Corporate Average Fuel Economy Standards
Model Years 2024–2026

Final Supplemental Environmental Impact Statement

Summary

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

NHTSA
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

SUMMARY

Foreword

The National Highway Traffic Safety Administration (NHTSA) prepared this supplemental environmental impact statement (SEIS) to analyze and disclose the potential environmental impacts of the Corporate Average Fuel Economy (CAFE) standards for passenger cars and light trucks for model years (MYs) 2024 to 2026. 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.[1]

This Final SEIS compares the potential environmental impacts of five alternatives for setting fuel economy standards for MY 2024–2026 passenger cars and light trucks (four action alternatives and the No Action Alternative). This SEIS analyzes the direct, indirect, and cumulative impacts of each action alternative relative to the No Action Alternative.

Background

The Energy Policy and Conservation Act of 1975 (EPCA) mandated that NHTSA establish and implement a regulatory program for motor vehicle fuel economy, known as the CAFE program, to reduce national energy consumption. 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 less than 8,500 pounds and medium-duty passenger vehicles with a gross vehicle weight rating less than 10,000 pounds. The Secretary of Transportation has delegated responsibility for implementing the CAFE program to NHTSA.

EISA, enacted by Congress in December 2007, amended the EPCA CAFE program requirements by providing DOT additional rulemaking authority and responsibilities. Consistent with its statutory authority, in a rulemaking to establish CAFE standards for MY 2017 and beyond passenger cars and light trucks, NHTSA developed two phases of standards. The first phase included final standards for MYs 2017–2021. The second phase, covering MYs 2022–2025, included standards that were not final, due to the statutory requirement that NHTSA set average fuel economy standards not more than five model years at a time. Rather, NHTSA wrote that those standards were *augural*, meaning that they represented its best estimate, based on the information available at that time, of what levels of stringency might be maximum feasible in those model years.

In 2018, NHTSA issued a notice of proposed rulemaking (NPRM) in which the agency proposed revising the MY 2021 light-duty fuel economy standards and issuing new fuel economy standards for MYs 2022–2026.[2] In the 2020 SAFE Vehicles Final Rule, NHTSA amended fuel economy standards for MY 2021 and

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[1] Because this SEIS is a continuation of a NEPA process that began before the effective date of a 2020 Council on Environmental Quality (CEQ) rule that amended the NEPA implementing regulations (September 14, 2020), NHTSA will apply the NEPA implementing regulations that were in effect prior to that date.

[2] The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks; Notice of Proposed Rulemaking, 83 FR 42986 (Aug. 24, 2018) (hereinafter "SAFE Vehicles NPRM").

established standards for MYs 2022–2026 that would increase in stringency at 1.5 percent per year from 2020 levels. Concurrent with the SAFE Vehicles Final Rule, NHTSA issued a Final EIS on March 31, 2020.[3]

On January 20, 2021, President Biden issued Executive Order (EO) 13990, *Protecting Public Health and the Environment and Restoring Science To Tackle the Climate Crisis*,[4] which directed NHTSA to consider publishing for notice and comment a proposed rule suspending, revising, or rescinding the SAFE Vehicles Final Rule by July 2021. Though EO 13990 prompted NHTSA's review, NHTSA is exercising its own authority, consistent with its statutory factors, to amend the CAFE standards for MY 2024–2026 passenger cars and light trucks in a final rule being issued concurrent with this Final SEIS. As NHTSA discusses in the preamble to the final rule, this action reflects a conclusion significantly different from the conclusion that NHTSA reached in the 2020 SAFE Vehicles Final Rule, but this is because important facts have changed, and because NHTSA has reconsidered how to balance the relevant statutory considerations in light of those facts. NHTSA concludes that significantly more stringent standards are maximum feasible. For a further discussion on NHTSA's explanation on this action, see Section VI.D in the final rule. As described in the final rule, NHTSA is retaining the existing CAFE standards for MYs 2021–2023 in light of EPCA's requirement that amendments that make an average fuel economy standard more stringent be prescribed at least 18 months before the beginning of the model year to which the amendment applies.[5]

To inform its development of the CAFE standards for MYs 2024–2026, NHTSA prepared this SEIS, pursuant to NEPA,[6] to evaluate the potential environmental impacts of a reasonable range of alternatives the agency is considering. NEPA directs that 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).[7] In revising the CAFE standards established in the SAFE Vehicles Final Rule, NHTSA is making substantial changes to the proposed action examined in the SAFE Vehicles Rule Final EIS and, as such, prepared this SEIS to inform its amendment of MY 2024–2026 CAFE standards.[8] Because this SEIS is a continuation of a NEPA process that began before the effective date of a 2020 CEQ rule that amended the NEPA implementing regulations,[9] NHTSA will continue to apply the NEPA implementing regulations that were in effect prior to that date.[10] This SEIS analyzes, discloses, and compares the potential environmental impacts of a reasonable range of alternatives, including a No

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[3] The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Year 2021–2026 Passenger Cars and Light Trucks Final Environmental Impact Statement (March 2020) (hereinafter "SAFE Vehicles Rule Final EIS"). Available at: https://www.nhtsa.gov/corporate-average-fuel-economy/safe.

[4] Executive Order 13990, Protecting Public Health and the Environment and Restoring Science To Tackle the Climate Crisis, 86 FR 7037 (Jan. 25, 2021).

[5] 49 U.S.C. § 32902(g)(2).

[6] 42 U.S.C. §§ 4321–4347.

[7] 42 U.S.C. § 4332.

[8] *See* 40 CFR § 1502.9(c)(1)(i) (2019).

[9] Update to the Regulations Implementing the Procedural Provisions of the National Environmental Policy Act; Final Rule, 85 FR 43304 (Jul. 15, 2020).

[10] 40 CFR § 1506.13 (2020) (specifying that the new NEPA implementing regulations apply to any NEPA process begun after September 14, 2020).

Action Alternative and a Preferred Alternative, and discusses impacts in proportion to their significance. NHTSA is issuing this Final SEIS concurrently with the final rule.

Purpose and Need for the Action

In accordance with EPCA, as amended by EISA, the purpose of NHTSA's rulemaking is to amend fuel economy standards for MY 2024–2026 passenger cars and light trucks to reflect "the maximum feasible average fuel economy level that the Secretary of Transportation decides the manufacturers can achieve in that model year." When determining the maximum feasible levels that manufacturers can achieve in each model year, EPCA requires that NHTSA consider the four statutory factors of technological feasibility, economic practicability, the effect of other motor vehicle standards of the government on fuel economy, and the need of the United States to conserve energy. In addition, when determining the maximum feasible levels, the agency considers relevant safety and environmental factors.

For MYs 2021–2030, NHTSA must establish separate average fuel economy standards for passenger cars and light trucks for each model year. Standards must be "based on one or more vehicle attributes related to fuel economy" and "express[ed]…in the form of a mathematical function."

Proposed Action and Alternatives

NHTSA's action is setting fuel economy standards for passenger cars and light trucks in accordance with EPCA, as amended by EISA. NHTSA has selected a reasonable range of alternatives within which to set CAFE standards and to evaluate the potential environmental impacts of the CAFE standards and alternatives under NEPA. NHTSA is establishing CAFE standards for MY 2024–2026 passenger cars and light trucks.

NHTSA has analyzed a range of action alternatives with fuel economy stringencies that increase annually, on average, 6 to 10 percent from MY 2024–2026 for passenger cars and for light trucks (depending on alternative). This range of action alternatives, as well as the No Action Alternative, encompasses a spectrum of possible standards NHTSA could determine is maximum feasible based on the different ways the agency could weigh EPCA's four statutory factors. The conclusion reached in this rulemaking is different than the conclusion NHTSA reached in the 2020 SAFE Vehicles Final Rule because NHTSA has reconsidered how to balance relevant statutory considerations. As discussed further in Section 1 of the preamble to the final rule, NHTSA's review of its standards responds to the President's direction in EO 13990, and the final rule responds to the agency's statutory mandate to improve energy conservation to insulate our nation's economy against external factors and reduce environmental degradation associated with petroleum consumption.

The No Action Alternative (also referred to as Alternative 0 in tables and figures) assumes that the MY 2021–2026 CAFE standards established in the SAFE Vehicles Final Rule remain unchanged. In addition, the No Action Alternative assumes that the MY 2026 SAFE Vehicles Final Rule standards continue to apply for MY 2027 and beyond. The No Action Alternative provides an analytical baseline against which to compare the environmental impacts of the other alternatives presented in the SEIS. Throughout this SEIS, estimated impacts are shown for four action alternatives that illustrate the following range of estimated average annual percentage increases in fuel economy for both passenger cars and light trucks:

Alt. 1 Alternative 1 would require a 10.5 percent annual increase for MY 2024 over MY 2023 and a 3.26 percent annual average annual fleet-wide increase in fuel economy for both passenger cars and light trucks for MYs 2025–2026.

Alt. 2 Alternative 2 would require an 8.0 percent average annual fleet-wide increase in fuel economy for both passenger cars and light trucks for MYs 2024–2026. Alternative 2 was identified as NHTSA's Preferred Alternative in the NPRM and Draft SEIS; however, Alternative 2.5 is now NHTSA's Preferred Alternative.

Alt. 2.5 Alternative 2.5 (Preferred Alternative/Proposed Action) would require an 8.0 percent average annual fleet-wide increase in fuel economy for both passenger cars and light trucks for MYs 2024 and 2025, and a 10.0 percent average annual fleet-wide increase in fuel economy for both passenger cars and light trucks for MY 2026.

Alt. 3 Alternative 3 would require a 10.0 percent average annual fleet-wide increase in fuel economy for both passenger cars and light trucks for MYs 2024–2026.

For purposes of analysis, NHTSA assumes that the MY 2026 CAFE standards for each alternative would continue indefinitely. Table S-1 shows the estimated average required fleet-wide fuel economy forecasts by model year for each alternative.

Table S-1. Projected Average Required Fleet-Wide Fuel Economy (mpg) for Combined U.S. Passenger Cars and Light Trucks by Model Year and Alternative

Model Year	Alt. 0 (No Action)	Alt. 1	Alt. 2	Alt. 2.5	Alt. 3
MY 2024	38.1	41.8	40.6	40.6	41.5
MY 2025	38.7	43.2	44.2	44.2	46.1
MY 2026	39.4	44.7	48.1	49.1	51.3

mpg = miles per gallon; MY = model year

The range under consideration in the alternatives encompasses a spectrum of possible standards that NHTSA could select based on how the agency weighs EPCA's four statutory factors. By providing environmental analyses at discrete representative points, the decision-makers and the public can determine the projected environmental effects of points that fall between the individual alternatives. The alternatives evaluated in this SEIS therefore provide decision-makers with the ability to select from a wide variety of other potential alternatives with stringencies that would increase annually at average percentage rates from 6 to 10 percent. This range includes, for example, alternatives with stringencies that would increase at different rates for passenger cars and for light trucks and stringencies that would increase at different rates in different years. These alternatives reflect differences in the degree of technology adoption across the fleet, in costs to manufacturers and consumers, and in conservation of oil and related reductions in greenhouse gas (GHG) emissions.

As noted in the preamble to the final rule, NHTSA has determined that Alternative 2.5 is technologically feasible, economically practicable, supports the need of the United States to conserve energy, and is complementary to other motor vehicle standards of the government that are simultaneously applicable. NHTSA concludes that Alternative 2.5 is maximum feasible for MYs 2024–2026.

Environmental Consequences

This section describes how the Proposed Action and alternatives could affect energy use, air quality, and climate, as reported in Chapter 3, *Energy*, Chapter 4, *Air Quality*, and Chapter 5, *Greenhouse Gas Emissions and Climate Change*, of this SEIS, respectively. Air quality and climate impacts are reported for the entire light-duty vehicle fleet (passenger cars and light trucks combined); results are reported separately for passenger cars and light trucks in Appendix A, *U.S. Passenger Car and Light Truck Results Reported Separately*. Chapter 6, *Life-Cycle Assessment Implications of Vehicle Energy, Materials, and Technologies,* describes the life-cycle environmental implications of some of the fuels, materials, and technologies that NHTSA forecasts vehicle manufacturers might use to comply with the Proposed Action. Chapter 7, *Other Impacts,* qualitatively describes potential additional impacts on hazardous materials and regulated wastes, historic and cultural resources, noise, and environmental justice.

The impacts on energy use, air quality, and climate include *direct*, *indirect*, and *cumulative impacts.*[11] 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. The cumulative impacts associated with the Proposed Action and alternatives are discussed in Chapter 8, *Cumulative Impacts.*

To derive the direct and indirect impacts of the action alternatives, NHTSA compares each action alternative to a No Action Alternative, which reflects baseline trends that would be expected in the absence of any regulatory action as discussed above. The No Action Alternative for this SEIS assumes that the MY 2021–2026 CAFE standards established in the SAFE Vehicles Final Rule remain unchanged. All alternatives assume the MY 2026 standards would continue indefinitely. Because EPCA, as amended by EISA, requires NHTSA to set CAFE standards for each model year, environmental impacts would also depend on future standards established by NHTSA but cannot be quantified at this time.

Energy

NHTSA's final standards would regulate fuel economy and, therefore, affect U.S. transportation fuel consumption. Transportation fuel accounts for 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. 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. Until a decade ago, most of this increase came not from increased domestic energy production but from the increase in imports, largely for use in the transportation sector.

Petroleum is by far the largest source of energy used in the transportation sector. In 2020, petroleum supplied 91 percent of transportation energy demand, and in 2050, petroleum is expected to supply 86 percent of transportation energy demand. Transportation accounts for the largest share of total U.S. petroleum consumption. In 2020, the transportation sector accounted for 78.9 percent of total U.S.

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[11] 40 CFR § 1508.8 (2019).

petroleum consumption. In 2050, transportation is expected to account for 76.9 percent of total U.S. petroleum consumption.[12]

With transportation expected to account for 76.9 percent of total petroleum consumption, U.S. net petroleum imports in 2050 are expected to result primarily from fuel consumption by light-duty and heavy-duty vehicles. The United States became a net energy exporter in 2019 for the first time in 67 years because of continuing increases in overall U.S. energy efficiency and recent developments in U.S. energy production.

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

Direct and Indirect Impacts

To calculate the impacts on fuel use for each action alternative, NHTSA subtracted projected fuel consumption under the No Action Alternative from the level under each action alternative. As the alternatives increase in stringency, total fuel consumption decreases. Table S-2 shows total 2020 to 2050 fuel consumption for each alternative and the direct and indirect fuel use impacts for each action alternative compared with the No Action Alternative through 2050. NHTSA used 2050 as the end year for its analysis as it is the year by which nearly the entire U.S. light duty vehicle fleet will be composed of MY 2024–2026 or later vehicles. This table reports total 2020 to 2050 fuel consumption in gasoline gallon equivalents (GGE) for diesel, gasoline, electricity, hydrogen, and biofuel for cars and light trucks. Gasoline is expected to account for 96 percent of energy consumption by passenger cars and light trucks in 2050.

Table S-2. Fuel Consumption and Decrease in Fuel Consumption by Alternative (billion gasoline gallon equivalent total for calendar years 2020–2050)

	Alt. 0 (No Action)	Alt. 1	Alt. 2	Alt. 2.5	Alt. 3
Fuel Consumption					
Cars	1,408	1,367	1,309	1,301	1,270
Light trucks	2,151	2,104	2,082	2,070	2,051
All light-duty vehicles	3,559	3,471	3,391	3,371	3,321
Decrease in Fuel Consumption Compared to the No Action Alternative					
Cars	-	-41	-99	-107	-138
Light trucks	-	-47	-69	-81	-100
All light-duty vehicles	-	-88	-168	-188	-238

Total light-duty vehicle fuel consumption from 2020 to 2050 under the No Action Alternative is projected to be 3,559 billion GGE. Light-duty vehicle fuel consumption from 2020 to 2050 under the Proposed Action and alternatives is projected to range from 3,471 billion GGE under Alternative 1 to 3,321 billion GGE under Alternative 3. All of the action alternatives would decrease fuel consumption

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[12] This Summary references pertinent data from the analysis in the EIS. Sources of such data are appropriately cited and referenced in those chapters.

compared to the No Action Alternative, with fuel consumption decreases that range from 88 billion GGE under Alternative 1 to 238 billion GGE under Alternative 3.

Air Quality

Air pollution and air quality can affect public health, public welfare, and the environment. The Proposed Action and alternatives would affect air pollutant emissions and air quality, which, in turn, would affect public health and welfare and the natural environment. The air quality analysis in Chapter 4, *Air Quality*, assesses the impacts of the alternatives on emissions of pollutants of concern from mobile sources, and the resulting impacts on human health. The reductions and increases in emissions would vary by pollutant, calendar year, and action alternative.

Under the authority of the Clean Air Act and its amendments, the U.S. Environmental Protection Agency (EPA) has established National Ambient Air Quality Standards (NAAQS) for six relatively common air pollutants known as *criteria pollutants*: 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 in the atmosphere from emissions of ozone precursor pollutants such as nitrogen oxides (NO_X) and volatile organic compounds (VOCs).

Criteria pollutants have been shown to cause the following adverse health impacts at various concentrations and exposures: 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.

In addition to criteria pollutants, motor vehicles emit some substances defined by the 1990 Clean Air Act amendments as toxic air pollutants. Toxic 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. DPM is a component of exhaust from diesel-fueled vehicles and falls almost entirely within the PM2.5 particle-size class. MSATs are also associated with adverse health impacts. 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 noncancer health impacts, 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 because of pollution controls on vehicles and regulation of the chemical content of fuels, despite continuing increases in vehicle travel and fuel consumption. Nevertheless, the U.S. transportation sector remains a major source of emissions of certain criteria pollutants or their chemical precursors. On-road mobile sources are responsible for emitting 17.2 million tons[13] per year of CO (25 percent of total U.S. emissions), 90,000 tons per year (1 percent) of PM2.5 emissions, and 216,000 tons per year (1 percent) of PM10 emissions. Passenger cars and light trucks contribute 93 percent of U.S. highway emissions of CO, 57 percent of highway emissions of PM2.5, and 55 percent of highway

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[13] These tons are U.S. tons (2,000 pounds).

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. All on-road mobile sources emit 1.4 million tons per year (8 percent of total nationwide emissions) of VOCs and 2.4 million tons per year (29 percent) of NO_X, which are chemical precursors of ozone. Passenger cars and light trucks account for 90 percent of U.S. highway emissions of VOCs and 51 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 0.5 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.

Methods

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

Key Findings for Air Quality

This SEIS provides findings for air quality impacts for 2025, 2035, and 2050. In general, emissions of criteria air pollutants decrease across all alternatives in later years (i.e., 2035 and 2050), with some exceptions. The changes in emissions are small in relation to total criteria pollutant emissions levels during this period and, overall, the health outcomes due to changes in criteria pollutant emissions through 2050 are projected to be beneficial. The directions and magnitudes of the changes in total emissions are not consistent across all pollutants. This reflects the complex interactions between tailpipe emissions rates of the various vehicle types, the technologies assumed to be incorporated by manufacturers in response to the standards, upstream emissions rates (which also reflect the assumption of increased adoption of plug-in electric vehicles [PEVs] after 2035), the relative proportions of gasoline, diesel, and other fuels in total fuel consumption changes, and changes in vehicle miles traveled from the rebound effect. Other CAFE Model inputs and assumptions, which are discussed in Chapter 2, *Proposed Action and Alternatives and Analysis Methods*, and at length in Section III.C of the final rule preamble, Chapter 2 of the Technical Support Document, and Chapter 3 of the Final Regulatory Impact Analysis (FRIA) issued concurrently with this Final SEIS, including the rate at which new vehicles are sold, will also affect these air quality impact estimates. It is important to stress that changes in these assumptions would alter the air pollution estimates. For example, if NHTSA has overestimated the rebound effect, then emissions would be lower; if NHTSA has underestimated the rebound effect, then emissions would be higher. These are estimates and should be viewed as such. In addition, the action alternatives would result in decreased incidence of PM2.5-related adverse health impacts in most years and alternatives due to the emissions decreases. Decreases in adverse health outcomes include decreased incidences of premature mortality, acute bronchitis, respiratory emergency room visits, and work-loss days.

Direct and Indirect Impacts

Criteria Pollutants

The air quality analysis identified the following impacts on criteria air pollutants.

- For CO, NO_X, and SO_2 in 2025, emissions increase slightly under the action alternatives compared to the No Action Alternative; however, for PM2.5, emissions decrease slightly under the action alternatives compared to the No Action Alternative. The emission increases generally get larger from Alternative 1 through Alternative 3 (the most stringent alternative in terms of required miles per gallon). These increases are quite small—all less than 1 percent.
- In 2025, across all criteria pollutants and action alternatives, the smallest increase in emissions is 0.03 percent and occurs for NO_X under Alternative 1; the largest increase is 0.6 percent and occurs for SO_2 under Alternative 3.
- In 2035 and 2050, emissions of CO, NO_X, PM2.5, and VOCs decrease under the action alternatives compared to the No Action Alternative, with the more stringent alternatives having the largest decreases. SO_2 emissions generally increase under the action alternatives compared to the No Action Alternative (except in 2035 under Alternative 1), with the more stringent alternatives having the largest increases.
- In 2035 and 2050, across all criteria pollutants and action alternatives, the smallest decrease in emissions is 0.1 percent and occurs for CO and SO_2 under Alternative 1; the largest decrease is 12.0 percent and occurs for VOCs under Alternative 3. The smallest increase in emissions is 0.03 percent and occurs for NO_X under Alternative 1; the largest increase is 7.4 percent and occurs for SO_2 under Alternative 3.

Toxic Air Pollutants

The air quality analysis identified the following impacts on toxic air pollutants.

- Under each action alternative in 2025 compared to the No Action Alternative, increases in emissions would occur for acetaldehyde, acrolein, benzene, and 1,3-butadiene by up to about 0.2 percent, and for formaldehyde by 0.1 percent. DPM emissions would decrease by as much as 0.7 percent. For 2025, the largest relative increase in emissions would occur for 1,3-butadiene, for which emissions would increase by up to 0.23 percent. Percentage increases in emissions of acetaldehyde, acrolein, and formaldehyde would be lower.
- Under each action alternative in 2035 and 2050 compared to the No Action Alternative, decreases in emissions would occur for all toxic air pollutants with the more stringent alternatives having the largest decreases. The largest relative decreases in emissions would occur for formaldehyde, for which emissions would decrease by as much as 10.3 percent. Percentage decreases in emissions of acetaldehyde, acrolein, benzene, 1,3-butadiene, and DPM would be less.

Changes in criteria pollutant emissions in 2035 are shown by alternative in Figure S-1. Changes in toxic air pollutant emissions in 2035 are shown by alternative in Figure S-2.

Health Impacts

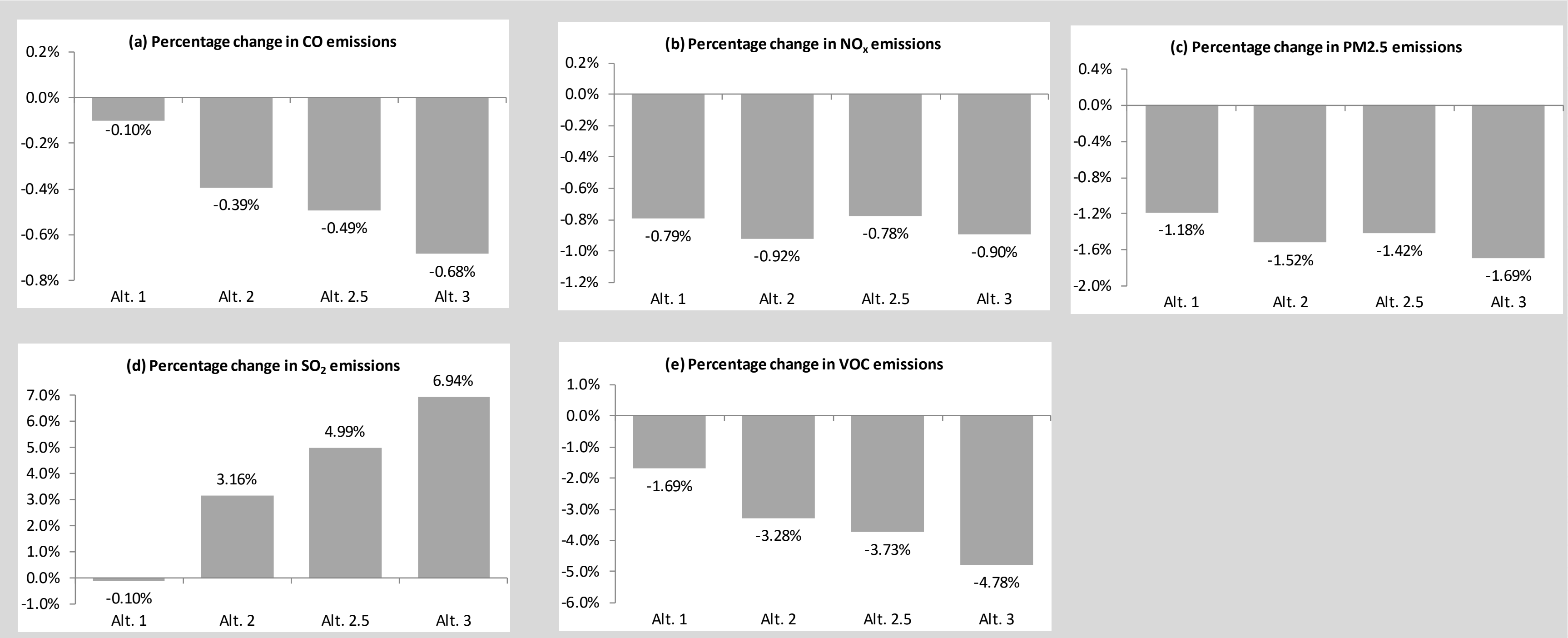
The air quality analysis identified the following health impacts.

- In 2025, all action alternatives would result in decreases in adverse health impacts (mortality, acute bronchitis, respiratory emergency room visits, and other health effects) nationwide compared to the

No Action Alternative, primarily as a result of decreases in emissions of PM2.5. Decreases in adverse health impacts would be largest for Alternative 1, smaller for Alternative 3, still smaller for Alternative 2, and smallest for Alternative 2.5 relative to the No Action Alternative. However, the differences among the action alternatives are small. These decreases result from projected decreases in emissions of PM2.5 under all action alternatives, which is in turn attributable to shifts in modeled technology adoption from the baseline and to where the rebound effect would be offset by upstream emissions reductions due to decreases in fuel usage. As mentioned above, it is important to stress that changes in these assumptions would alter these health impact results; however, NHTSA believes that these assumptions are reasonable.

- In 2035 and 2050, all action alternatives would result in decreased adverse health impacts nationwide compared to the No Action Alternative as a result of general decreases in emissions of NO_X and PM2.5. The decreases in adverse health impacts get larger from Alternative 1 to Alternative 3 in 2035 and 2050, except that for some health impacts in 2035 and 2050 the decreases are smaller for Alternative 2.5 than for Alternative 2. These decreases reflect the generally increasing stringency of the action alternatives as they become implemented.

Figure S-1. Nationwide Percentage Changes in Criteria Pollutant Emissions from U.S. Passenger Cars and Light Trucks for 2035 by Alternative Compared to the No Action Alternative, Direct and Indirect Impacts

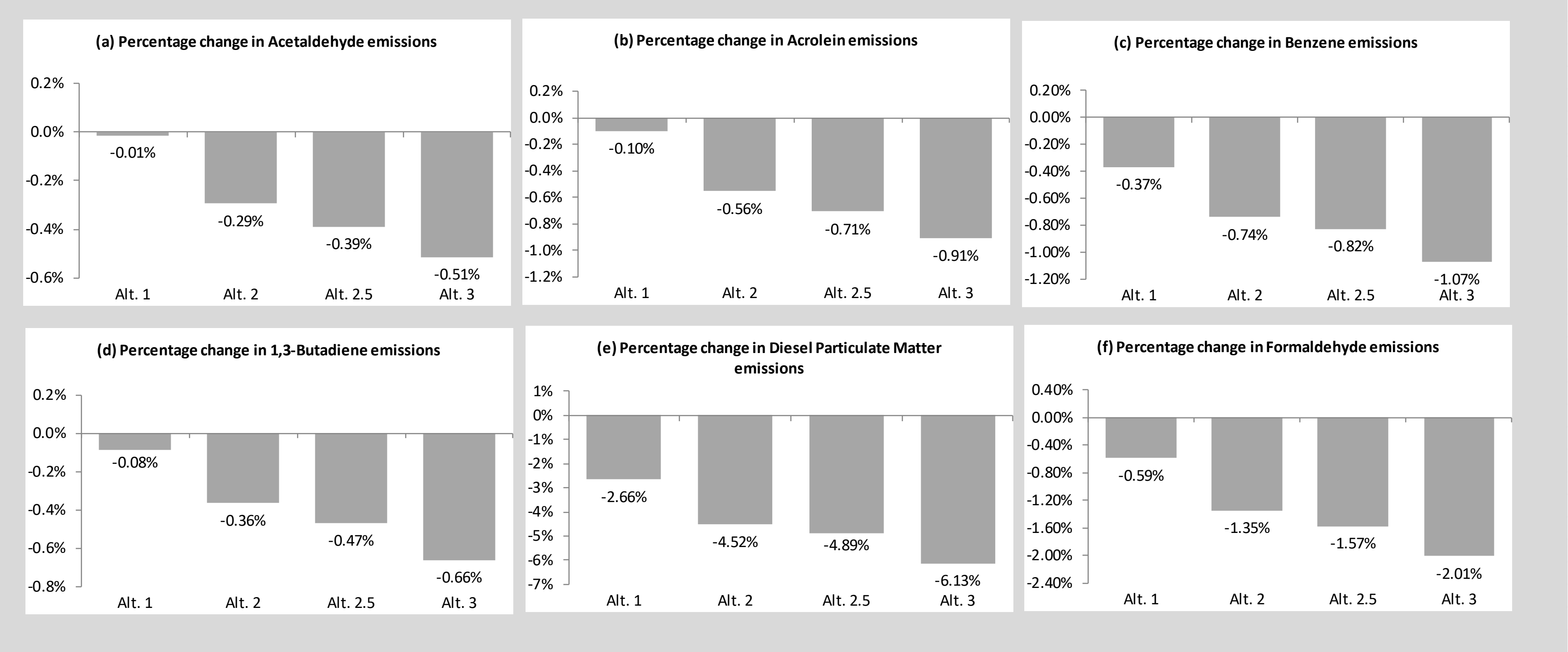


Notes:

Negative values indicate emissions decreases; positive values are emissions increases.

CO = carbon monoxide; NO_X = nitrogen oxides; PM2.5 = particulate matter 2.5 microns or less in diameter; SO_2 = sulfur dioxide; VOC = volatile organic compounds

Figure S-2. Nationwide Percentage Changes in Toxic Air Pollutant Emissions from U.S. Passenger Cars and Light Trucks for 2035 by Alternative Compared to the No Action Alternative, Direct and Indirect Impacts



Notes:
Negative values indicate emissions decreases; positive values are emissions increases.

Greenhouse Gas Emissions and Climate Change

This section describes how the Proposed Action and alternatives could affect the anticipated pace and extent of future changes in global climate. In this SEIS, the discussion of climate change direct and indirect impacts focuses on impacts associated with decreases in GHG emissions from the Proposed Action and alternatives as compared to projected GHG emissions under the No Action Alternative, including impacts on atmospheric carbon dioxide (CO_2) concentrations, global mean surface temperature, sea level, precipitation, and ocean pH.

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 reradiate 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. Human activities, particularly fossil-fuel combustion, have been identified by the Intergovernmental Panel on Climate Change (IPCC) as primarily responsible for increasing the concentrations of GHGs in the atmosphere; this buildup of GHGs is changing Earth's energy balance. Climate simulations support arguments that the warming experienced over the past century requires the inclusion of both natural GHGs and other climatic forcers (e.g., solar activity), as well as human-made climate forcers.

Global climate change refers to long-term (i.e., multi-decadal) trends in global average surface temperature, precipitation, ice cover, sea level, cloud cover, sea-surface temperatures and currents, ocean pH, and other climatic conditions. Average surface temperatures have increased since the Industrial Revolution (IPCC 2021a). Annual average global temperature has increased by 1.0 degree Celsius (°C) (1.8 degrees Fahrenheit [°F]) from 1901 to 2016, and global temperatures are rising at an increasing rate (U.S. Global Change Research Program [GCRP] 2017). Global mean sea level rose by about 1.0 to 1.7 millimeters (0.04 to 0.07 inch) per year from 1901 to 1990, a total of 11 to 14 centimeters (4 to 5 inches) (GCRP 2017). After 1993, global mean sea level rose at a faster rate of about 3 millimeters (0.12 inch) per year (GCRP 2017). Consequently, global mean sea level has risen by about 7 centimeters (3 inches) since 1990, and by 16 to 21 centimeters (7 to 8 inches) since 1900 (GCRP 2017). Global mean sea level rose faster in the 20th century than in any prior century over the last three millennia (IPCC 2021a).

Global atmospheric CO_2 concentration has increased 48.4 percent from approximately 278 parts per million (ppm) in 1750 (before the Industrial Revolution) (IPCC 2021a) to approximately 412 ppm in 2020 (NOAA 2021). Atmospheric concentrations of methane (CH_4) and nitrous oxide (N_2O) increased approximately 158 and 19 percent, respectively, over roughly the same period (IPCC 2021a). IPCC concluded, "it is unequivocal that human influence has warmed the atmosphere, ocean and land. … Overall, the evidence for human influence has grown substantially over time and from each IPCC report to the subsequent one." (IPCC 2021a).

IPCC, GCRP, and other leading groups focused on global climate change have independently concluded that human activity is the main driver for recent observed climatic changes (IPCC 2021a; GCRP 2017). Other observed changes include melting glaciers, diminishing snow cover, shrinking sea ice, ocean acidification, increasing atmospheric water vapor content, changing precipitation intensities, shifting seasons, and many more (IPCC 2021a; GCRP 2017).

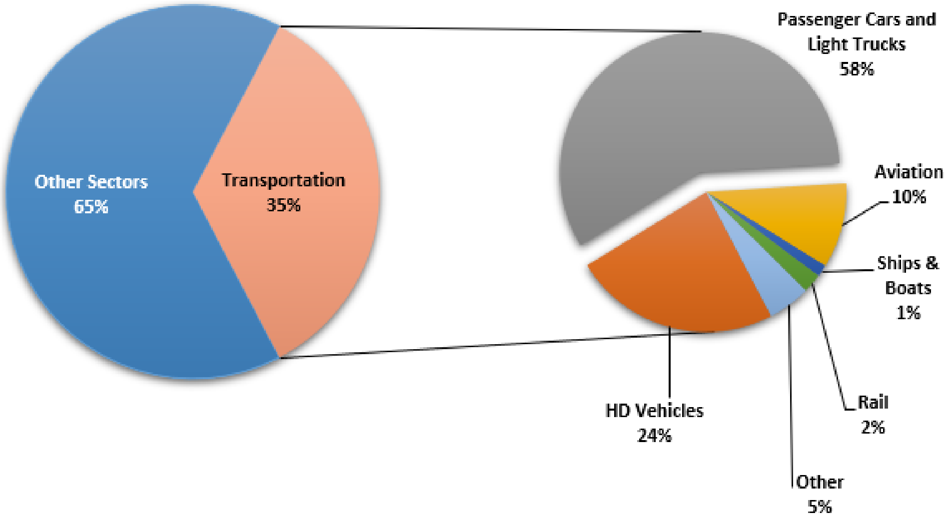
This SEIS draws primarily on panel-reviewed synthesis and assessment reports from IPCC and GCRP, supplemented with past reports from the U.S. Climate Change Science Program (CCSP), the National Research Council, and the Arctic Council.

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

Human activities that emit GHGs to the atmosphere include fossil fuel production and combustion; industrial processes and product use; agriculture, forestry, and other land use; and waste management. Emissions of CO_2, CH_4, and N_2O account for approximately 98 percent of global annual anthropogenic GHG emissions (World Resources Institute [WRI] 2021). Isotopic- and inventory-based studies have indicated that the rise in the global CO_2 concentration is largely a result of the release of carbon that has been stored underground through the combustion of fossil fuels (coal, petroleum, and natural gas) used to produce electricity, heat buildings, and power motor vehicles and airplanes, among other uses.

According to the WRI's Climate Watch, emissions from the United States account for approximately 14 percent of total global CO_2 emissions.[14] EPA's National Greenhouse Gas Inventory for 1990 to 2019 indicates that, in 2019, the U.S. transportation sector contributed about 35 percent of total U.S. CO_2 emissions, with passenger cars and light trucks accounting for 58 percent of total U.S. CO_2 emissions from transportation (EPA 2021a). Therefore, approximately 21 percent of total U.S. CO_2 emissions are from passenger cars and light trucks, and these vehicles in the United States account for 3 percent of total global CO_2 emissions (based on comprehensive global CO_2 emissions data available for 2018).[15] Figure S-3 shows the proportion of U.S. CO_2 emissions attributable to the transportation sector and the contribution of each mode of transportation to those emissions.

Figure S-3. Contribution of Transportation to U.S. Carbon Dioxide Emissions and Proportion Attributable by Mode (2019)



Source: EPA 2021a
HD = heavy duty

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[14] The estimate for CO_2 emissions from fossil fuel combustion and industry excludes emissions and sinks from land use change and forestry (WRI 2021).

[15] Ibid.

Key Findings for Climate

The Proposed Action and alternatives would decrease U.S. passenger car and light truck fuel consumption and CO_2 emissions compared with the No Action Alternative, resulting in reductions in the anticipated increases in global CO_2 concentrations, temperature, precipitation, sea level, and ocean acidification that would otherwise occur. They would also, to a small degree, reduce the impacts and risks associated with climate change.

Estimates of GHG emissions and decreases are presented for each of the action alternatives. Key climate effects on atmospheric CO_2 concentration, global mean surface temperature, precipitation, sea level, and ocean pH, which result from changes in GHG emissions, are also presented for each of the action alternatives. These effects are gradual and increase over time. Changes to these climate variables are typically modeled to 2100 or longer because of the amount of time it takes to show the full extent of the effects of GHG emissions on the climate system.

The impacts of the Proposed Action and alternatives on global mean surface temperature, precipitation, sea level, and ocean pH would be small in relation to global emissions trajectories. 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

For the analysis of direct and indirect impacts, NHTSA used the Global Change Assessment Model (GCAM) Reference scenario and the Shared Socioeconomic Pathway (SSP) 3-7.0 scenario to represent the reference case emissions scenarios (i.e., future global emissions assuming no comprehensive global actions to mitigate GHG emissions). NHTSA selected the GCAMReference and SSP3-7.0 scenarios for their incorporation of a comprehensive suite of GHG and pollutant gas emissions, including carbonaceous aerosols and a global context of emissions with a full suite of GHGs and ozone precursors. Both of these scenarios yield a radiative forcing of approximately 7.0 watts per square meter in the year 2100.

Greenhouse Gas Emissions

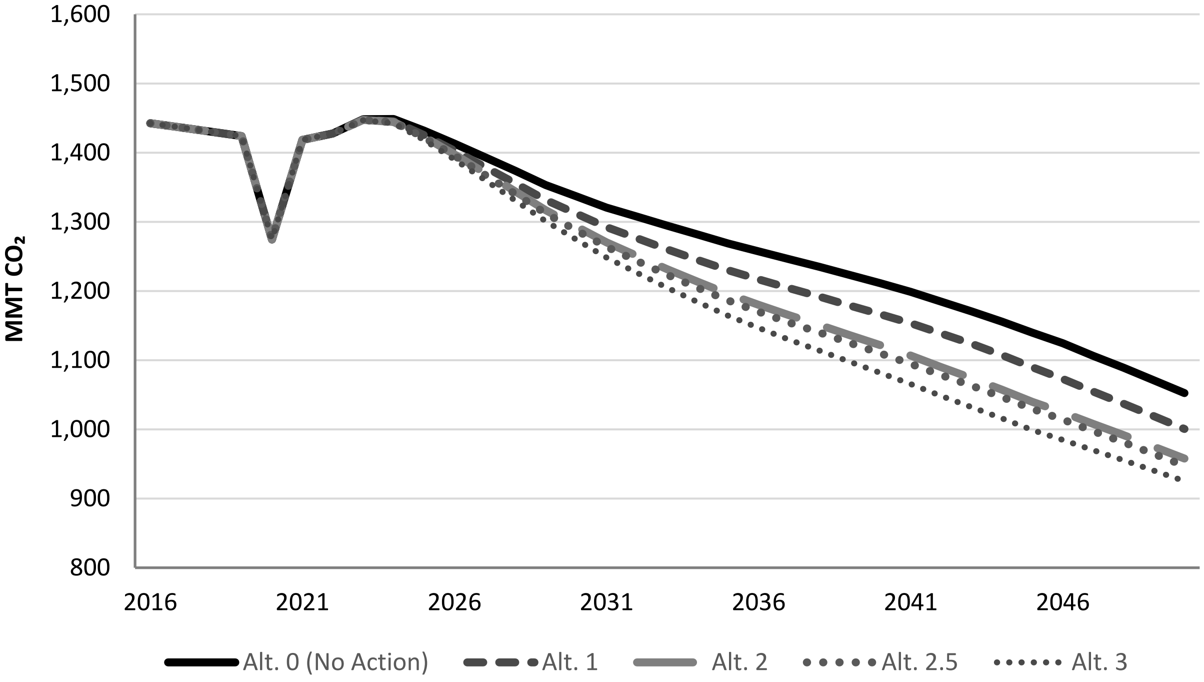
The alternatives would have the following impacts related to GHG emissions.

- Figure S-4 shows projected annual CO_2 emissions from passenger cars and light trucks under each alternative. Passenger cars and light trucks are projected to emit 89,200 million metric tons of carbon dioxide ($MMTCO_2$) from 2021 through 2100 under the No Action Alternative. Alternative 1 and Alternative 2 would decrease these emissions by 4 and 7 percent respectively through 2100. The Preferred Alternative (Alternative 2.5) would decrease these emissions by 8 percent through 2100. Alternative 3 would decrease these emissions by 10 percent through 2100. Emissions would be highest under the No Action Alternative, and emission reductions would increase from Alternative 1 to Alternative 3. All CO_2 emissions estimates associated with the Proposed Action and alternatives include upstream emissions.
- Compared with total projected CO_2 emissions of 967 $MMTCO_2$ from all passenger cars and light trucks under the No Action Alternative in the year 2100, the Proposed Action and alternatives are expected to decrease CO_2 emissions from passenger cars and light trucks in the year 2100 5 percent under Alternative 1, 9 percent under Alternative 2, and 12 percent under Alternative 3. Under the

Preferred Alternative, the 2100 total projected CO_2 emissions for all passenger cars and light trucks are 870 $MMTCO_2$, reflecting a 10 percent decrease.

- Compared to GCAMReference total global CO_2 emissions projection of 4,950,865 $MMTCO_2$ under the No Action Alternative from 2021 through 2100, the Proposed Action and alternatives are expected to reduce global CO_2 by 0.07 percent under Alternative 1, 0.13 percent under Alternative 2, 0.15 percent under the Preferred Alternative, and 0.18 percent under Alternative 3 by 2100. Using the SSP3-7.0 total global emissions projection of 5,277,281 $MMTCO_2$ over this same period, the Proposed Action and alternatives are expected to reduce global CO_2 by 0.07 percent under Alternative 1, 0.12 percent under Alternative 2, 0.14 percent under the Preferred Alternative, and 0.17 percent under Alternative 3 by 2100.
- The emissions reductions in 2025 compared with emissions under the No Action Alternative are approximately equivalent to the annual emissions from 1,143,017 vehicles under Alternative 1, 1,613,007 vehicles under Alternative 2, 1,763,066 vehicles under the Preferred Alternative, and 2,379,681 vehicles under Alternative 3. (A total of 253,949,461 passenger cars and light truck vehicles are projected to be on the road in 2025 under the No Action Alternative.)

Figure S-4. Projected Annual Carbon Dioxide Emissions ($MMTCO_2$) from All U.S. Passenger Cars and Light Trucks by Alternative



$MMTCO_2$ = million metric tons of carbon dioxide

Carbon Dioxide Concentration, Global Mean Surface Temperature, Sea Level, Precipitation, and Ocean pH

CO_2 emissions affect the concentration of CO_2 in the atmosphere, which in turn affects global temperature, sea level, precipitation, and ocean pH.

- Estimated CO_2 concentrations in the atmosphere for 2100 under the GCAMReference scenario would range from 788.33 ppm under Alternative 3 to approximately 789.11 ppm under the No

Action Alternative, indicating a maximum atmospheric CO_2 decrease of approximately 0.78 ppm compared to the No Action Alternative. Atmospheric CO_2 concentration under Alternative 1 would decrease by 0.31 ppm compared with the No Action Alternative. The CO_2 concentrations under the SSP3-7.0 emissions scenario in 2100 would range from 799.57 ppm under Alternative 3 to approximately 800.39 ppm under the No Action Alternative, indicating a maximum atmospheric CO_2 decrease of approximately 0.82 ppm compared to the No Action Alternative. Alternative 1 would decrease by 0.30 ppm compared with the No Action Alternative.

- Under the GCAMReference scenario, global mean surface temperature is projected to increase by approximately 3.48°C (6.27°F) under the No Action Alternative by 2100. Implementing the most stringent alternative (Alternative 3) would decrease this projected temperature rise by 0.003°C (0.006°F), while implementing Alternative 1 would decrease projected temperature rise by 0.001°C (0.002°F). Figure S-5 shows the increase in projected global mean surface temperature under each action alternative compared with temperatures under the No Action Alternative under GCAMReference.
- Under the SSP3-7.0 emissions scenario, global mean surface temperature is projected to increase by approximately 3.56°C (6.41°F) under the No Action Alternative by 2100. Implementing the most stringent alternative (Alternative 3) would decrease this projected temperature rise by 0.004°C (0.007°F), while implementing Alternative 1 would decrease projected temperature rise by 0.001°C (0.002°F). Figure S-6 shows the increase in projected global mean surface temperature under each action alternative compared with temperatures under the No Action Alternative under SSP3-7.0.
- Projected sea-level rise in 2100 under the GCAMReference scenario ranges from a high of 76.28 centimeters (30.03 inches) under the No Action Alternative to a low of 76.22 centimeters (30.01 inches) under Alternative 3. Alternative 3 would result in a decrease in sea-level rise equal to 0.07 centimeter (0.03 inch) by 2100 compared with the level projected under the No Action Alternative. Alternative 1 would result in a decrease of 0.03 centimeter (0.01 inch) compared with the No Action Alternative. Projected sea-level rise in 2100 under the SSP3-7.0 scenario ranges from a high of 78.53 centimeters (30.92 inches) under the No Action Alternative to a low of 78.43 centimeters (30.88 inches) under Alternative 3. Alternative 3 would result in a decrease in sea-level rise equal to 0.10 centimeter (0.04 inch) by 2100 compared with the level projected under the No Action Alternative. Alternative 1 would result in a decrease of 0.02 centimeter (0.008 inch) compared with the No Action Alternative.
- Under the GCAMReference scenario, 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 0.00 to 0.01 percent. Under the SSP3-7.0 scenario, global mean precipitation is anticipated to increase by 6.09 percent by 2100 under the No Action Alternative. Under the action alternatives, this increase in precipitation would be reduced by 0.00 to 0.01 percent.
- Ocean pH in 2100 under the GCAMReference scenario is anticipated to be 8.2180 under Alternative 3, about 0.0004 more than the No Action Alternative. Under Alternative 1, ocean pH in 2100 would be 8.2178, or 0.0002 more than the No Action Alternative. Ocean pH in 2100 under the SSP3-7.0 scenario is anticipated to be 8.2123 under Alternative 3, about 0.0004 more than the No Action Alternative. Under Alternative 1, ocean pH in 2100 would be 8.2120, or 0.0002 more than the No Action Alternative.

Figure S-5. Reductions in Global Mean Surface Temperature Compared with the No Action Alternative—GCAMReference

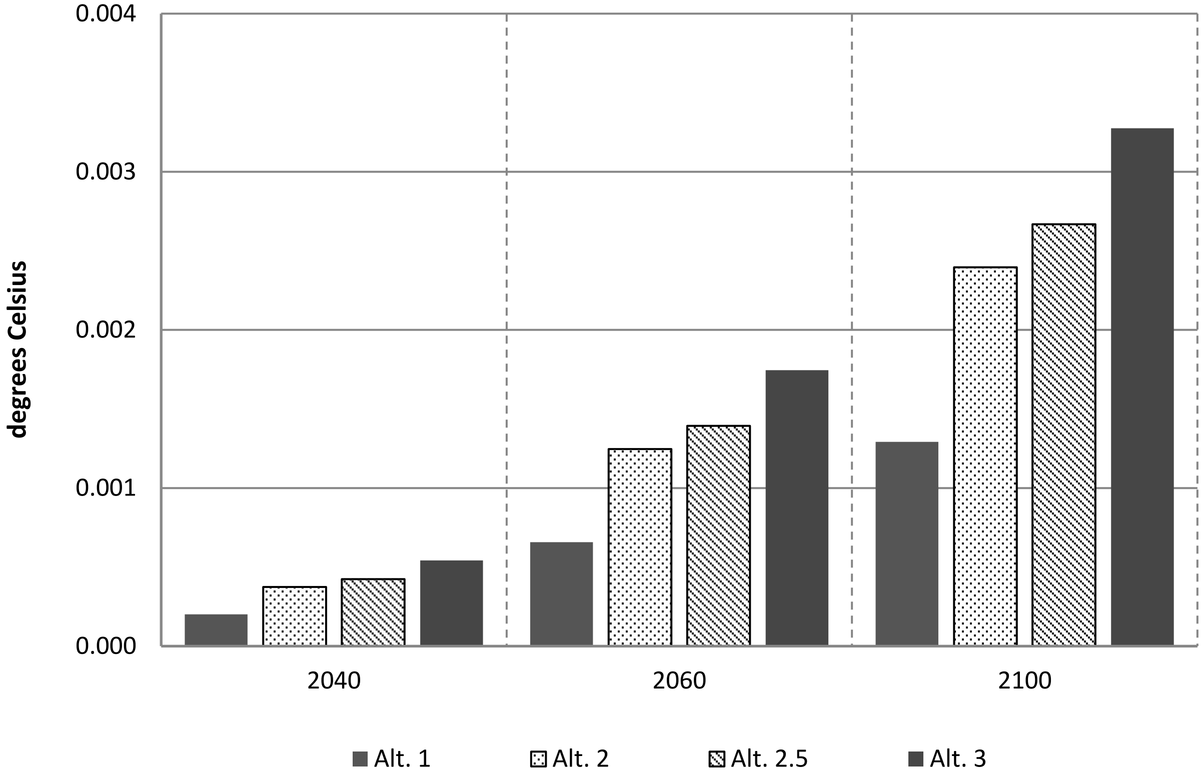
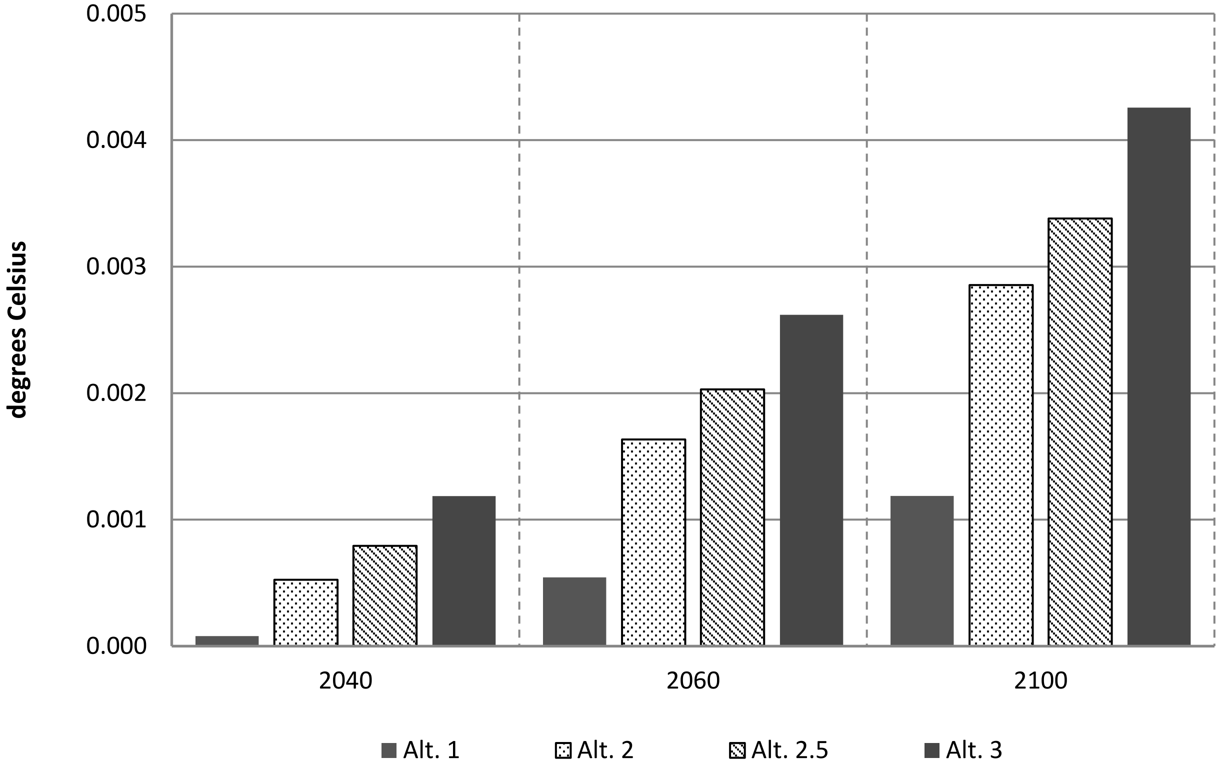


Figure S-6. Reductions in Global Mean Surface Temperature Compared with the No Action Alternative—SSP3-7.0



Cumulative Impacts

The cumulative impact analysis evaluates the impact of the Proposed Action and alternatives in combination with other past, present, and reasonably foreseeable future actions that affect the same resource. The other actions that contribute to cumulative impacts can vary by resource and are defined independently for each resource. However, the underlying inputs, models, and assumptions of the CAFE Model already take into account many past, present, and reasonably foreseeable future actions that affect U.S. transportation sector fuel use and U.S. mobile source air pollutant emissions. Therefore, the analysis of direct and indirect impacts of the Proposed Action and alternatives inherently incorporates projections about the impacts of past, present, and reasonably foreseeable future actions in order to develop a realistic baseline.

For energy and air quality, the focus of the cumulative impacts analysis is on trends in electric vehicle sales and use. For climate, the analysis reflects actions in global climate change policy to reduce GHG emissions. The cumulative impacts analysis for climate also includes qualitative discussions of the cumulative impacts of climate change on key natural and human resources and the nonclimate effects of CO_2.

Energy

Changes in passenger travel, oil and gas exploration, global electric vehicle market projections, and electric vehicle charging infrastructure, as well as changes in the electric grid mix may affect U.S. energy use over the long term. In addition to U.S. energy policy, manufacturer investments in PEV technologies and manufacturing in response to government mandates (including foreign PEV quotas) may affect market trends and energy use. All of these potential cumulative actions would reduce U.S. petroleum consumption and slightly increase U.S. electricity consumption.

Air Quality

Market-driven changes in the energy sector are expected to affect U.S. emissions and could result in future increases or decreases in emissions. Trends in the prices of fossil fuels and the costs of renewable energy sources will affect the electricity generation mix and, consequently, the upstream emissions from energy production and distribution as well as electric vehicle use. Temporal patterns in charging of electric vehicles by vehicle owners would affect any increase in power plant emissions. Potential changes in federal regulation of emissions from power plants also could result in future increases or decreases in aggregate emissions from these sources.

The forecasts of upstream and downstream emissions that underlie the air quality impact analysis assume the continuation of existing emissions standards for vehicles, oil and gas development operations, and industrial processes such as fuel refining. These standards have become tighter over time as state and federal agencies have sought to reduce emissions to help bring nonattainment areas into attainment. To the extent that the trend toward tighter emissions standards could change in the future, total nationwide emissions from vehicles and industrial processes could change accordingly.

Cumulative changes in health impacts due to air pollution are expected to be consistent with trends in emissions. Higher emissions would be expected to lead to an overall increase in adverse health impacts while lower emissions would be expected to lead to a decrease in adverse health impacts, compared to conditions in the absence of cumulative impacts.

Greenhouse Gas Emissions and Climate Change

The global emissions scenario used in the cumulative impacts analysis 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, yielding a moderate level of global GHG reductions from the baseline global emissions scenario used in the direct and indirect analysis. The analysis of cumulative impacts also extends to include not only the immediate effects of GHG emissions on the climate system (atmospheric CO_2 concentrations, temperature, sea level, precipitation, and ocean pH) but also the impacts of past, present, and reasonably foreseeable future human activities that are changing the climate system on key resources (e.g., freshwater resources, terrestrial ecosystems, coastal ecosystems).

Greenhouse Gas Emissions

The following cumulative impacts related to GHG emissions are anticipated.

- Projections of total emissions reductions from 2021 to 2100 under the Proposed Action and alternatives and other reasonably foreseeable future actions compared with the No Action Alternative range from 3,500 $MMTCO_2$ (under Alternative 1) to 8,800 $MMTCO_2$ (under Alternative 3). The Proposed Action and alternatives would decrease total vehicle emissions by between 4 percent (under Alternative 1) and 10 percent (under Alternative 3) by 2100.

- Compared with projected total global CO_2 emissions of 4,044,005 $MMTCO_2$ from all sources from 2021 to 2100 under GCAM6.0, the incremental impact of this rulemaking is expected to decrease global CO_2 emissions between 0.10 (Alternative 1) and 0.22 (Alternative 3) percent by 2100. Using the SSP2-4.5 emissions scenario, global CO_2 emissions from 2021 to 2100 are projected to be 1,873,002 $MMTCO_2$. Global emissions through 2021 are considerably less than in the GCAM6.0 scenario due to the projections that emissions will begin to decline around mid-century. The incremental impact of this rulemaking is expected to reduce global CO_2 emissions between 0.20 (Alternative 1) and 0.50 (Alternative 3) percent by 2100.

Climate Change Indicators

The following cumulative impacts related to the climate change indicators of atmospheric CO_2 concentration, global mean surface temperature, precipitation, sea level, and ocean pH are anticipated.

- Estimated atmospheric CO_2 concentrations from the GCAM6.0 scenario in 2100 range from a high of 687.29 ppm under the No Action Alternative to a low of 686.49 ppm under Alternative 3, the lowest CO_2 emissions alternative. This is a decrease of 0.80 ppm compared with the No Action Alternative. Estimated atmospheric CO_2 concentrations from the SSP2-4.5 scenario in 2100 range from 568.07 ppm (No Action Alternative) to 567.34 ppm (Alternative 3). This is a decrease of 0.73 ppm compared with the No Action Alternative.
- Under the GCAM6.0 scenario, global mean surface temperature increases for the Proposed Action and alternatives compared with the No Action Alternative in 2100 range from a low of 0.001°C (0.002°F) under Alternative 1 to a high of 0.005°C (0.009°F) under Alternative 3. Figure S-7 illustrates the increases in global mean temperature under each action alternative compared with the No Action Alternative. Similarly, under the SSP2-4.5 scenario global mean surface temperature increases range from 0.001°C (0.002°F) under Alternative 1 to 0.005°C (0.009°F) under Alternative 3 (Figure S-8).
- Using the GCAM6.0 scenario, global mean precipitation is anticipated to increase by 4.77 percent by 2100 under the No Action Alternative. Under the action alternatives, this increase in precipitation would be reduced by 0.00 to 0.01 percent. Using the SSP2-4.5 scenario, global mean precipitation is anticipated to increase 4.78 percent under the No Action Alternative, with the action alternatives reducing this effect by 0.00 to 0.01 percent.
- 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 70.11 centimeters (27.60 inches) under Alternative 3, indicating a maximum increase of sea-level rise of 0.11 centimeter (0.04 inch) by 2100. Under the SSP2-4.5 scenario, sea-level rise in 2100 ranges from 60.73 centimeters (23.91 inches) under the No Action Alternative to 60.63 centimeters (23.87 inches) under Alternative 3, for a maximum decrease of 0.10 centimeter (0.04 inch) by 2100.
- Ocean pH in 2100 is anticipated to be 8.2727 under Alternative 3, about 0.005 more than the No Action Alternative. Alternatively, the SSP2-4.5 scenario identifies ocean pH values ranging from 8.3458 (No Action Alternative) to 8.3463 (Alternative 3) for a maximum increase in pH of 0.0005 by 2100.

Figure S-7. Reductions in Global Mean Surface Temperature Compared with the No Action Alternative, Cumulative Impacts—GCAM6.0

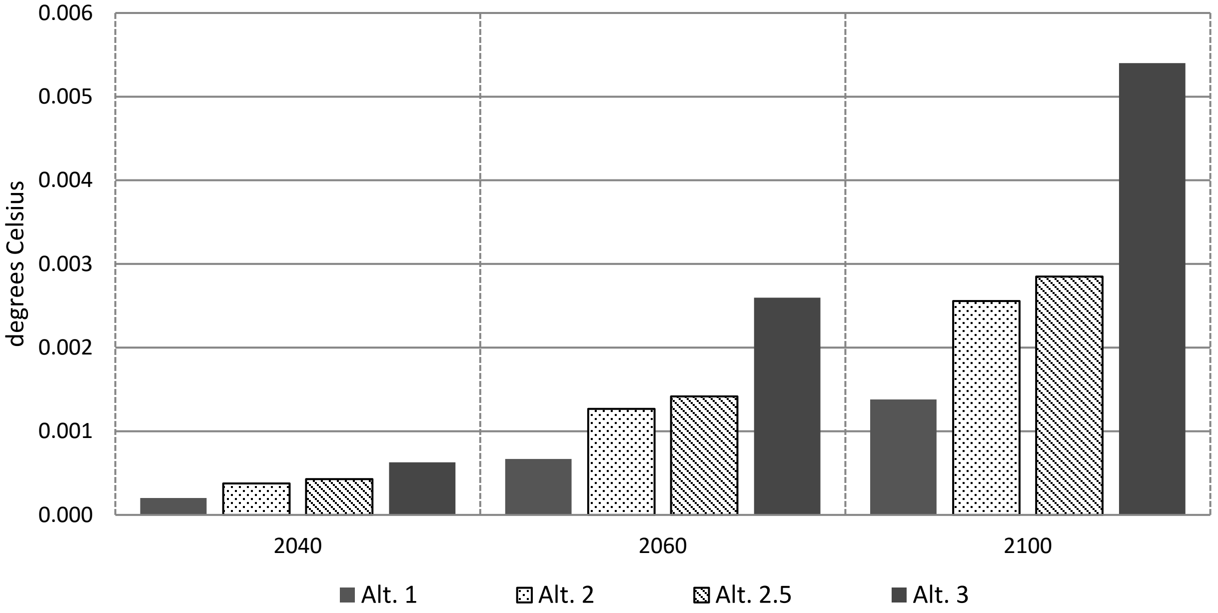
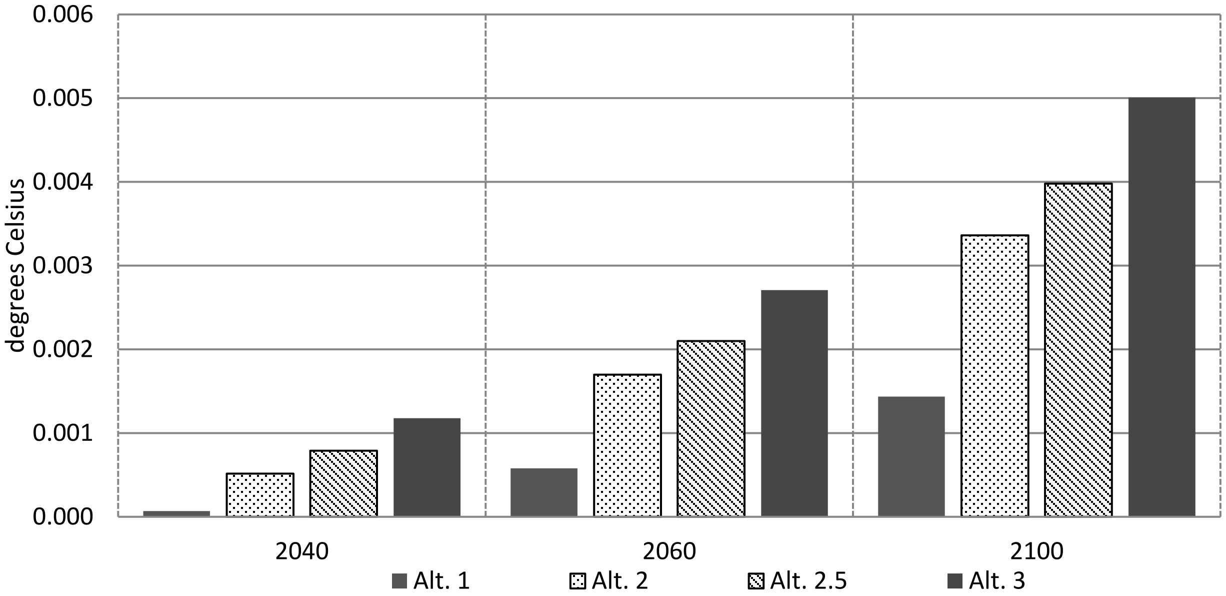


Figure S-8. Reductions in Global Mean Surface Temperature Compared with the No Action Alternative, Cumulative Impacts—SSP2-4.5



Health, Societal, and Environmental Impacts of Climate Change

The Proposed Action and 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 3) using the three degree sensitivity analysis by the year 2100 is between 0.73 ppm and 0.80 ppm lower concentration of CO_2, three thousandths of a degree increase in temperature rise, a small percentage change in the rate of precipitation increase, between 0.10 and 0.11 centimeter (0.04 inch) decrease in sea-level rise, and an increase of between 0.0004 and 0.0005 in ocean pH. Although the projected reductions in CO_2 and climate effects are small compared with total projected future climate change, they are quantifiable, directionally consistent, and would represent an important contribution to reducing the risks associated with climate change.

Many specific impacts of climate change on health, society, and the environment cannot be estimated quantitatively. Therefore, NHTSA provides a qualitative discussion of these impacts by presenting the findings of peer-reviewed panel reports including those from IPCC, GCRP, CCSP, the National Research Council, and the Arctic Council, among others. While the action alternatives would decrease growth in GHG emissions and reduce the impact of climate change across resources relative to the No Action Alternative, they would not entirely prevent climate change and associated impacts. Long-term climate change impacts identified in the scientific literature are briefly summarized below, and vary regionally, including in scope, intensity, and directionality (particularly for precipitation). While it is difficult to attribute any particular impact to emissions resulting from this rulemaking, overall impacts are very likely to be beneficially affected by reduced emissions from the action alternatives.

- Impacts on freshwater resources could include changes in rainfall and streamflow patterns, warming temperatures and reduced snowpack, changes in water availability paired with increasing water demand for irrigation and other needs, and decreased water quality from increased algal blooms. Inland flood risk could increase in response to an increasing intensity of precipitation events, drought, changes in sediment transport, and reductions in snowpack and the timing of snowmelt.
- 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 and other gases.
- Impacts on ocean systems, coastal regions, and low-lying areas could include the loss of coastal areas due to inundation, submersion or erosion from sea-level rise and storm surge, with increased vulnerability of the built environment and associated economies. Changes in key habitats (e.g., increased temperatures, decreased oxygen, decreased ocean pH, increased salinization) and reductions in key habitats (e.g., coral reefs) may affect the distribution, abundance, and productivity of many marine species.
- 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 grazing lands in response to fire, insect infestations, increases in weeds, drought, disease outbreaks, or extreme weather events. Increased concentrations of CO_2 in the ambient air can also stimulate plant growth to some degree, a phenomenon known as the CO_2 fertilization effect, although the impact varies by species and location. Many marine fish species could migrate to deeper and/or colder waters in response to rising ocean temperatures, and global potential fish

catches could decrease. Impacts on food and agriculture including changing yields, food processing, storage, and transportation, could affect food prices, socioeconomic conditions, and food security globally.

- Impacts on rural and urban areas could affect water and energy supplies, wastewater and stormwater systems, transportation, telecommunications, provision of social services, incomes (especially agricultural), air quality, and safety. The impacts could be greater for vulnerable populations such as lower-income populations, historically underserved populations, some communities of color and tribal and Indigenous communities, the elderly, those with existing health conditions, and young children.
- Impacts on human health could include increases in mortality and morbidity due to excessive heat and other extreme weather events, increases in respiratory conditions due to poor air quality and aeroallergens, increases in water and food-borne diseases, increases in mental health issues, and changes in the seasonal patterns and range of vector-borne diseases. The most disadvantaged groups such as children, the elderly, the sick, those experiencing discrimination, historically underserved populations, some communities of color and tribal and Indigenous communities, and low-income populations are especially vulnerable and may experience disproportionate health impacts.
- Impacts on human security could include increased threats in response to adversely affected livelihoods, compromised cultures, increased or restricted migration, increased risk of armed conflicts, reduction in adequate essential services such as water and energy, and increased geopolitical rivalry.

In addition to the individual impacts of climate change on various sectors, compound events may occur more frequently. Compound events consist of two or more extreme weather events occurring simultaneously or in sequence when underlying conditions associated with an initial event amplify subsequent events and, in turn, lead to more extreme impacts. To the extent the action alternatives would result in reductions in projected increases in global CO_2 concentrations, this rulemaking would contribute to reducing the risk of compound events induced by climate change.