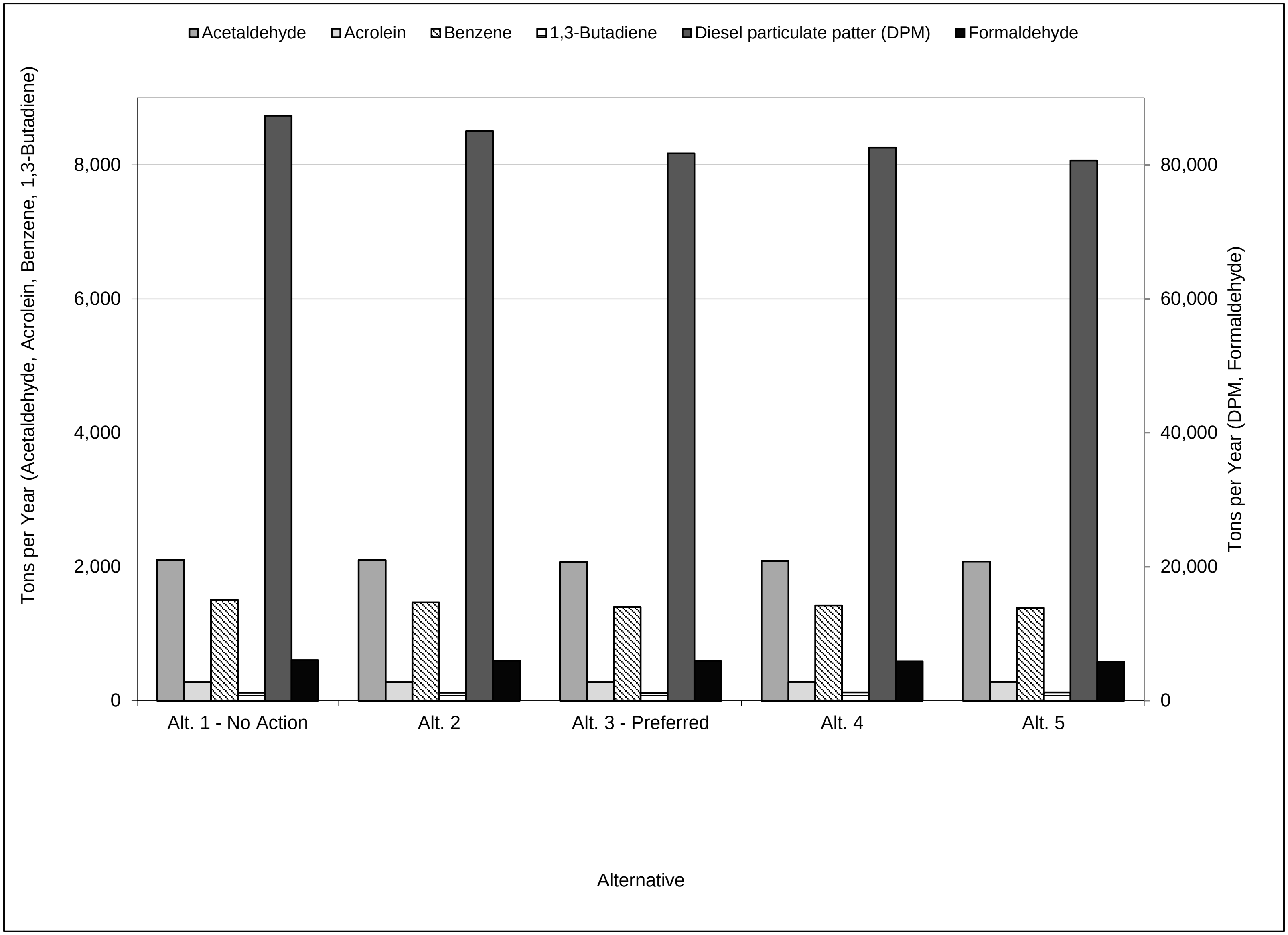
- Emissions of MSATs are highest under the No Action Alternative; they generally decline as fuel consumption decreases from the least stringent action alternative (Alternative 2) to the most stringent alternative (Alternative 5), with the exception of Alternatives 2, 4, and 5 for acrolein and 1,3-butadiene (Figure S-5). The emissions changes are relatively small, less than 9 percent for all MSATs under all alternatives and years.
- Emissions changes were greatest under Alternatives 4 and 5 for all MSATs, with the exception that changes in acetaldehyde and acrolein emissions were greatest under the Preferred Alternative in some years. By 2050 these reductions ranged from a reduction of 9 percent for benzene (under Alternative 5) to an increase of 4 percent for 1,3-butadiene (under Alternative 4).
- Under the Preferred Alternative, emissions of all MSATs in 2040 are the same or reduced compared to emissions under the No Action Alternative. By 2050, emissions of 1,3-butadiene were reduced by less than 1 percent, emissions of acrolein by 1 percent, emissions of acetaldehyde by 1 percent, emissions of formaldehyde by 3 percent, emissions of DPM by 7 percent, and emissions of benzene by 8 percent.

Health and Monetized Health Benefits

- All action alternatives would generally result in reduced adverse health effects (mortality, acute bronchitis, emergency room visits for asthma, and work-loss days) nationwide compared with the No Action Alternative, with the same or increasing reductions from the least stringent (Alternative 2) to the most stringent (Alternative 5) alternatives, with the exception of Alternative 4 in some analysis years.
- Estimated monetized health benefits in 2040 range from $2.3 to $17.0 billion for all alternatives.
- Estimated monetized health benefits in 2040 range from $2.3 to $5.8 billion under Alternative 2, $5.6 to $13.9 billion under the Preferred Alternative, $5.1 to $12.6 billion under Alternative 4, and $6.8 to $17.0 billion under Alternative 5.

See Section 4.2.2 of this EIS for cumulative impacts data on criteria and hazardous air pollutant emissions and the monetized health benefits for the alternatives.

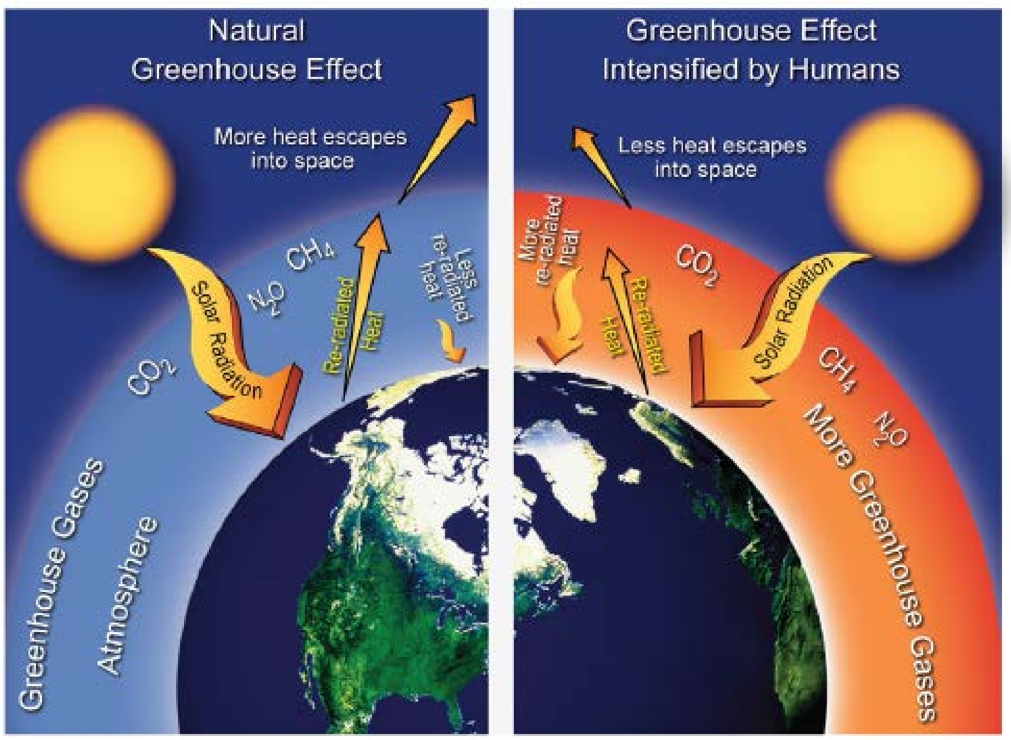
Figure S-5. Nationwide Toxic Air Pollutant Emissions (tons/year) from U.S. HD Vehicles for 2040 by Alternative, Cumulative Impacts



Climate

Earth absorbs heat energy from the sun and returns most of this heat to space as terrestrial infrared radiation. GHGs trap heat in the lower atmosphere (the atmosphere extending from Earth's surface to approximately 4 to 12 miles above the surface) by absorbing heat energy emitted by Earth's surface and lower atmosphere, and reradiating much of it back to Earth's surface, thereby causing warming. This process, known as the *greenhouse effect*, is responsible for maintaining surface temperatures that are warm enough to sustain life. Most GHGs, including CO_2, methane (CH_4), nitrous oxide (N_2O), water vapor, and ozone, occur naturally. Human activities, particularly fossil-fuel combustion, lead to the presence of increased concentrations of GHGs in the atmosphere, thereby intensifying the warming associated with the Earth's greenhouse effect (Figure S-6).

Figure S-6. Human Influence on the Greenhouse Effect



Source: GCRP (U.S. Global Change Research Program) 2014. Global Climate Change Impacts in the United States. 2014: Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program. Washington, DC.

Since the industrial revolution, when fossil fuels began to be burned in increasing quantities, concentrations of GHGs in the atmosphere have increased. Atmospheric concentrations of CO_2 have increased by more than 40 percent since pre-industrial times, while the concentration of CH_4 is now 150 percent above pre-industrial levels. This buildup of GHGs in the atmosphere is changing the Earth's energy balance and causing the planet to warm, which in turn affects sea levels, precipitation patterns, cloud cover, ocean temperatures and currents, and other climatic conditions. Scientists refer to this phenomenon as "global climate change."

During the past century, Earth's surface temperature has risen by approximately 0.8 degree Celsius (°C) (1.4 degrees Fahrenheit [°F]), and sea levels have risen 19 centimeters (7.5 inches), with a rate of increase of approximately 3.2 millimeters (0.13 inch) per year from 1993 to 2010. These observed changes in the global climate are largely a result of GHG emissions from human activities. The United Nations Environment Programme and the World Meteorological Organization established Intergovernmental Panel on Climate Change (IPCC) has concluded that "[H]uman influence has been detected in warming of the atmosphere and the ocean, in changes in the global water cycle, in reductions in snow and ice, in global mean sea-level rise, and in changes in some climate extremes…It is *extremely likely* that human influence has been the dominant cause of the observed warming since the mid-20th century."

Throughout this EIS, NHTSA has relied extensively on findings of the IPCC, U.S. Climate Change Science Program (CCSP), National Research Council (NRC), Arctic Council, U.S. Global Change Research Program (GCRP), and EPA. This discussion focuses heavily on the most recent thoroughly peer-reviewed and credible assessments of global and U.S. climate change. *See* Section 5.1 of this EIS for more detail.

Impacts of Climate Change

Climate change is expected to have a wide range of effects on temperature, sea level, precipitation patterns, and severe weather events, which in turn could affect human health and safety, infrastructure, food and water supplies, and natural ecosystems. For example:

- Impacts on freshwater resources could include changes in water demand such as significant increases in irrigation needs, water shortages, general variability in water supply, and increasing flood risk in response to flooding, drought, changes in snowpack and the timing of snow melt, changes in weather patterns, and saltwater intrusions from sea-level rise.
- Impacts on terrestrial and freshwater ecosystems could include shifts in the range and seasonal migration patterns of species, relative timing of species' life-cycle events, potential extinction of sensitive species that are unable to adapt to changing conditions, increases in the occurrence of forest fires and pest infestations, and changes in habitat productivity due to increased atmospheric concentrations of CO_2.
- Impacts on ocean systems, coastal, and low-lying areas could include the loss of coastal areas due to submersion and/or erosion, reduction in coral reefs and other key habitats thereby affecting the distribution, abundance, and productivity of many marine species, increased vulnerability of the built environment and associated economies to severe weather and storm surges, and increased salinization of estuaries and freshwater aquifers.
- Impacts on food, fiber, and forestry could include increasing tree mortality, forest ecosystem vulnerability, productivity losses in crops and livestock, and changes in the nutritional quality of pastures and grazelands in response to fire, insect infestations, increases in weeds, drought, disease outbreaks, and/or extreme weather events. Many marine fish species could migrate to deeper and/or colder water in response to rising ocean temperatures. Impacts on food, including yields, food processing, storage, and transportation, could affect food prices and food security globally.
- Impacts on rural and urban areas could include affecting water and energy supplies, wastewater and stormwater systems, transportation, telecommunications, provision of social services, agricultural incomes, and air quality. The impacts could be greater for vulnerable populations such as lower-income populations, the elderly, those with existing health conditions, and young children.

- Impacts on human health could include increased mortality and morbidity due to excessive heat, increases in respiratory conditions due to poor air quality and aeroallergens, increases in water and food-borne diseases, changes in the seasonal patterns of vector-borne diseases, and increases in malnutrition. The most disadvantaged groups such as children, elderly, sick, and low-income populations are especially vulnerable.
- Impacts on human security could include increased threats in response to adversely affected livelihoods, compromised cultures, increased and/or restricted migration, increased risk of armed conflicts, reduction in providing adequate essential services such as water and energy, and increased geopolitical rivalry.

Climate change has been projected to have a direct impact on stratospheric ozone recovery, although there are large elements of uncertainty within these projections.

In addition to its role as a GHG in the atmosphere, CO_2 is transferred from the atmosphere to water, plants, and soil. In water, CO_2 combines with water molecules to form carbonic acid. When CO_2 dissolves in seawater, a series of well-known chemical reactions begins that increases the concentration of hydrogen ions and makes seawater more acidic, which adversely affects corals and other marine life.

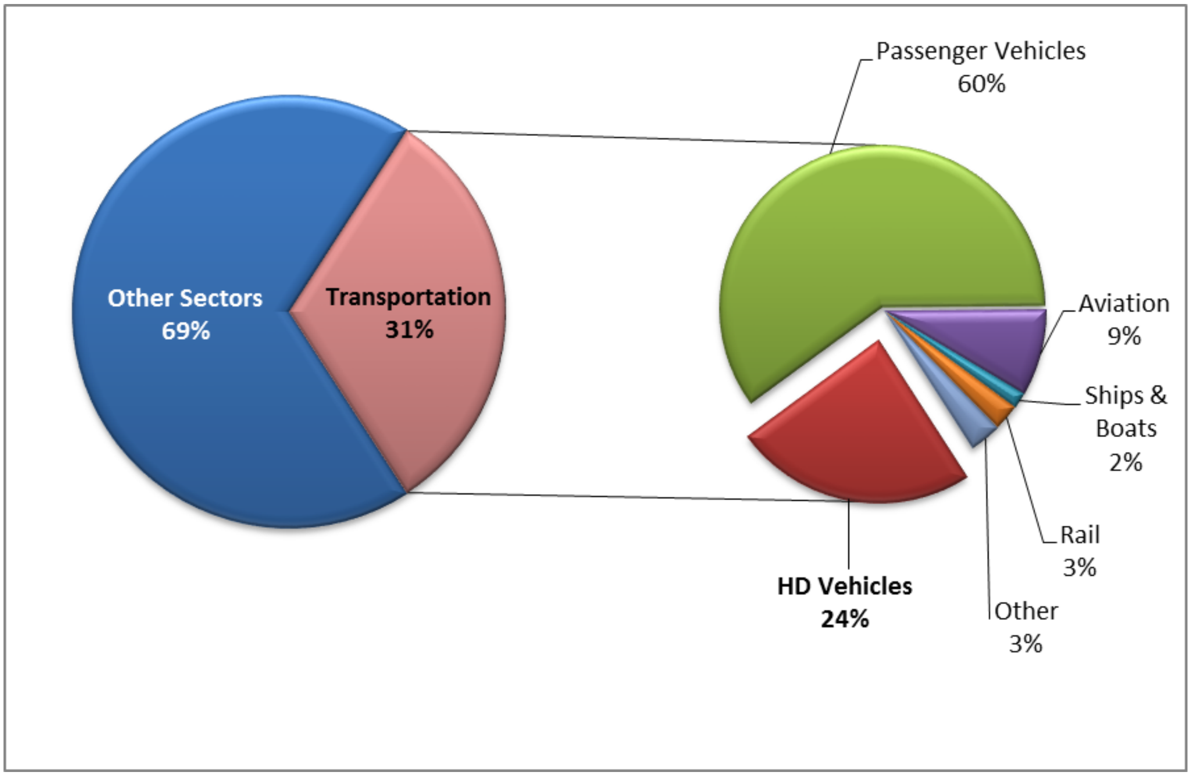
Increased concentrations of CO_2 in the atmosphere can also stimulate plant growth to some degree, a phenomenon known as the CO_2 fertilization effect. The available evidence indicates that different plants respond in different ways to enhanced CO_2 concentrations under varying climatic conditions.

Contribution of the U.S. Transportation Sector to U.S. and Global CO_2 Emissions

Contributions to the buildup of CO_2 and other GHGs in the atmosphere vary greatly from country to country and depend heavily on the level of industrial and economic activity. Emissions from the United States account for approximately 15.1 percent of total global CO_2 emissions (according to the World Resources Institute's Climate Analysis Indicators Tool).

As shown in Figure S-7, the U.S. transportation sector accounted for 31.3 percent of total U.S. CO_2 emissions in 2014, with HD vehicles accounting for 24.2 percent of total U.S. CO_2 emissions from transportation. Therefore, approximately 7.6 percent of total U.S. CO_2 emissions were from HD vehicles. These U.S. HD vehicles account for 1.1 percent of total global CO_2 emissions, based on the comprehensive global CO_2 emissions data available for 2012 (WRI 2016).

Figure S-7. Contribution of Transportation to U.S. CO_2 Emissions and Proportion Attributable by Mode, 2014



Source: EPA 2016c. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2014. EPA 430-R-16-002.

Key Findings for Climate

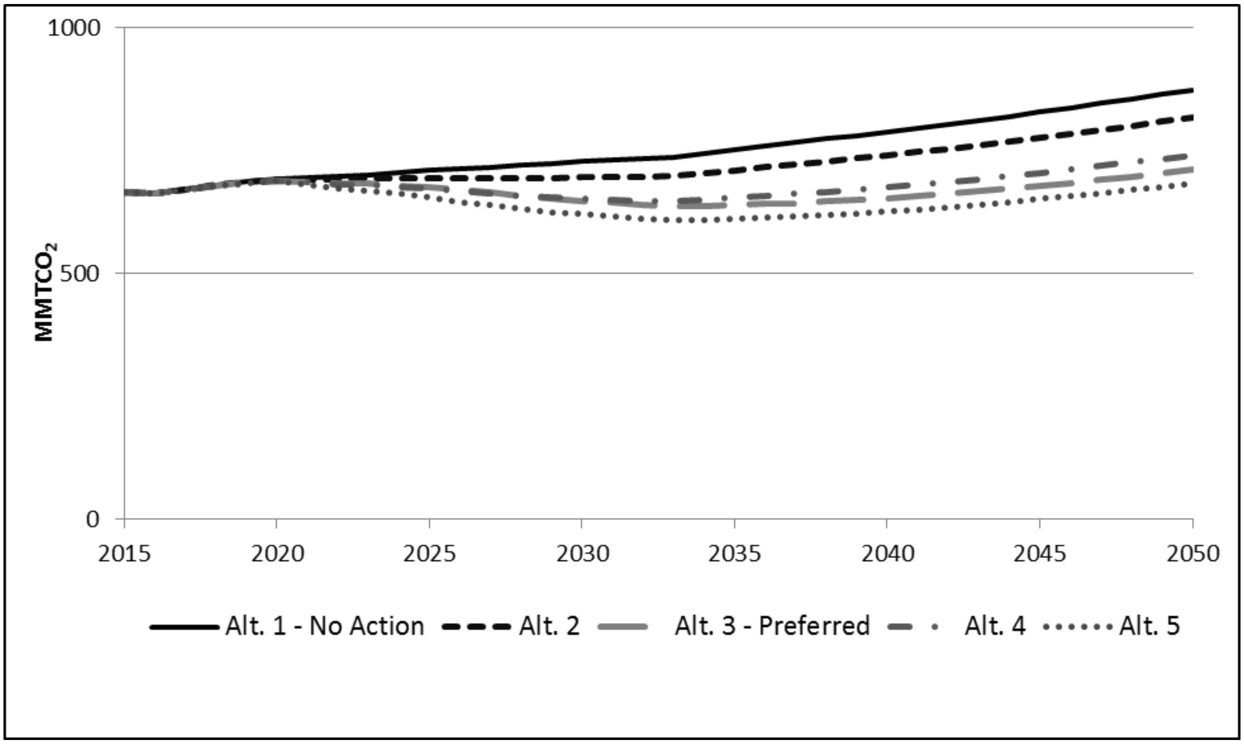
The action alternatives would decrease the growth in global GHG emissions compared with the No Action Alternative, resulting in reductions in the anticipated increases in CO_2 concentrations, temperature, precipitation, and sea level that would otherwise occur. They would also, to a small degree, reduce the impacts and risks of climate change.

Under the No Action Alternative, total CO_2 emissions from HD vehicles in the United States will increase substantially between 2018 and 2100.[2] Growth in the number of HD vehicles in use throughout the United States, combined with assumed increases in their average use, is projected to result in growth in VMT. Because CO_2 emissions are a direct consequence of total fuel consumption, the same result is projected for total CO_2 emissions from HD vehicles.

NHTSA estimates that the action alternatives will reduce fuel consumption and CO_2 emissions compared with what they would be in the absence of the standards (i.e., fuel consumption and CO_2 emissions under the No Action Alternative) (Figure S-8).

[2] Because CO_2 accounts for such a large fraction of total GHGs emitted during fuel production and use—more than 97 percent, even after accounting for the higher GWPs of other GHGs—NHTSA's consideration of GHG impacts focuses on reductions in CO_2 emissions expected under the action alternatives.

Figure S-8. Projected Annual CO_2 Emissions ($MMTCO_2$) from All HD Vehicles by Alternative, Direct and Indirect Impacts



The global emissions scenario used in the cumulative impacts analysis (and described in Chapter 5 of this EIS) differs from the global emissions scenario used for climate change modeling of direct and indirect impacts. In the cumulative impacts analysis, the Reference Case global emissions scenario used in the climate modeling analysis reflects reasonably foreseeable actions in global climate change policy; in contrast, the global emissions scenario used for the analysis of direct and indirect impacts assumes that no significant global controls on GHG emissions will be adopted. *See* Section 5.3.3.3.2 of the EIS for more explanation of the cumulative impacts methodology.

Estimates of GHG emissions and reductions (direct and indirect impacts and cumulative impacts) are presented below for each of the five alternatives. Key climate effects, such as mean global increase in surface temperature and sea-level rise, which result from changes in GHG emissions, are also presented for each of the five alternatives. These effects are typically modeled to 2100 or longer because of the amount of time required for the climate system to show the effects of the GHG emissions reductions. This inertia reflects primarily the amount of time required for the ocean to warm in response to increased radiative forcing.

The impacts of the action alternatives on global mean surface temperature, precipitation, or sea-level rise are small in relation to the expected changes associated with the emissions trajectories that assume that no significant global controls on GHG emissions are adopted. This is because of the global and multi-sectoral nature of the climate problem. Although these effects are small, they occur on a global scale and are long lasting; therefore, in aggregate, they can have large consequences for health and welfare and can make an important contribution to reducing the risks associated with climate change.

Direct and Indirect Impacts

<u>Greenhouse Gas Emissions</u>

- HD vehicles are projected to emit 67,500 million metric tons of carbon dioxide ($MMTCO_2$) in the period 2018–2100 under the No Action Alternative. Alternative 2 would reduce these emissions by 6 percent by 2100, the Preferred Alternative by 16 percent, Alternative 4 by 13 percent, and Alternative 5 by 19 percent. Figure S-8 shows projected annual CO_2 emissions from HD vehicles under each alternative. As shown in the figure, emissions are highest under the No Action Alternative, while Alternatives 2 through 5 show increasing reductions in emissions compared with emissions under the No Action Alternative (with the exception of Alternative 4, which would have lower emissions reductions than the Preferred Alternative for certain analysis years).
- Compared with total projected CO_2 emissions of 801 $MMTCO_2$ from all HD vehicles under the No Action Alternative in 2100, the action alternatives are expected to reduce CO_2 emissions from HD vehicles in 2100 by 6 percent under Alternative 2, 18 percent under the Preferred Alternative, 15 percent under Alternative 4, and 22 percent under Alternative 5.
- Compared with total global CO_2 emissions from all sources of 5,063,078 $MMTCO_2$ under the No Action Alternative from 2018 through 2100, the action alternatives are expected to reduce global CO_2 emissions between 0.1 and 0.3 percent by 2100.

The emissions reductions in 2025 under each of the action alternatives compared with emissions under the No Action Alternative are approximately equivalent to the annual emissions from 0.5 million HD vehicles under Alternative 2, 1.1 million HD vehicles under the Preferred Alternative, 1.2 million HD vehicles under Alternative 4, and 1.8 million HD vehicles under Alternative 5.

<u>CO_2 Concentration, Global Mean Surface Temperature, Sea-Level Rise, and Precipitation</u>

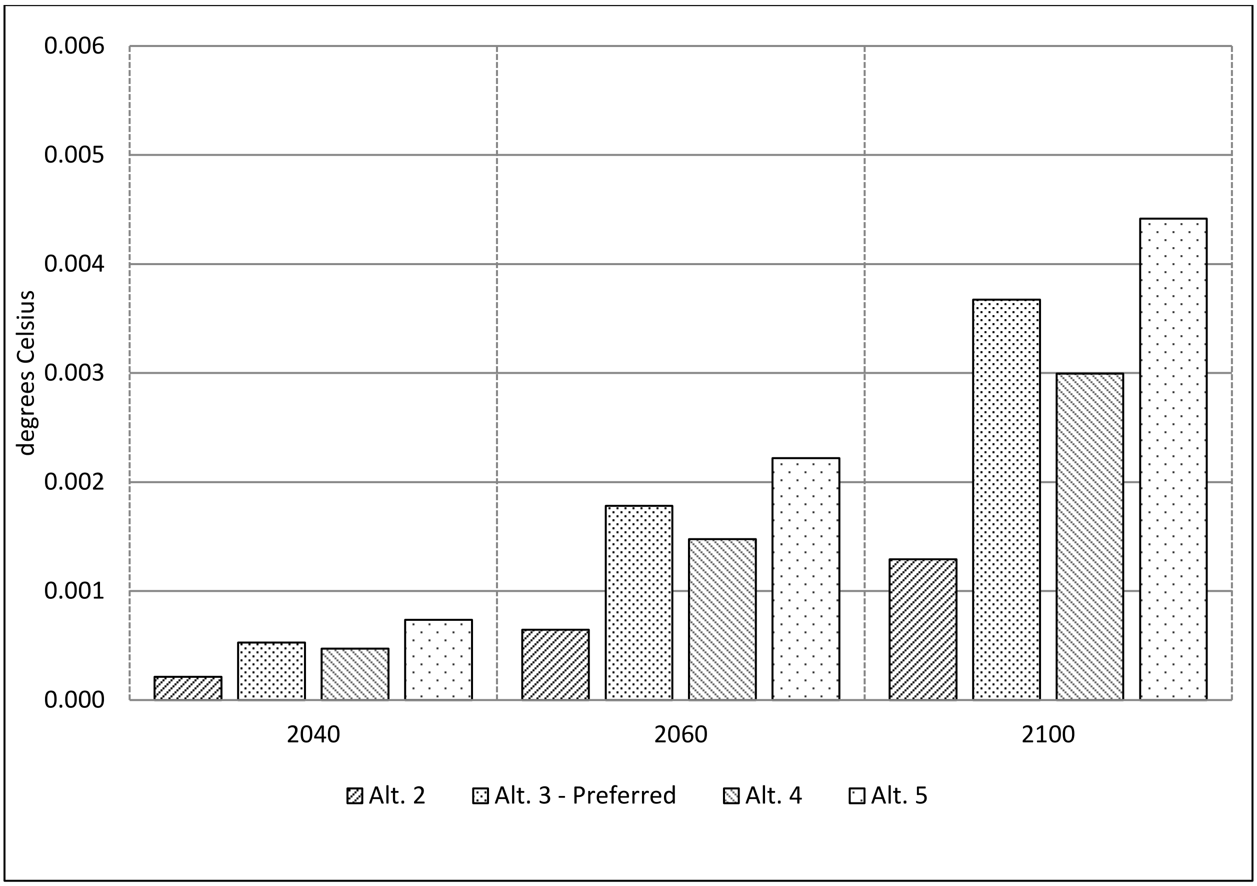
CO_2 emissions affect the concentration of CO_2 in the atmosphere, which in turn affects global temperature, sea level, and precipitation patterns. For the analysis of direct and indirect impacts, NHTSA used the Global Change Assessment Model Reference scenario (*see* Section 5.3.3.3.1 of this EIS for more details) to represent the Reference Case emissions scenario (i.e., future global emissions assuming no additional climate policy).

- Estimated CO_2 concentrations in the atmosphere for 2100 would range from 788.0 parts per million (ppm) under Alternative 5 to approximately 789.1 ppm under the No Action Alternative, indicating a maximum atmospheric CO_2 reduction of approximately 1.1 ppm compared to the No Action Alternative. The Preferred Alternative would reduce global CO_2 concentrations by approximately 1.0 ppm from CO_2 concentrations under the No Action Alternative.
- Global mean surface temperature is anticipated to increase by approximately 3.48°C (6.27°F) under the No Action Alternative by 2100. Implementing the most stringent alternative (Alternative 5) would reduce this projected temperature increase by 0.004°C (0.008°F), while implementing the least stringent alternative (Alternative 2) would reduce projected temperature increase by up to 0.001°C (0.002°F). The Preferred Alternative would decrease projected temperature increase under the No Action Alternative by 0.004°C (0.008°F). Figure S-9 shows the reduction in projected global

mean surface temperature under each action alternative compared with temperatures under the No Action Alternative.

- Projected sea-level rise in 2100 ranges from a high of 76.28 centimeters (30.03 inches) under the No Action Alternative to a low of 76.19 centimeters (30.00 inches) under Alternative 5. Therefore, the most stringent alternative would result in a maximum reduction in sea-level rise equal to 0.09 centimeter (0.03 inch) by 2100 compared with the level projected under the No Action Alternative. Sea-level rise under the Preferred Alternative would be reduced by 0.07 centimeter (0.03 inch) compared with the No Action Alternative.
- Global mean precipitation is anticipated to increase by 5.85 percent by 2100 under the No Action Alternative. Under the action alternatives, this increase in precipitation would be reduced by less than 0.01 percent.

Figure S-9. Reduction in Global Mean Surface Temperature Compared with the No Action Alternative, Direct and Indirect Impacts

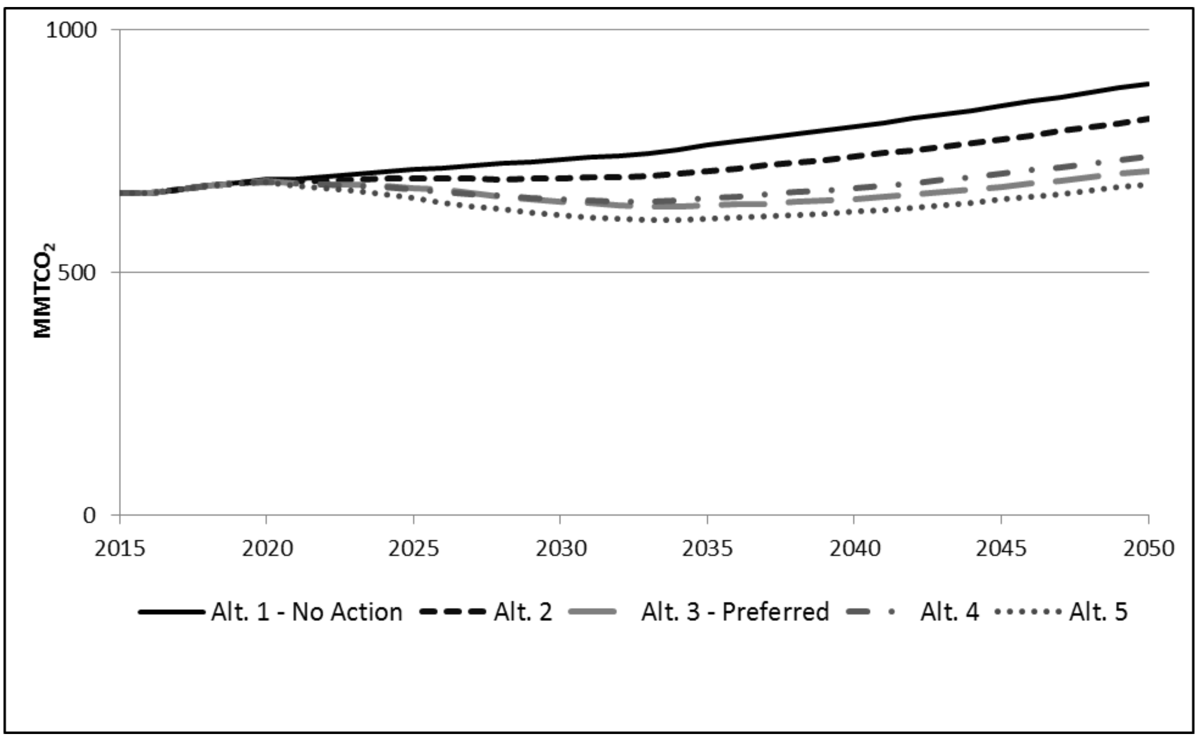


Cumulative Impacts

Greenhouse Gas Emissions

- Projections of total emissions reductions over the 2018–2100 period under the action alternatives and other reasonably foreseeable future actions (i.e., forecast HD vehicle fuel efficiency increases resulting from market-driven demand) compared with the No Action Alternative range from 5,000 $MMTCO_2$ (under Alternative 2) to 14,200 $MMTCO_2$ (under Alternative 5). Falling between these two extremes, the Preferred Alternative would reduce emissions by 12,100 $MMTCO_2$. The action alternatives would reduce total HD vehicle emissions by between 7 percent (under Alternative 2) and 21 percent (under Alternative 5) by 2100. Again falling between these two extremes, the Preferred Alternative would reduce total HD vehicle emissions by 18 percent by 2100. Figure S-10 shows projected annual CO_2 emissions from HD vehicles by alternative compared with the No Action Alternative.
- Compared with projected total global CO_2 emissions of 4,154,831 $MMTCO_2$ from all sources from 2018–2100, the incremental impact of this rulemaking is expected to reduce global CO_2 emissions between 0.1 and 0.3 percent by 2100.

Figure S-10. Projected Annual CO_2 Emissions ($MMTCO_2$) from HD Vehicles by Alternative, Cumulative Impacts

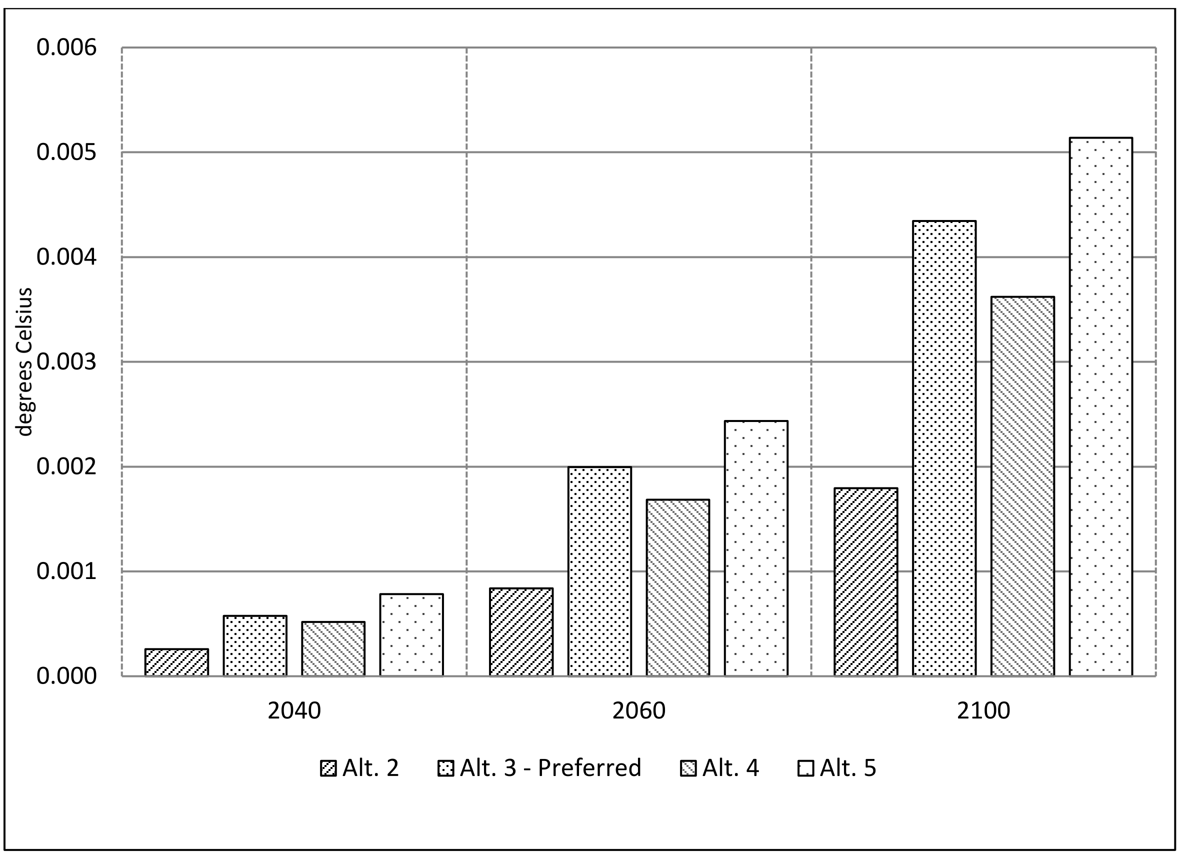


CO$_2$ Concentration, Global Mean Surface Temperature, Sea-Level Rise, and Precipitation

- Estimated atmospheric CO_2 concentrations in 2100 range from a low of 686.1 ppm under Alternative 5 to a high of 687.3 ppm under the No Action Alternative. The Preferred Alternative would result in CO_2 concentrations of 686.3 ppm, a reduction of 1.0 ppm compared with the No Action Alternative.
- The reduction in global mean temperature increase for the action alternatives compared with the No Action Alternative in 2100 ranges from a low of 0.002°C (0.004°F) under Alternative 2 to a high of 0.005°C (0.009°F) under Alternative 5. The Preferred Alternative would result in a reduction of 0.004°C (0.007°F) from the projected temperature increase of 2.838°C (5.108°F) under the No Action Alternative. Figure S-11 illustrates the reductions in the increase in global mean temperature under each action alternative compared with the No Action Alternative.
- Projected sea-level rise in 2100 ranges from a high of 70.22 centimeters (27.65 inches) under the No Action Alternative to a low of 70.12 centimeters (27.61 inches) under Alternative 5, indicating a maximum reduction of sea-level rise equal to 0.10 centimeter (0.04 inch) by 2100 from the level that could occur under the No Action Alternative. Sea-level rise under the Preferred Alternative would be 70.14 centimeters (27.62 inches), a 0.09-centimeter (0.04-inch) reduction compared with the No Action Alternative.

See Section 5.4 of this EIS for more details about direct, indirect, and cumulative impacts on climate.

Figure S-11. Reduction in Global Mean Surface Temperature Compared with the No Action Alternative, Cumulative Impacts



Health, Societal, and Environmental Impacts of Climate Change

The action alternatives would reduce the impacts of climate change that would otherwise occur under the No Action Alternative. The magnitude of the changes in climate effects that would be produced by the most stringent action alternative (Alternative 5) by the year 2100 is roughly 1.2 ppm less CO_2, a few thousandths of a degree difference in temperature increase, a small percentage change in the rate of precipitation increase, and about 1 millimeter (0.03 inch) of sea-level rise. Although the projected reductions in CO_2 and climate effects are small compared with total projected future climate change, they are quantifiable and directionally consistent and would represent an important contribution to reducing the risks associated with climate change. Although NHTSA does quantify the reductions in monetized damages that can be attributable to each action alternative (in the social cost of carbon analysis), many specific impacts on health, society, and the environment cannot be estimated quantitatively. Therefore, NHTSA provides a detailed discussion of the impacts of climate change on various resource sectors in Section 5.5 of the EIS. Section 5.6 discusses the changes in non-climate impacts (such as ocean acidification by CO_2) associated with the alternatives.