Medium- and Heavy-Duty Fuel Efficiency Improvement Program

Draft Environmental Impact Statement

Summary

October 2010

NHTSA

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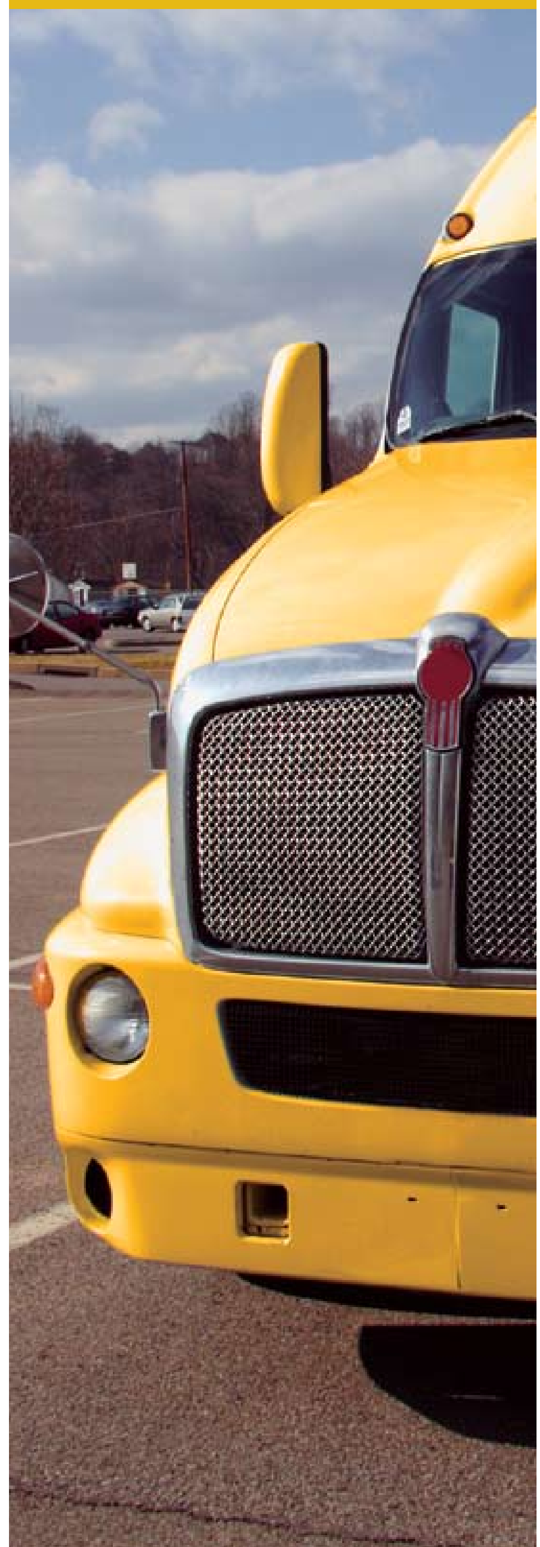


FOREWORD

The National Highway Traffic Safety Administration (NHTSA) prepared this Environmental Impact Statement (EIS) to analyze and disclose the potential environmental impacts of and reasonable alternatives for the proposed Fuel Efficiency Improvement Program for the total fleet of commercial medium- and heavy-duty vehicles pursuant to Council on Environmental Quality (CEQ) regulations implementing the National Environmental Policy Act (NEPA), U.S. Department of Transportation (DOT) Order 5610.1C, and NHTSA regulations. This EIS compares the potential environmental impacts of ten alternative approaches that NHTSA is considering, including the Preferred Alternative and the No Action Alternative. It also analyzes direct, indirect, and cumulative impacts and analyzes impacts in proportion to their significance. Note that footnotes and supporting citations are not included in this summary section. Consult the relevant chapters of this EIS for that 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, and as amended by the Energy Independence and Security Act of 2007 (EISA), EPCA sets forth extensive requirements concerning the establishment of average fuel economy standards for passenger automobiles and non-passenger automobiles, which are motor vehicles that weigh 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 was enacted in December 2007, providing the U.S. Department of Transportation (DOT) U.S. DOT (and by delegation, NHTSA) new authority to implement, via rulemaking and regulations, “a commercial medium- and heavy-duty on-highway vehicle and work truck fuel efficiency improvement program,” to regulate the fuel consumption of motor vehicles weighing more than 10,000 pounds. This provision also 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 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.” The commercial medium- and heavy-duty on-highway vehicles and work trucks are hereinafter referred to collectively as HD vehicles. Pursuant to EISA, the HD Fuel Efficiency Improvement Program NHTSA adopts must provide not less than four full model years of regulatory lead time and three full model years of regulatory stability.

Consistent with these requirements, NHTSA is proposing that mandatory standards begin in model year (MY) 2016 and that the standards remain stable for three model years. Although EISA prevents NHTSA from enacting mandatory standards before MY 2016, NHTSA is proposing optional voluntary compliance standards for MYs 2014–2015 prior to mandatory regulation in MY 2016. As directed by EISA, this rulemaking is being conducted in consultation with the U.S. Environmental Protection Agency (EPA) and the Department of Energy (DOE).

In summary, the EISA directives at 49 U.S.C. § 32902(k)(2) and (k)(3) contain the following requirements specific to the HD Fuel Efficiency Improvement Program: (1) the program must be “designed to achieve the

maximum feasible improvement;" (2) the various required aspects of the program must be appropriate, cost effective, and technologically feasible for HD vehicles; and (3) the standards adopted under the program must provide not less than four model years of regulatory lead time and three model years of regulatory stability. In considering these requirements, NHTSA will also account for relevant environmental and safety considerations.

Further guiding the establishment of NHTSA's HD Fuel Efficiency Improvement Program, on May 21, 2010 President Obama issued a memorandum entitled "Improving Energy Security, American Competitiveness and Job Creation, and Environmental Protection through a Transformation of our Nation's Fleet of Cars and Trucks" to the Secretary of Transportation, the Administrator of NHTSA, the Administrator of EPA, and the Secretary of Energy. The memorandum requested that the Administrators of EPA and NHTSA begin work on a Joint Rulemaking under EISA and the Clean Air Act and to establish fuel efficiency and greenhouse gas (GHG) emissions standards for commercial medium- and heavy-duty vehicles beginning with MY 2014, with the aim of issuing a Final Rule by July 30, 2011. The proposed NHTSA HD Fuel Efficiency Improvement Program and this EIS are consistent with this directive.

The President requested that, before promulgating a final rule, the Administrators of EPA and NHTSA: "Propose and take comment on strategies, including those designed to increase the use of existing technologies, to achieve substantial annual progress in reducing transportation sector emissions and fossil fuel consumption …" The President also requested that NHTSA implement fuel efficiency standards and EPA implement GHG emissions standards that take into account the market structure of the trucking industry and the unique demands of HD vehicle applications; seek harmonization with applicable State standards; consider the findings and recommendations published in the National Academy of Sciences report on HD truck regulation; strengthen the industry and enhance job creation in the United States; and seek input from all stakeholders, while recognizing the continued leadership role of California and other States.

Under NEPA, a Federal agency must analyze environmental impacts if the agency implements a proposed major Federal action, provides funding for that action, or issues a permit for that action. Specifically, NEPA directs that "to the fullest extent possible," Federal agencies proposing "major Federal actions significantly affecting the quality of the human environment" must prepare "a detailed statement" on the environmental impacts of the proposed action (including alternatives to the proposed action). To inform its development of the HD Fuel Efficiency Improvement Program required under EISA, NHTSA prepared this Draft EIS (DEIS) to analyze and disclose the potential environmental impacts of a proposed preferred alternative and other proposed alternative actions pursuant to CEQ NEPA implementing regulations, DOT Order 5610.1C, and NHTSA regulations. This EIS compares the potential environmental impacts among alternatives, including a No Action Alternative. It also analyzes the potential direct, indirect, and cumulative impacts of the alternatives, and discusses impacts in proportion to their significance.

On May 25, 2010, NHTSA invited EPA and the Federal Motor Carrier Safety Administration (FMCSA) to become cooperating agencies with NHTSA in the development of the EIS for the HD rulemaking. Under 40 CFR § 1501.6, a Federal agency that has special expertise with respect to any environmental issue that should be addressed in the EIS may be a cooperating agency upon request of the lead agency. EPA has special expertise in the areas of climate change and air quality and FMCSA has special expertise in HD vehicles. EPA and FMCSA accepted NHTSA's invitation and agreed to become cooperating agencies. The staff of both agencies participated in technical discussions and reviewed and commented on draft sections and the draft final version of the DEIS.

PURPOSE AND NEED FOR THE PROPOSED ACTION

For this EIS, NHTSA's proposed action is to set HD vehicle fuel consumption standards, in accordance with the EISA mandate to "implement a commercial medium- and heavy-duty on-highway vehicle and work truck fuel efficiency improvement program." NHTSA and EPA are proposing coordinated and harmonized fuel consumption and GHG emissions standards for HD vehicles built in MYs 2014–2018. NHTSA is proposing standards for HD vehicles beginning in MY 2016, and voluntary compliance standards for MYs 2014–2015 HD vehicles.

NEPA requires that proposed alternatives be developed based on the action's purpose and need. The purpose and need statement explains why the action is needed, describes the action's intended purpose, and serves as the basis for developing the range of alternatives to be considered in the NEPA analysis. As noted above, in accordance with EISA, NHTSA must establish a fuel efficiency improvement program for HD vehicles "designed to achieve the maximum feasible improvement, and [must] adopt and implement appropriate test methods, measurement metrics, fuel economy standards, and compliance and enforcement protocols that are appropriate, cost-effective, and technologically feasible for commercial medium- and heavy-duty on-highway vehicles and work trucks." The standards adopted under NHTSA's fuel efficiency improvement program must provide not less than four model years of regulatory lead time and three model years of regulatory stability. In considering these various requirements, NHTSA will also account for relevant environmental and safety requirements.

ALTERNATIVES

NHTSA and EPA are proposing standards for each of the following categories, which together comprise all HD vehicles and all engines used in such vehicles:

- Class 2b and 3 HD Pickups and Vans
- Class 2b through 8 Vocational Vehicles
- Class 7 and 8 Combination Tractors

Table S-1 and Figure S-1 show the vehicle classifications. For more details about these vehicle categories *see* Section 2.3.

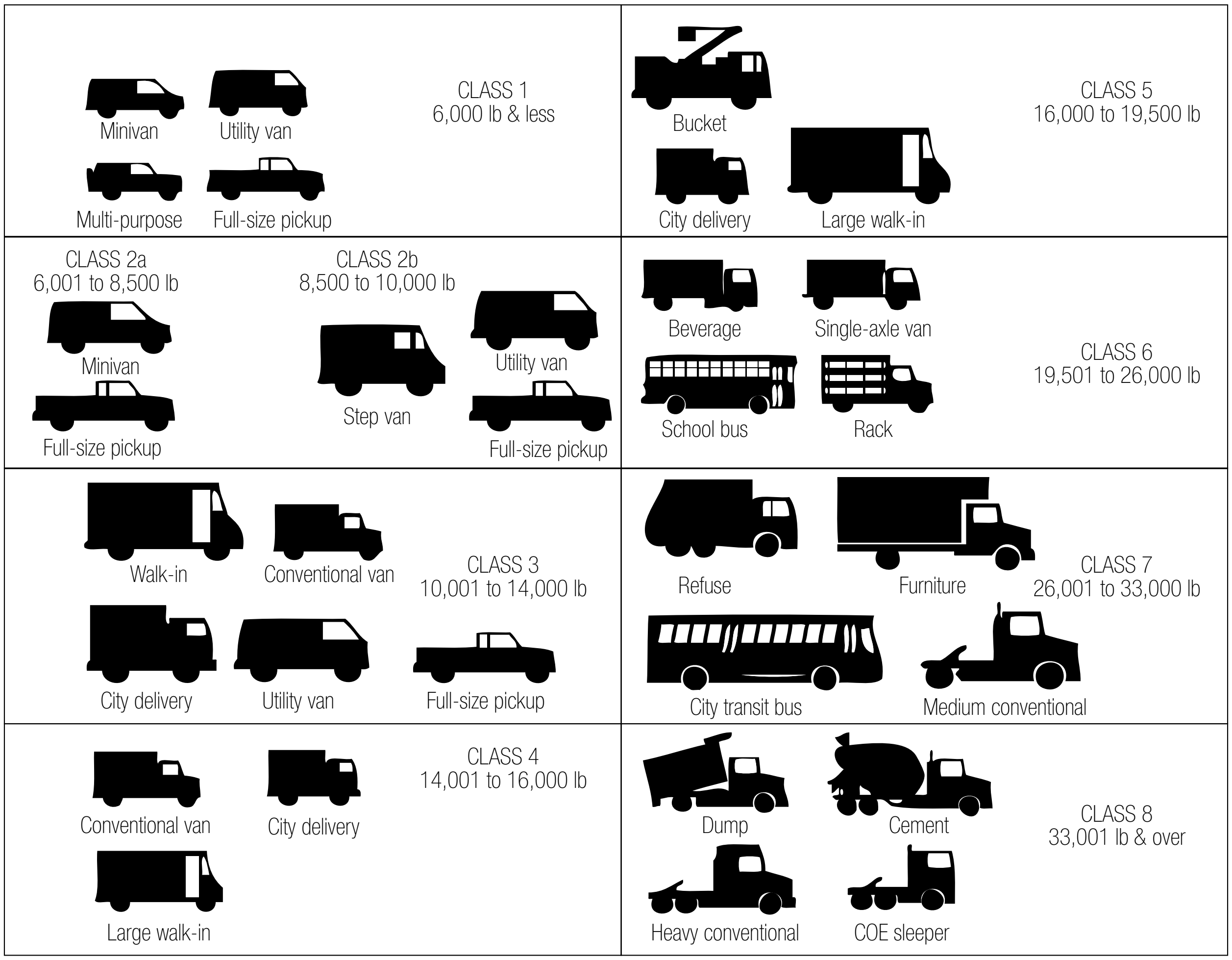
In developing a reasonable range of alternatives for this EIS, NHTSA was guided by the requirements of EISA described above. The NEPA analysis presented in this EIS informs the agency's action in setting HD vehicle fuel consumption standards.

The specific alternatives selected for evaluation by NHTSA encompass a reasonable range to evaluate the potential environmental impacts of the proposed HD Fuel Efficiency Improvement Program and alternatives under NEPA. At one end of this range is the No Action Alternative (Alternative 1), which assumes

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 lbs	10,001-14,000 lbs	14,001-16,000 lbs	16,001-19,500 lbs	19,501 -26,000 lbs	26,001-33,000 lbs	> 33,001 lbs
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



no action would occur under the HD National Program. Under this alternative, neither NHTSA nor EPA would issue a rule regarding the HD fuel consumption standards or GHG emissions. The No Action Alternative assumes that average fuel efficiency levels in the absence of an HD Fuel Efficiency Improvement Program would equal the agencies' collective market forecast – the level of fuel efficiency and GHG performance NHTSA believes manufacturers would continue to achieve, without regulation. Costs and benefits of other alternatives are calculated relative to the baseline of the No Action Alternative. The No Action Alternative, by definition, would yield no incremental costs or benefits. Similarly, the No Action Alternative would yield no additional environmental improvement other than might occur from market forces.

NHTSA has also examined nine action alternatives, each of which would regulate the HD vehicle fleet (or portions of that fleet) in a different way. The analysis of action alternatives examines the environmental impacts associated with applying specific fuel consumption standards to HD engines and one or more of the following vehicle categories: HD pickups and vans, vocational vehicles, and combination tractors. This analytical approach was selected in view of the complexity of the HD vehicle fleet, the applicability of differing fuel-savings technologies to different portions of that fleet, and the relative degree of homogeneity among vehicles within broad categories (HD pickups and vans, vocational vehicles, and combination tractors).

Below is a brief description of the nine action alternatives. NHTSA added five alternatives to those first proposed in the Notice of Intent, Alternatives 4, 5, 6A, 6B, and 8. Alternative 6 is the agency's Preferred Alternative. For a detailed explanation of the alternatives, *see* Section 2.3 of this EIS.

- **Alternative 1** specifies no fuel consumption standards (No Action).
- **Alternative 2** specifies standards for all HD engines used in Classes 2b through 8 vehicles (in gallons per 100 brake-horsepower-hour [gal/100 bhp-hr]).
- **Alternative 3** specifies standards for each of the following:
  - Class 8 tractors (in gallons per 1,000 ton-miles [gal/1,000 ton-miles])
  - Engines used in Class 8 tractors (in gal/100 bhp-hr).
- **Alternative 4** specifies standards for each of the following:
  - Classes 7 and 8 tractors (in gal/1,000 ton-miles)
  - HD engines used in Classes 2b through 8 vehicles (in gal/100 bhp-hr).
- **Alternative 5** specifies standards for each of the following:
  - Classes 7 and 8 tractors (in gal/1,000 ton-miles)
  - HD engines used in Classes 2b through 8 vehicles (in gal/100 bhp-hr)
  - HD pickups and vans (in gallons per 100 miles [gal/100 miles]).
- **Alternative 6**, the Preferred Alternative, specifies standards for each of the following:
  - Classes 7 and 8 tractors (in gal/1,000 ton-miles)
  - Classes 2b through 8 vocational vehicles (in gal/1,000 ton-miles)
  - HD engines used in Classes 2b through 8 vehicles (in gal/100 bhp-hr)
  - HD pickups and vans (in gal/100 miles).
- **Alternative 6A** specifies standards 15 percent less stringent than the Preferred Alternative, Alternative 6, for each of the following:
  - Classes 7 and 8 tractors (in gal/1,000 ton-miles)
  - Classes 2b through 8 vocational vehicles (in gal/1,000 ton-miles)
  - HD engines used in Classes 2b through 8 vehicles (in gal/100 bhp-hr)
  - HD pickups and vans (in gal/100 miles).
- **Alternative 6B** specifies standards 20 percent more stringent than the Preferred Alternative, Alternative 6, for each of the following:
  - Classes 7 and 8 tractors (in gal/1,000 ton-miles)
  - Classes 2b through 8 vocational vehicles (in gal/1,000 ton-miles)
  - HD engines used in Classes 2b through 8 vehicles (in gal/100 bhp-hr)
  - HD pickups and vans (in gal/100 miles).
- **Alternative 7** specifies standards for each of the following:
  - Classes 7 and 8 tractors (in gal/1,000 ton-miles)
  - Classes 2b through 8 vocational vehicles (in gal/1,000 ton-miles)
  - HD engines used in Classes 2b through 8 vehicles (in gal/100 bhp-hr)
  - HD pickups and vans (in gal/100 miles)
  - Trailers pulled by Classes 7 and 8 tractors (reducing gal/1,000 ton-miles standard for combination tractor-trailers).

- **Alternative 8** specifies standards for each of the following:
  - Classes 7 and 8 tractors (in gal/1,000 ton-miles)
  - Classes 2b through 8 vocational vehicles (in gal/1,000 ton-miles)
  - HD engines used in Classes 2b through 8 vehicles (in gal/100 bhp-hr)
  - HD pickups and vans (in gal/100 miles)
  - Trailers pulled by Classes 7 and 8 tractors, with more stringent standards specified for HD pickups and vans and vocational vehicles, associated with accelerated adoption of hybrid engine technology (reducing gal/100 miles standard for HD pickups and vans and reducing gal/1,000 ton-miles standard for tractor-trailers and vocational vehicles).

POTENTIAL ENVIRONMENTAL CONSEQUENCES

This section describes how the proposed action and alternatives could affect energy use, air quality, and climate, which are the resources for which NHTSA performed a quantitative assessment.

This EIS also describes potential additional impacts on water resources, biological resources, safety, hazardous materials and regulated wastes, noise, and environmental justice. NHTSA assesses those resource areas qualitatively.

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

When comparing direct and indirect effects with cumulative effects, it is important to understand that the methodology for evaluating direct effects analyzes the direct impacts of fuel efficiency requirements for MYs 2014–2018 under each action alternative, assuming no further increases in average new HD vehicle fuel efficiency after 2018. The cumulative analysis includes, as a reasonably foreseeable action, increases in fuel efficiency of the HD vehicle fleet beyond 2018 based on Annual Energy Outlook (AEO) projections until 2050. The cumulative impacts analysis considers both national and global potential impacts.

The alternatives in the tables and figures that follow are arranged in ascending order of fuel savings, to aid in the environmental analysis and the comparison of alternatives. Consequently, the alternatives appear out of numerical sequence.

Energy Use

Energy intensity in the United States (energy use per dollar of gross domestic product) is expected to decline by an average of 1.9 percent per year from 2008 to 2035. Despite this continuing improvement in economy-wide energy efficiency, transportation fuel consumption has grown steadily through annual increases, and now represents the major use of petroleum in the U.S. economy.

The transportation sector is the second largest consumer of energy in the United States (after the industrial sector) and, as shown in Figure S-2, represents 28 percent of U.S. total energy use. According to the EIA, more than half of U.S. energy consumption in the transportation sector – ranging from 60 percent in 2008 to 50 percent by 2035–can be attributed to gasoline consumption from light vehicles. Diesel consumption from heavy-duty vehicles made up 17 percent of energy consumption in the U.S. transportation sector in 2008, and is projected to increase to 20 percent of energy consumption in the U.S. transportation sector in 2035. Going forward in time, the transportation sector will continue to be the largest component of total U.S. energy consumption after the industrial sector.

As shown in Figure S-3, about 70 percent of the petroleum used in the United States is consumed by the transportation sector. NHTSA's analysis of fuel consumption in this EIS assumes that fuel consumed by HD vehicles will consist predominantly of diesel and gasoline fuel derived from petroleum for the foreseeable future. Petroleum consumption by HD vehicles will continue to grow. In 2008, the proportion of petroleum consumption by HD vehicles out of all highway modes of transportation (*e.g.* light-duty vehicles, commercial light trucks – 8,500 to 10,000 pounds, and HD vehicles) was approximately 19 percent. The EIA projects that this proportion will drop by 1 to 2 percent, along with total energy consumption in the transportation sector, due to onset of the economic recession that began during the latter half of 2008. However, it is expected to recover by 2013, and is expected to reach 23 percent by 2035.

Key Findings for Energy Use

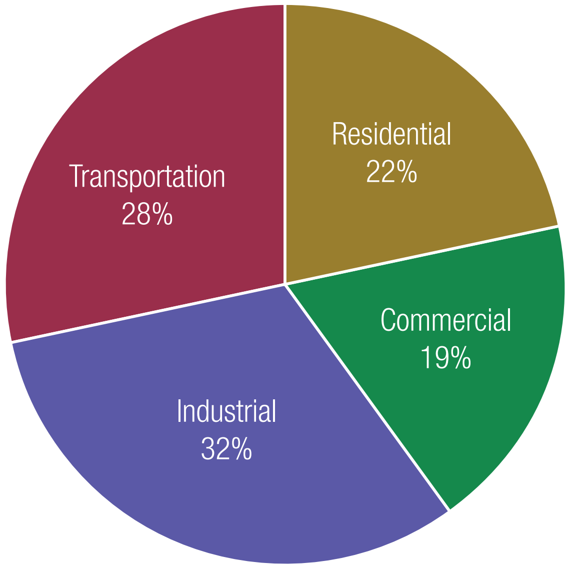
To calculate fuel savings for each proposed alternative, NHTSA subtracted fuel consumption under each alternative from the No Action Alternative level. The fuel consumption and savings figures presented below are for 2050, when nearly the entire U.S. fleet will likely be composed of MY 2014-2018 and later vehicles.

Direct and Indirect Effects

HD Pickups and Vans:

- Total annual fuel savings in 2050 ranges from 0.72 billion gallons for Alternative 2 (Engine Only) to 2.65 billion gallons for Alternative 8 (Accelerated Hybrid Adoption) when compared to the No Action Alternative (Alternative 1). *See* Figure S-4.

Figure S-2. U.S. Energy Consumption by Sector, 2008



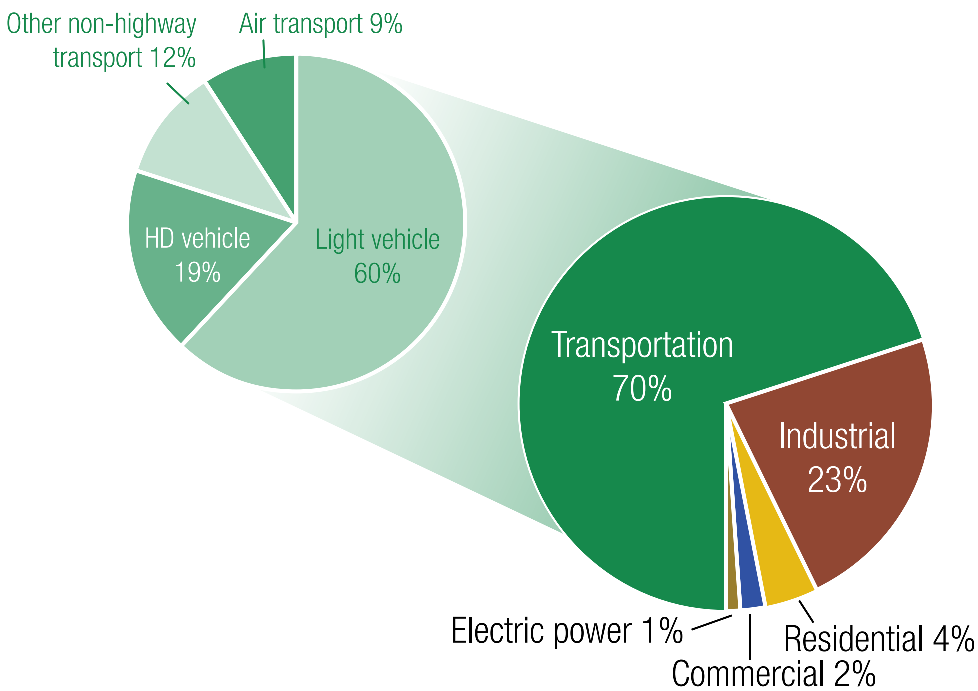
Source: EIA (Energy Information Administration). 2009. Table 2.1a – Energy Consumption by Sector, 1949-2009. Annual Energy Review 2009. DOE/EIA-0384(2009). U.S. Department of Energy. Washington, D.C. *Available at:* <http://www.eia.doe.gov/emeu/aer/pdf/aer.pdf>. (Accessed: October 15, 2010).

- Fuel consumption under the No Action Alternative and Alternative 3 is 11.64 billion gallons in 2050. Alternative 3 does not regulate HD pickups and vans. Consumption under the other alternatives ranges from 10.92 billion gallons for Alternative 2 (Engine Only) to 8.99 for Alternative 8 (Accelerated Hybrid Adoption).
- Fuel consumption under the Preferred Alternative (Alternative 6) is 10.27 billion gallons in 2050, representing a savings of 1.37 billion gallons compared with fuel consumption under the No Action Alternative.

Vocational Vehicles:

- Total annual fuel savings in 2050 ranges from 1.18 billion gallons for Alternative 2 (Engine Only) to 5.22 billion gallons for Alternative 8 (Accelerated Hybrid Adoption) when compared to the No Action Alternative (Alternative 1). *See* Figure S-5.

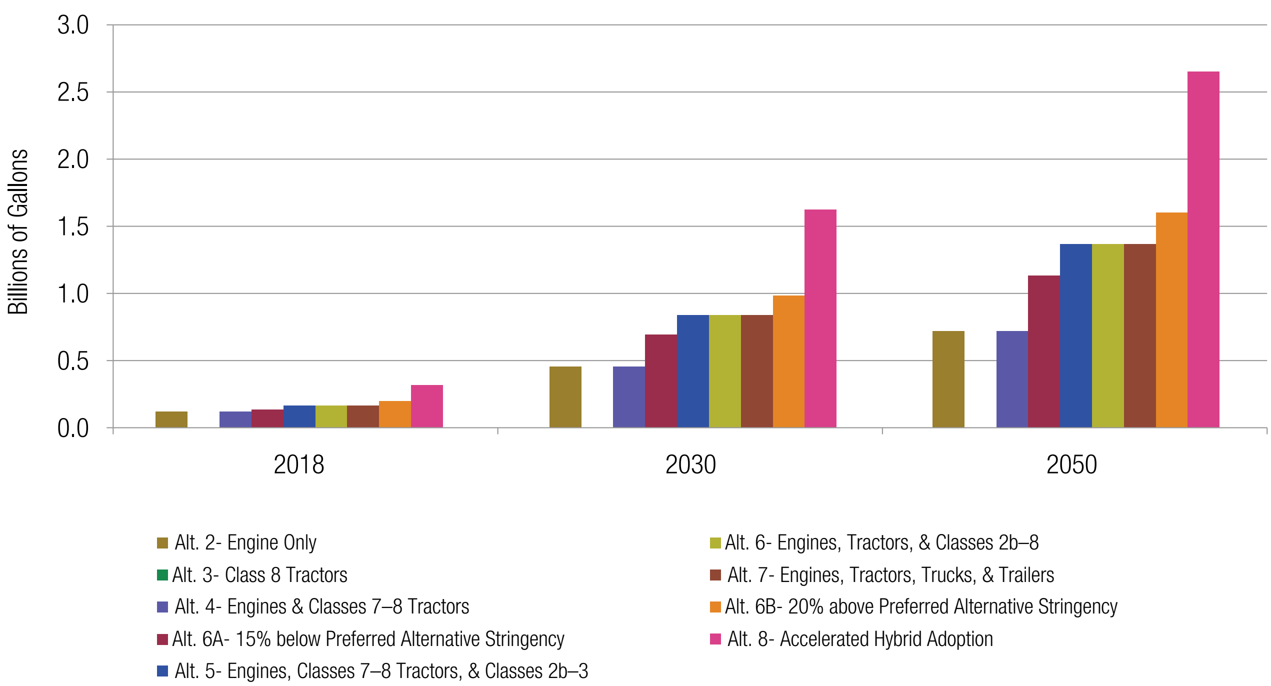
Figure S-3. U.S. Petroleum Consumption by Sector, 2008



Source: EIA. 2010. Table 7 – Transportation Sector Key Indicators and Delivered Energy Consumption, 2007-2035. Annual Energy Outlook 2010. DOE/EIA-0383(2010). April. U.S. Department of Energy. Washington, D.C. *Available at:* <http://www.eia.doe.gov/oiaf/aeo/>. (Accessed: August 4, 2010).

Source: EIA. 2009. Table 5.13a – Estimated Petroleum Consumption: Residential and Commercial Sectors; Table 5.13b – Estimated Petroleum Consumption: Industrial Sector; Table 5.13c – Estimated Petroleum Consumption: Transportation Sector; Table 5.13d – Estimated Petroleum Consumption: Electric Power Sector. Annual Energy Review 2009. DOE/EIA-0384(2009). U.S. Department of Energy. Washington, D.C. *Available at:* <http://www.eia.doe.gov/emeu/aer/pdf/aer.pdf>. (Accessed: October 15, 2010).

Figure S-4. HD Pickup and Van Annual Fuel Savings by Alternative



- Fuel consumption under the No Action Alternative and Alternative 3 is 25.10 billion gallons in 2050. Alternative 3 does not regulate vocational vehicles. Consumption under the other alternatives ranges from 23.92 billion gallons for Alternative 2 (Engine Only) to 19.88 billion gallons for Alternative 8 (Accelerated Hybrid Adoption).
- Fuel consumption under the Preferred Alternative (Alternative 6) is 23.11 billion gallons, representing a savings of 1.99 billion gallons compared with fuel consumption under the No Action Alternative.

Combination Tractors:

- Total annual fuel savings in 2050 ranges from 2.61 billion gallons for Alternative 2 (Engine Only) to 6.39 billion gallons for Alternative 6B (20% above Preferred Alternative Stringency) when compared to the No Action Alternative (Alternative 1). *See* Figure S-6.
- Fuel consumption under the No Action Alternative is 51.65 billion gallons in 2050. Consumption under the other alternatives ranges from 49.04 billion gallons for Alternative 2 (Engine Only) to 45.27 billion gallons for Alternative 6B (20% above Preferred Alternative Stringency).
- Fuel consumption under the Preferred Alternative (Alternative 6) is 46.07 billion gallons in 2050, representing a savings of 5.58 billion gallons compared with fuel consumption under the No Action Alternative.

All HD Vehicles (Pickups and Vans, Vocational Vehicles, and Combination Tractors):

- Total annual fuel savings in 2050 ranges from 4.51 billion gallons for Alternative 2 (Engine Only) to 13.93 billion gallons for Alternative 8 (Accelerated Hybrid Adoption) when compared to the No Action Alternative (Alternative 1). *See* Figure S-7.
- Fuel consumption under the No Action Alternative is 88.39 billion gallons in 2050. Consumption under the other alternatives ranges from 83.88 billion gallons for Alternative 2 (Engine Only) to 74.47 for Alternative 8 (Accelerated Hybrid Adoption).
- Fuel consumption under the Preferred Alternative (Alternative 6) is 79.45 billion gallons in 2050, representing a savings of 8.94 billion gallons compared with fuel consumption under the No Action Alternative.

Cumulative Effects

- Total annual fuel savings in 2050 range from 4.11 billion gallons for Alternative 2 (Engine Only) to 12.68 billion gallons for Alternative 8 (Accelerated Hybrid Adoption) when compared to the No Action Alternative (Alternative 1). *See* Figure S-8.
- Fuel consumption under the No Action Alternative is 80.88 billion gallons in 2050. Consumption under the other alternatives ranges from 76.76 billion gallons for Alternative 2 (Engine Only) to 68.19 billion gallons for Alternative 8 (Accelerated Hybrid Adoption).
- Fuel consumption under the Preferred Alternative (Alternative 6) is 72.71 billion gallons in 2050, representing a savings of 8.16 billion gallons compared with fuel consumption under the No Action Alternative.

For readers interested in additional details about the direct and indirect effects of the alternatives on annual fuel consumption, *see* Section 3.2 of this EIS. For readers interested in additional details about the cumulative effects of each alternative on annual fuel consumption, *see* Section 4.2 of this EIS.

Figure S-5. Vocational Vehicles Annual Fuel Savings by Alternative

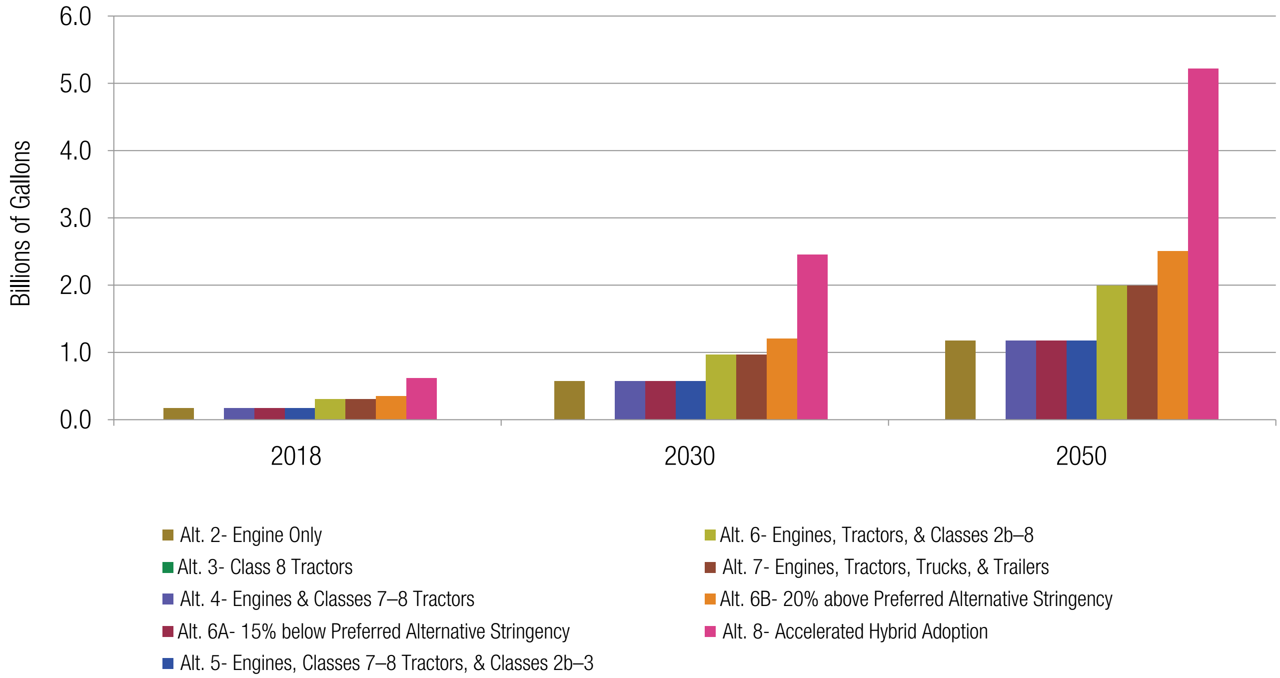


Figure S-6. Combination Tractor Annual Fuel Savings by Alternative

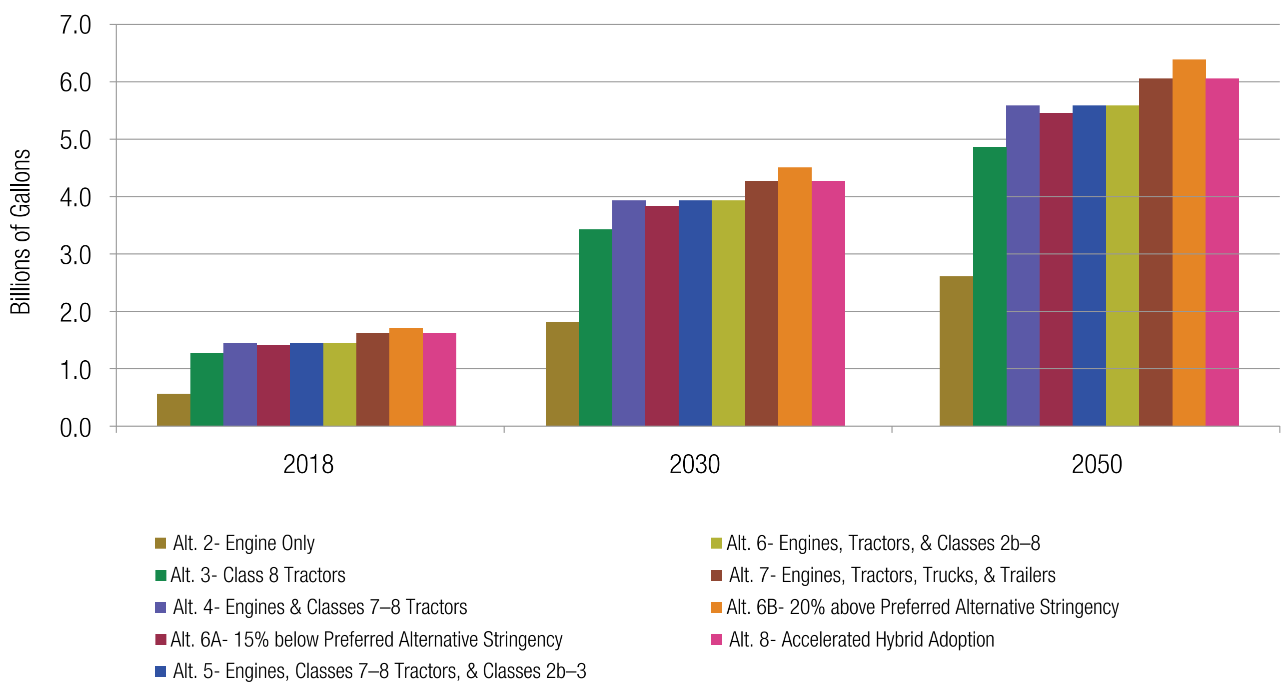


Figure S-7. All HD Vehicles Annual Fuel Savings by Alternative

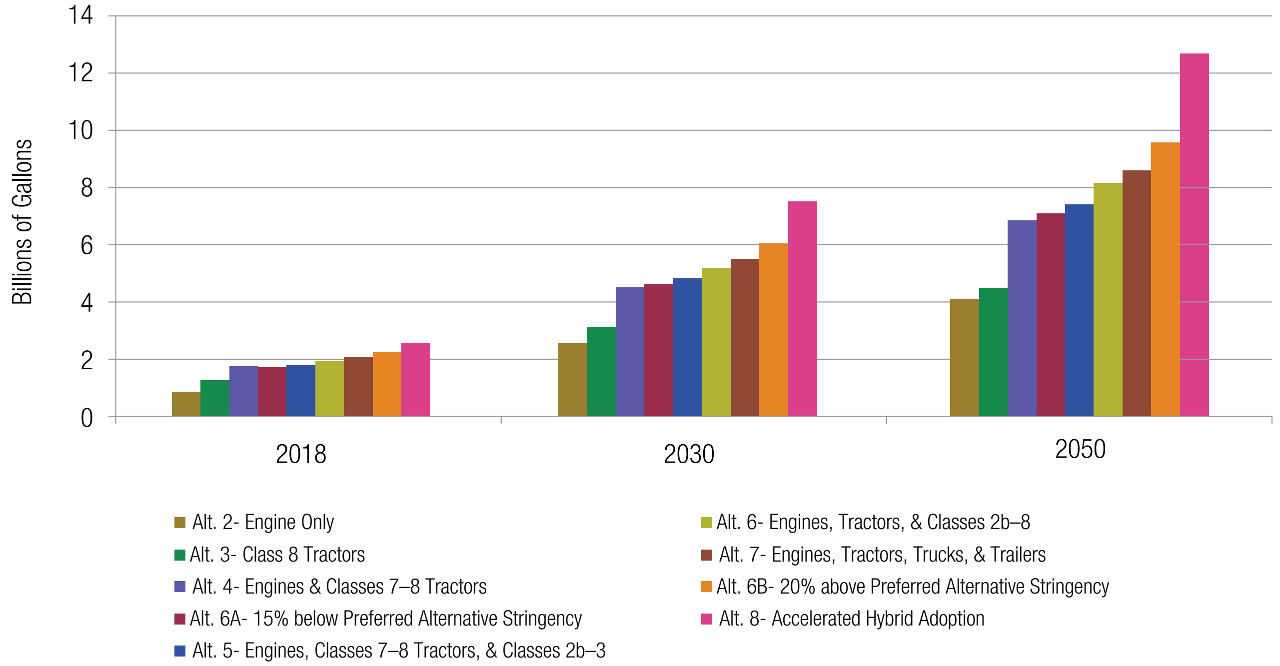
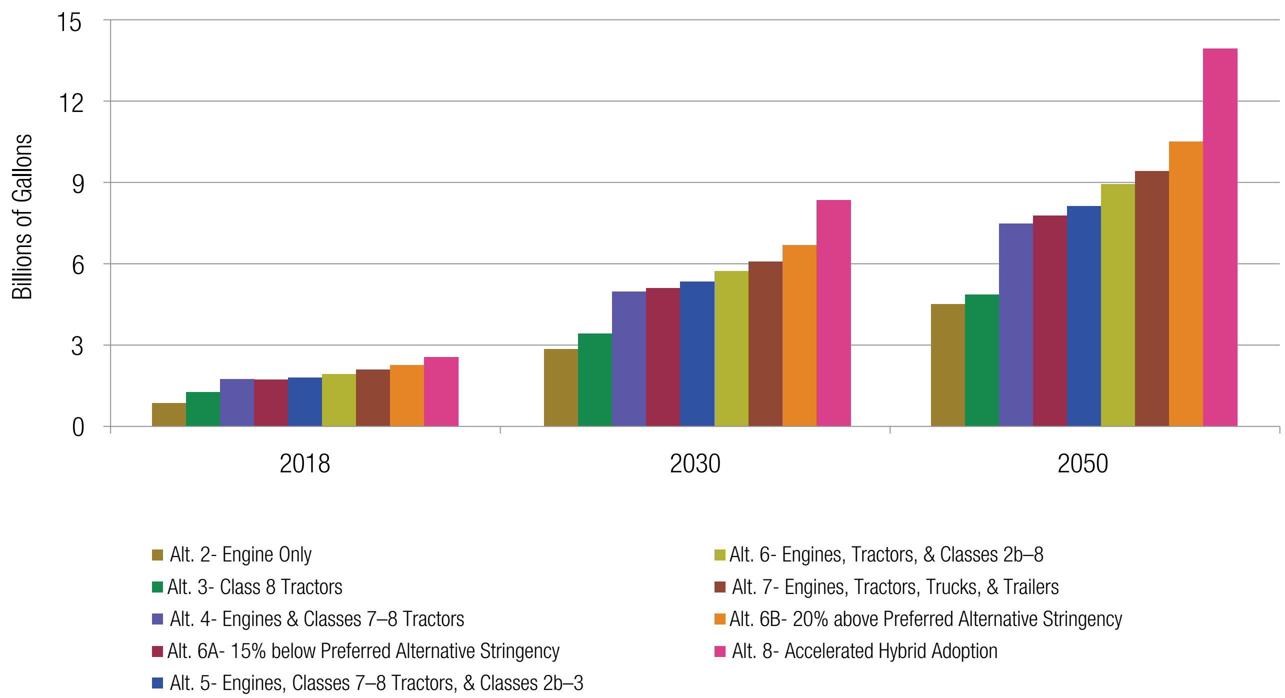


Figure S-8. Cumulative HD Vehicle Annual Fuel Savings by Alternative



Air Quality

Air pollution and air quality can affect public health, public welfare, and the environment. The alternative HD standards 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 and the resulting health effects and monetized health benefits.

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 (PM_{10}) and 2.5 microns ($PM_{2.5}$ or fine particles). Ozone is not emitted directly from vehicles, but is formed from emissions of the ozone precursor pollutants 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 $PM_{2.5}$ particle-size class.

Health Effects of the Pollutants

The criteria pollutants assessed in this EIS have been shown to cause a range of 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; and
- Cancer and premature death.

MSATs are also associated with health effects. For example, acetaldehyde, benzene, 1,3 butadiene, formaldehyde, and certain components of DPM are all classified by EPA as either known or probable human carcinogens. In addition, many MSATs are also associated with noncancer 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 (including HD vehicles) have declined dramatically since 1970 as a result of pollution controls on vehicles and regulation of the chemical content of fuels.

Highway vehicles (including HD vehicles) remain responsible for about 50 percent of total U.S. emissions of carbon monoxide, 4 percent of $PM_{2.5}$ emissions, and 1 percent of PM_{10} emissions. HD vehicles contribute 6 percent of U.S. highway emissions of CO, 66 percent of highway emissions of $PM_{2.5}$, and 55 percent of highway emissions of PM_{10}. Highway vehicles also contribute about 21 percent of total nationwide emissions of VOCs and 32 percent of NO_x, both of which are chemical precursors of ozone. In addition, NO_x is a $PM_{2.5}$ precursor and VOCs can be $PM_{2.5}$ precursors. HD vehicles contribute 8 percent of U.S. highway emissions of VOC and 50 percent of NO_x. Highway vehicles contribute less than 1 percent of SO_2, but SO_2 and other oxides of sulfur (SO_x) are important because they contribute to the formation of $PM_{2.5}$ in the atmosphere. With the elimination of lead in automotive gasoline, lead is no longer emitted from motor vehicles in more than negligible quantities, and thus is not assessed in this analysis.

Key Findings for Air Quality

The findings for direct and indirect effects are shown for 2030 which represents a mid-term forecast year when a large proportion of HD vehicles would at least meet the MYs 2014-2018 standards. Findings for cumulative effects are shown for 2050. By 2050, almost all HD vehicles in operation would meet the MYs 2014–2018 standards, and the impact of these standards would be determined primarily by VMT growth rather than further tightening of the standards. The No Action Alternative results in the highest emissions of most criteria pollutants, although some of the action alternatives result in slightly higher emissions of some criteria pollutants. For MSATs, some of the alternatives result in slightly higher emissions of some hazardous air pollutants, when compared with emission levels under the No Action Alternative.

Monetized $PM_{2.5}$-related health benefits, and related incidence of reduced health effects from the emission reductions, were estimated by multiplying direct $PM_{2.5}$ and $PM_{2.5}$ precursor emission reductions (NO_x, SO_x, and VOCs) by the pollutant-specific benefit-per-ton estimates provided by EPA. Health outcomes include premature mortality, chronic bronchitis, respiratory emergency room visits, and work-loss days. The economic benefits associated with reductions in health effects presented in this EIS take into account a valuation of human health, as determined by EPA.

EPA used the value of statistical life (VSL) metric to calculate the economic benefits associated with reducing the risk of premature mortality. The VSL refers to the aggregate estimated value of reducing small risks across a large number of people. It is based on how people themselves would value reducing these risks, *i.e.,* their "willingness to pay." An estimated VSL of $6.3 million (in 2000 dollars), as established by EPA in 2009, was used for the EIS. For other health-related effects, EPA used willingness-to-pay estimates derived from the valuation literature, estimated healthcare expenses, and lost wages in the valuation of economic benefits.

Direct and Indirect Effects

Criteria Pollutants

- Emissions of criteria pollutants are generally highest under the No Action Alternative (Alternative 1) and generally decline as fuel consumption decreases across the alternatives.

- Emissions of CO and NO_x are slightly higher under Alternatives 2 (Engine Only) than under the No Action Alternative, but decline below the No Action Alternative emissions levels as fuel consumption decreases under Alternatives 3 through 8.
- Emissions of $PM_{2.5}$ are slightly higher under Alternatives 3 through 7 than under the No Action Alternative, but generally decline as fuel consumption decreases under Alternatives 3 through 8. This is due to the assumption that sleeper cab tractor trucks would use the auxillary power units instead of idling for long time periods.
- Emissions of NO_x, SO_2, and VOCs are lowest under Alternative 8 (Accelerated Hybrid Option), emissions of CO are lowest under Alternative 3, and emissions of $PM_{2.5}$ are generally lowest under Alternative 2 (Engine Only).
- Under Alternative 6 (the Preferred Alternative) emissions of CO, NO_x, SO_2, and VOCs would be reduced compared to the No Action Alternative. Emissions under the Preferred Alternative generally would be lower than under Alternatives 1 through 5 and 6A, but higher than under Alternatives 6B, 7, and 8. Under the Preferred Alternative emissions of $PM_{2.5}$ would be lower than under Alternatives 3 through 5 and 6A, but higher than under Alternatives 1, 2, 6B, 7, and 8.

Hazardous Air Pollutants

- Toxic air pollutant emissions show both increases and decreases depending on the pollutant and alternative analyzed. Where there are increases in toxic air pollutant emissions, they are generally small in relation to emission levels under the No Action Alternative. Where there are decreases in toxic air pollutants, they are generally greater in magnitude than the increases.
- Emissions of acetaldehyde, acrolein, benzene, and formaldehyde generally increase from the No Action Alternative to Alternative 2 (Engine Only), and then generally decrease or are the same with each successive alternative from Alternative 2 to Alternative 8 (Accelerated Hybrid Option). Emissions of these pollutants are highest under Alternative 2 and lowest under Alternative 8.
- Emissions of 1,3-butadiene are highest under Alternative 2, lowest under Alternative 3, and approximately the same from Alternatives 4 through 8.
- Emissions of DPM are lowest under Alternative 2 (Engine Only) or Alternative 8 (Accelerated Hybrid Option) depending on the year, are highest under Alternative 3, and decline under each successive alternative from Alternative 3 to 8.
- Under Alternative 6 (the Preferred Alternative) emissions of acetaldehyde, acrolein, benzene, 1,3-butadiene, and formaldehyde would be reduced or approximately equivalent compared to the Alternatives 1 through 5 and 6A. DPM emissions under the Preferred Alternative would be slightly higher in 2030 and 2050 compared to the Alternatives 1 and 2, but lower than under Alternatives 3 through 5 and 6A. Under the Preferred Alternative toxic air pollutant emissions would be slightly higher than or approximately equivalent to emissions under Alternatives 6B, 7, and 8.

Health and Health Benefits

- Alternatives 2 through 8 would reduce adverse health effects nationwide compared with the No Action Alternative (Alternative 1). Reductions generally increase as fuel consumption decreases across alternatives.
- The monetized benefits follow the same patterns as reductions in adverse health effects. When estimating quantified and monetized health impacts, EPA relies on results from two $PM_{2.5}$-related premature mortality studies it considers equivalent (Pope *et al.* 2002 and

Laden *et al.* 2006). EPA recommends that monetized benefits be shown using incidence estimates derived from each of these studies and valued using both a 3-percent and 7-percent discount rate to account for an assumed lag in the occurrence of mortality after exposure (EPA assumes a 20-year distributed "cessation lag"), for a total of four separate calculations of monetized health benefits. *See* Sections 3.3.2.4.2 and 3.3.3.3.3 in Section 3.3 of this EIS. Estimated benefits in annual health costs range from $224 million for Alternative 2 (Engine Only) (the lowest of the four calculations) to $4.6 billion for Alternative 8 (Accelerated Hybrid Option) (the highest of the four calculations).

- Under the Preferred Alternative, health outcomes would be fewer and monetized health benefits would be greater than under Alternatives 2 through 5 and 6A. Health outcomes would be greater and monetized health benefits would be less than under Alternatives 6B, 7, and 8.

Cumulative Effects

Criteria Pollutants

- Emissions of criteria pollutants are generally highest under the No Action Alternative, and generally decline as fuel consumption decreases across the alternatives, with the exceptions noted below.
- Emissions of CO and NO_x are slightly higher under Alternative 2 (Engine Only) than under the No Action Alternative, but decline below the No Action Alternative emissions levels as fuel consumption decreases under Alternatives 3 through 8.
- Emissions of $PM_{2.5}$ are slightly higher under Alternatives 3 through 7 than under the No Action Alternative, but generally decline as fuel consumption decreases under Alternatives 3 through 8.
- Emissions of SO_2 and VOCs are highest under the No Action Alternative, and decline consistently under Alternatives 2 through 8 in all analysis years.
- Emissions of NOx, SO_2, and VOCs are generally lowest under Alternative 8 (Accelerated Hybrid Adoption), emissions of CO are lowest under Alternative 3 (Class 8 Tractors), and emissions of PM2.5 in 2050 are lowest under Alternative 2 (Engine Only).
- Under Alternative 6 (the Preferred Alternative) cumulative emissions of CO, NO_x, SO_2, and VOCs would be reduced compared to the No Action Alternative. Emissions under the Preferred Alternative generally would be lower than under Alternatives 1 through 5 and 6A, but higher than under Alternatives 6B, 7, and 8. Under the Preferred Alternative cumulative emissions of $PM_{2.5}$ would be lower than under Alternatives 3 through 5 and 6A, but higher than under Alternatives 1, 2, 6B, 7, and 8.

Hazardous Air Pollutants

- Toxic air pollutant emissions show both increases and decreases depending on the pollutant and alternative. Where there are increases in toxic air pollutant emissions, they are generally small in relation to emission levels under the No Action Alternative. Where there are decreases in toxic air pollutant emissions, they are generally greater in magnitude than the increases.
- Emissions of acetaldehyde, acrolein, benzene, and formaldehyde generally increase from the No Action Alternative to Alternative 2 (Engine Only), and then generally decrease or are equivalent across the alternatives from Alternative 2 to Alternative 8. Emissions of these pollutants in 2050 are highest under Alternative 2 (Engine Only) and lowest under Alternative 8 (Accelerated Hybrid Adoption).

- Emissions of acetaldehyde, acrolein, benzene, and formaldehyde generally increase from the No Action Alternative to Alternative 2 (Engine Only), and then generally decrease or are equivalent from Alternative 2 to Alternative 8. Emissions of these pollutants in 2050 are highest under Alternative 2 (Engine Only) and lowest under Alternative 8 (Accelerated Hybrid Adoption).
- Emissions of 1,3-butadiene are nearly the same under all alternatives. Emissions of 1,3 butadiene in 2050 are highest under the No Action Alternative and Alternative 2 (Engine Only), and lowest under Alternative 3 (Class 8 Tractors).
- Emissions of DPM are lowest under Alternative 2 (Engine Only) or 8 (Accelerated Hybrid Adoption) depending on the year, are highest in Alternative 3 (Class 8 Tractors), and generally decline from Alternative 3 to 8.
- Under Alternative 6 (the Preferred Alternative) emissions of acetaldehyde, acrolein, benzene, 1,3-butadiene, and formaldehyde would be reduced or approximately equivalent compared to the Alternatives 1 through 5 and 6A. DPM emissions under the Preferred Alternative would be slightly higher in 2030 and 2050 compared to the Alternatives 1 and 2, but lower than under Alternatives 3 through 5 and 6A. Under the Preferred Alternative toxic air pollutant emissions would be slightly higher than or approximately equivalent to emissions under Alternatives 6B, 7, and 8.

Health and Health Benefits

- Alternatives 2 through 8 would reduce adverse health effects nationwide compared with the No Action Alternative. Reductions generally increase as fuel consumption decreases across alternatives.
- The monetized benefits also follow the same patterns as reductions in adverse health effects. Estimated annual monetized health benefits in 2050 range from $362 million for Alternative 2 (lowest of the four calculations) to $7.5 billion for Alternative 8 (highest of the four calculations).
- Under the Preferred Alternative, cumulative health outcomes would be fewer and monetized health benefits would be greater than under Alternatives 2 through 5 and 6A. Cumulative health outcomes would be greater and monetized health benefits would be less than under Alternatives 6B, 7, and 8.

For readers interested in additional detail, Tables 3.3.3-1 through 3.3.3-10 in Section 3 of this EIS provide data on the direct effects of criteria pollutant and hazardous air pollutant emissions, as well as monetized health benefits for the alternatives. Tables 4.3.3-1 through 4.3.3-4 in Section 4 of this EIS provide cumulative effects data on criteria pollutant and hazardous air pollutant emissions. Table 4.3.3 9 in Section 4 of this EIS provides cumulative effects data on monetized health benefits for the alternatives.

Climate

Earth's natural greenhouse effect makes the planet habitable for life (*see* Figure S-9). CO_2 and other GHGs trap heat in the troposphere (the layer of the atmosphere that extends from Earth's surface up to about 8 miles), absorb heat energy emitted by Earth's surface and its lower atmosphere, and re radiate much of it back to the surface. Without GHGs in the atmosphere, most of this heat energy would escape back to space.

The amount of CO_2 and other natural GHGs in the atmosphere, such as methane (CH_4), nitrous oxide (N_2O), water vapor, and ozone, has fluctuated over time, but natural emissions of GHGs are largely balanced by natural sinks, such as vegetation (which, when buried and compressed over long periods of time, becomes fossil fuel) and the oceans, which remove the gases from the atmosphere.

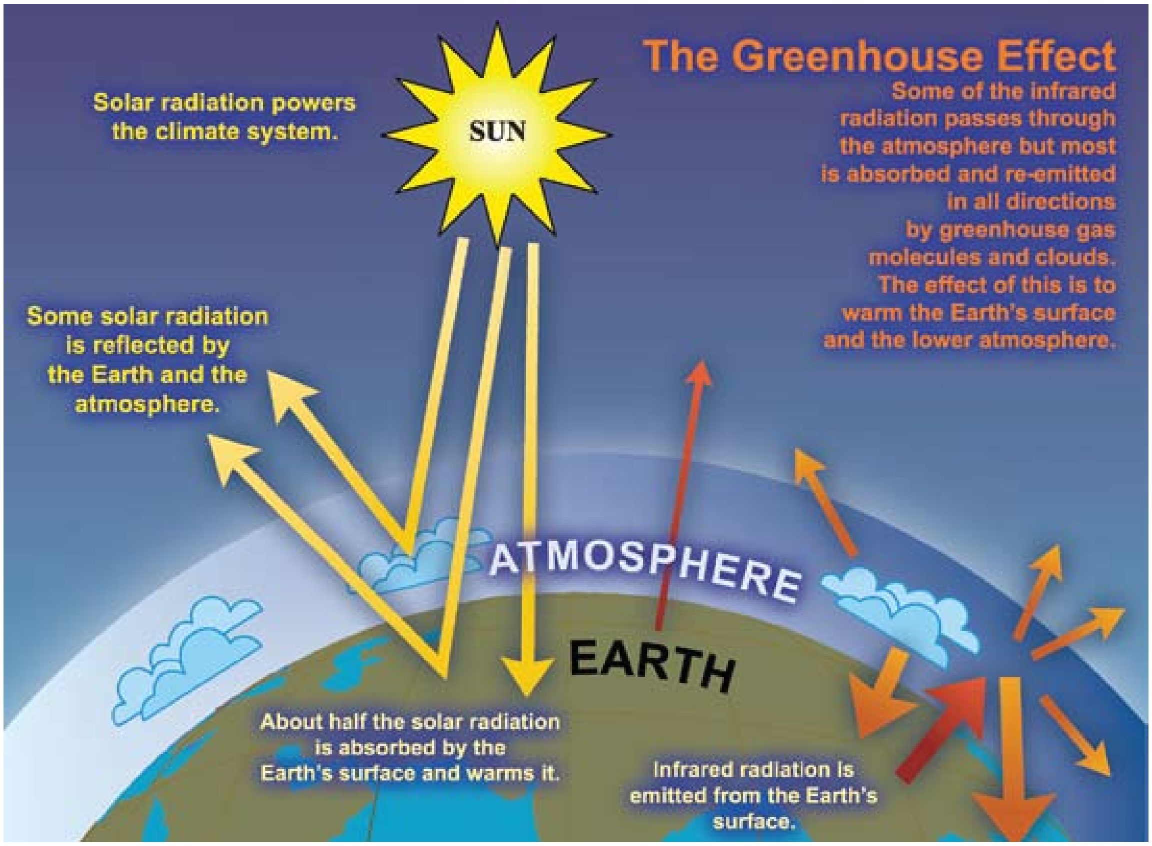
Since the industrial revolution, when fossil fuels began to be burned in increasing quantities, concentrations of GHGs in the atmosphere have increased. CO_2 has increased by more than 38 percent since pre-industrial times, while methane's concentration is now 149 percent above pre-industrial levels.

This buildup of GHGs in the atmosphere is upsetting 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 an average of about 1.3 degrees Fahrenheit (°F) or 0.74 degrees Celsius (°C), and sea levels have risen 6.7 inches (0.17 meter), with a maximum rate of about 0.08 inch (2 millimeters) per year over the past 50 years on the northeastern coast of the United States.

As stated in a recent NRC report, "There is a strong, credible body of evidence, based on multiple lines of research, documenting that climate is changing, and these changes are in large part caused by human activities" (NRC 2010). These activities--such as the combustion of fossil fuel, the production of agricultural commodities, and the harvesting of trees--contribute to increased concentrations of GHGs in the atmosphere, which in turn trap increasing amounts of heat, altering the earth's energy balance.

Figure S-9. The Greenhouse Effect



Source: IPCC (Intergovernmental Panel on Climate Change). 2007. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (Eds.)] Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. 996 pgs.

Throughout this EIS, NHTSA has relied extensively on findings of the United Nations Intergovernmental Panel on Climate Change (IPCC), the U.S. Climate Change Science Program (CCSP), the National Research Council (NRC), the U.S. Global Change Research Program (GCRP), and EPA. Our discussion focuses heavily on the most recent, thoroughly peer-reviewed, and credible assessments of global and U.S. climate change: the IPCC Fourth Assessment Report (Climate Change 2007), the EPA Endangerment and Cause or Contribute Findings for Greenhouse Gases under Section 202(a) of the Clean Air Act and the accompanying Technical Support Document (TSD), and CCSP, GCRP, NRC, and National Science and Technology Council reports that include Synthesis and Assessment Products, Global Climate Change Impacts in the United States, America's Climate Choices, and Scientific Assessment of the Effects of Global Change on the United States. This EIS frequently cites these sources and the studies they review.

Impacts of Climate Change

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

- Impacts on freshwater resources could include changes in precipitation patterns; decreasing aquifer recharge in some locations; changes in snowpack and timing of snowmelt; saltwater intrusion from sea-level changes; changes in weather patterns resulting in flooding or drought in certain regions; increased water temperature; and numerous other changes to freshwater systems that disrupt human use and natural aquatic habitats.
- Impacts on terrestrial ecosystems could include shifts in species range and migration patterns, potential extinctions of sensitive species unable to adapt to changing conditions, increases in the occurrence of forest fires and pest infestation, and changes in habitat productivity due to increased atmospheric concentrations of CO_2.
- Impacts on coastal ecosystems could include the loss of coastal areas due to submersion and erosion, additional impacts from severe weather and storm surges, and increased salinization of estuaries and freshwater aquifers.
- Impacts on land use could include flooding and severe-weather impacts on coastal, floodplain, and island settlements; extreme heat and cold waves; increases in drought in some locations; and weather- or sea-level-related disruptions of the service, agricultural, and transportation sectors.
- Impacts on human health could include increased mortality and morbidity due to excessive heat, increases in respiratory conditions due to poor air quality, increases in water and food-borne diseases, changes in the seasonal patterns of vector-borne diseases, and increases in malnutrition.

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 make seawater more acidic, which has adverse effects on 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.

Contribution of U.S. Transportation Sector to Climate Change

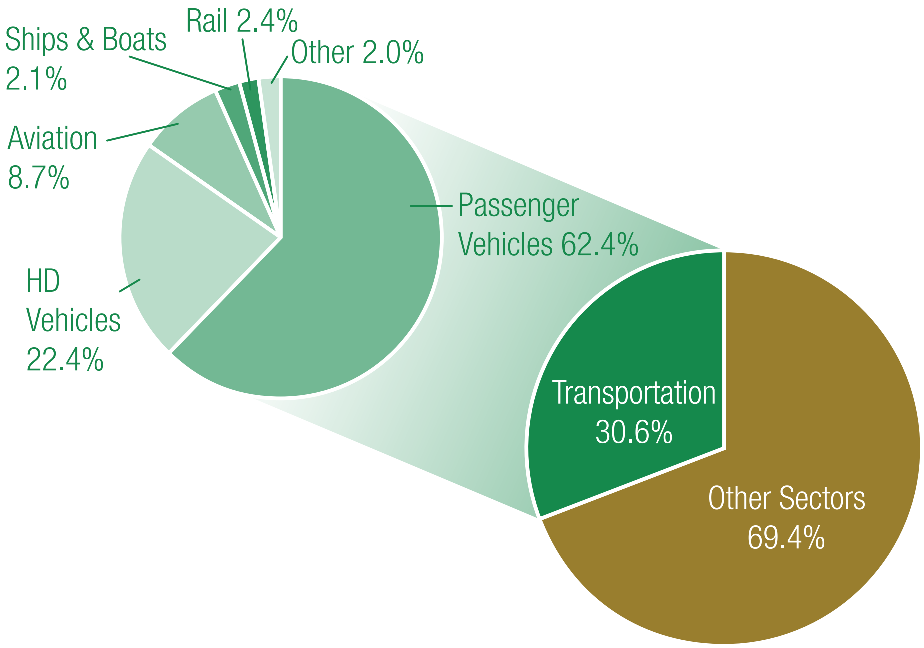
Contributions to the buildup of GHGs in the atmosphere vary greatly from country to country and depend heavily on the level of industrial and economic activity. Emissions from the United States account for about 17.4 percent of total global CO_2 emissions. As shown in Figure S-10, the U.S. transportation sector contributed 30.6 percent of total U.S. CO_2 emissions in 2008, with HD vehicles accounting for 22.4 percent of total U.S. CO_2 emissions from transportation. Thus, 6.9 percent of total U.S. CO_2 emissions come from HD vehicles. From a global perspective, HD vehicles in the United States account for roughly 1.2 percent of total global CO_2 emissions, as compared to 3.3 percent for U.S. light-duty vehicles.

Key Findings for Climate

The proposed action and alternatives would decrease the growth in global GHG emissions, resulting in reductions in the anticipated increases that are otherwise projected to occur in CO_2 concentrations, temperature, precipitation, and sea level. They would also, to a small degree, reduce the impacts and risks of climate change.

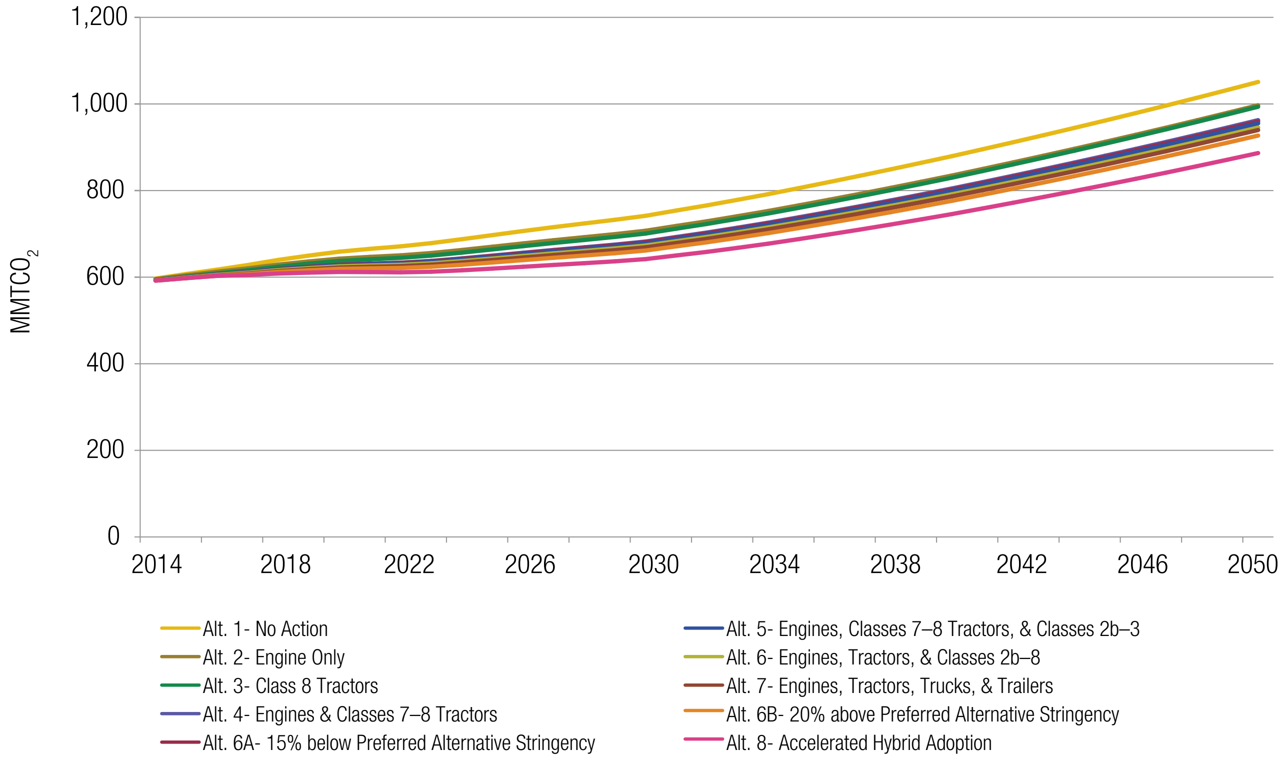
Note that under all alternatives analyzed in this EIS, growth in the number of HD vehicles in use throughout the United States, combined with assumed increases in their average use (annual VMT per vehicle), is projected to result in growth in total HD vehicle travel. This growth in travel outpaces improvements in fuel efficiency for each of the action alternatives, resulting in projected increases in total fuel consumption by HD vehicles in the United States (*see* Figure S-11).

Figure S-10. U.S. Transportation Sector's Contribution to U.S. CO_2 Emissions



Source: EPA (U.S. Environmental Protection Agency). 2010. Inventory of U.S. Greenhouse Gas Emissions and Sinks. Washington, D.C. EPA 430-R-10-006. 441 pgs. Last Revised: April 15, 2010. *Available at:* <http://www.epa.gov/climatechange/emissions/usinventoryreport.html>. (Accessed: August 9, 2010).

Figure S-11. Projected Annual Greenhouse Gas Emissions (million metric tons) from HD Vehicles by Alternative, Direct and Indirect Impacts



Because CO_2 emissions are a direct consequence of fuel consumption, the same result is projected for total CO_2 emissions from HD vehicles. NHTSA estimates that the proposed HD Fuel Efficiency Improvement Program will reduce fuel consumption and CO_2 emissions from what they otherwise are estimated to be in the absence of the program (*i.e.,* fuel consumption and CO_2 emissions under the No Action Alternative).

The global emissions scenario used in the cumulative effects analysis (and described in Chapter 4 of this EIS) differs from the global emissions scenario used for the climate change modeling for direct and indirect effects. In the cumulative analysis, the reference case climate change scenario used in the 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 effects assumes that no significant global controls on GHG emissions are adopted. *See* Section 4.4.3.3 of this EIS for additional explanation of the cumulative effects methodology.

Below, estimates of GHG emissions and reductions (both direct and indirect effects and cumulative effects) are summed for the period 2014 through 2100 under each of the ten alternatives. Climate effects such as mean global increase in surface temperature and sea level rise are typically modeled to 2100 or longer due to the amount of time required for the climate system to show the effects of the greenhouse gas emissions (or in this case emission reductions). This inertia primarily reflects the amount of time required for the ocean to warm in response to the increased radiative forcing.

Direct and Indirect Effects

Greenhouse Gas Emissions

- Compared with total projected U.S. CO_2 emissions in 2100 of 7,193 million metric tons of carbon dioxide equivalent ($MMTCO_2$), the action alternatives would reduce total U.S. CO_2 emissions by 0.7 to 2.1 percent in 2100. Figure S-11 shows projected annual GHG emissions and reductions from HD vehicles by alternative.
- Compared with cumulative global emissions of 5,204,115 $MMTCO_2$ over this period, the action alternatives are expected to reduce annual global CO_2 emissions by between 0.1 percent (Alternative 2, Engine Only) and 0.2 percent (Alternative 8, Accelerated Hybrid Adoption).
- Average annual CO_2 emission reductions from the alternatives range from 44 to 134 $MMTCO_2$ over 2014–2100, equivalent to the annual CO_2 emissions of 11 to 35 coal-fired power plants.
- The emission reductions from the alternatives are equivalent to the annual emissions of between 0.54 million HD vehicles (Alternative 2) and 1.60 million HD vehicles (Alternative 8) in 2018, compared with the No Action Alternative. Emission reductions in 2018 from the Preferred Alternative (Alternative 6) are equivalent to the annual emissions of 1.20 million HD vehicles.

In January 2010, President Obama submitted to the United Nations Framework Convention on Climate Change (UNFCCC) a GHG target for the United States in the range of 17 percent below 2005 levels by 2020, in association with the Copenhagen Accord, and in conformity with anticipated U.S. energy and climate legislation. Although this rulemaking contributes to meeting that goal, the alternatives would result in projected CO_2 emissions from the HD vehicle sector in 2020 in the range of 8.2 to 13.6 percent above 2005 levels. Thus, no alternative would reduce 2020 emissions from HD vehicles to 17 percent below 2005 levels, due to the fact that total VMT increases under all scenarios. *See* Figure S-12.

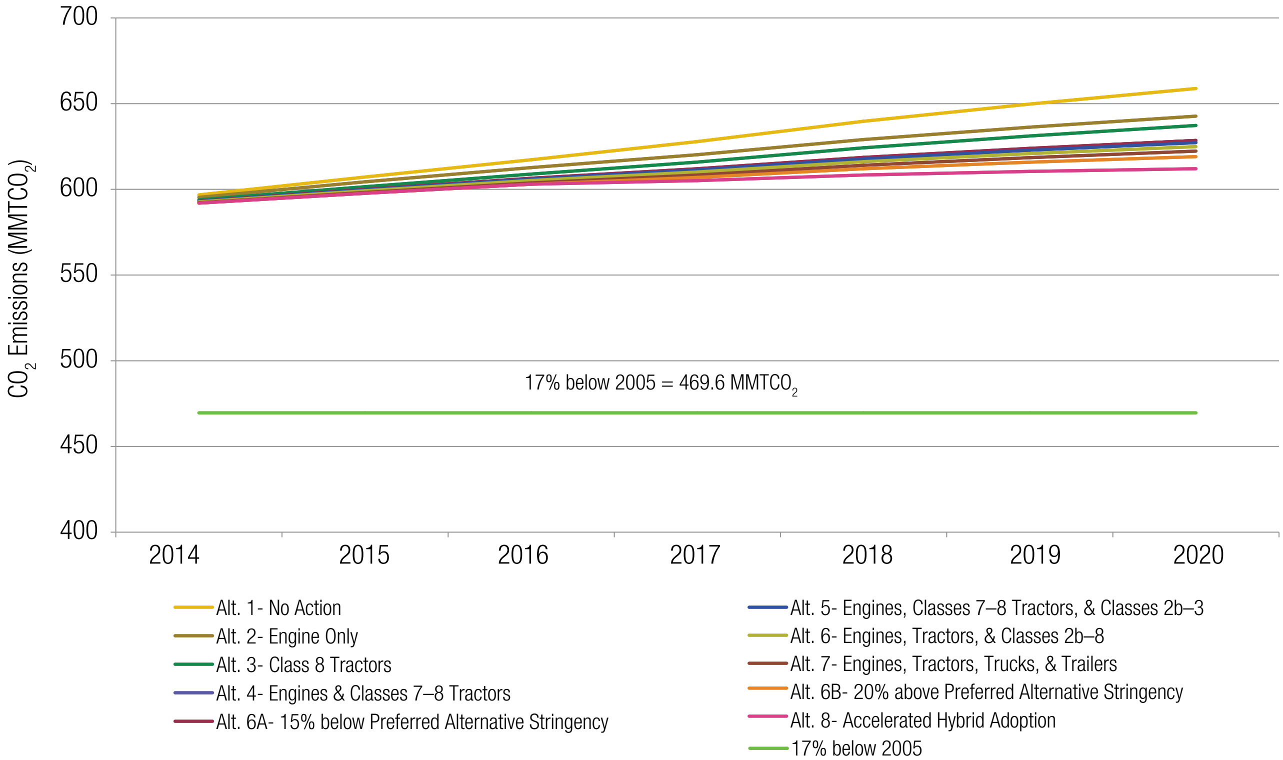
The President's stated policy goal outlined above does not specify that every emitting sector of the economy must contribute equally proportional emission reductions. Significantly, the action of setting standards under the HD Fuel Efficiency Improvement Program does not directly regulate total emissions from HD vehicles. *See* Section 3.4.4.1 of this EIS for additional discussion relating NHTSA's action to this policy goal.

CO_2 Concentration, Global Mean Surface Temperature, Sea-Level Rise, and Precipitation

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 effects, NHTSA used the GCAM reference scenario to represent the reference case emissions scenario; that is, future global emissions assuming no additional climate policy. The impacts of the proposed action and alternatives on temperature, precipitation, or sea-level rise are small in absolute terms, because the action alternatives result in a small proportional change to the emissions trajectories in the Reference Case scenario to which the alternatives were compared. Although these effects are small, they occur on a global scale and are long-lived.

- Estimated CO_2 concentrations in the atmosphere for 2100 range from 783.8 parts per million (ppm) under Alternative 8 (Accelerated Hybrid Option) to 784.9 ppm under the No Action Alternative (Alternative 1).
- For 2100, the reduction in temperature for the action alternatives, as compared to the No Action Alternative, ranges from 0.002 °F (0.001 °C) to 0.007 °F (0.004 °C). *See* Figure S-13.

Figure S-12. Projected Annual CO_2 Emissions from HD Vehicles by Alternative Compared with 17 Percent below 2005 Levels, Direct and Indirect Impacts



Note: CO_2 emissions for HD vehicles in 2005 are 565.8 $MMTCO_2$.

Figure S-13. Reduction in Global Mean Temperature Compared with the No Action Alternative, Direct and Indirect Impacts

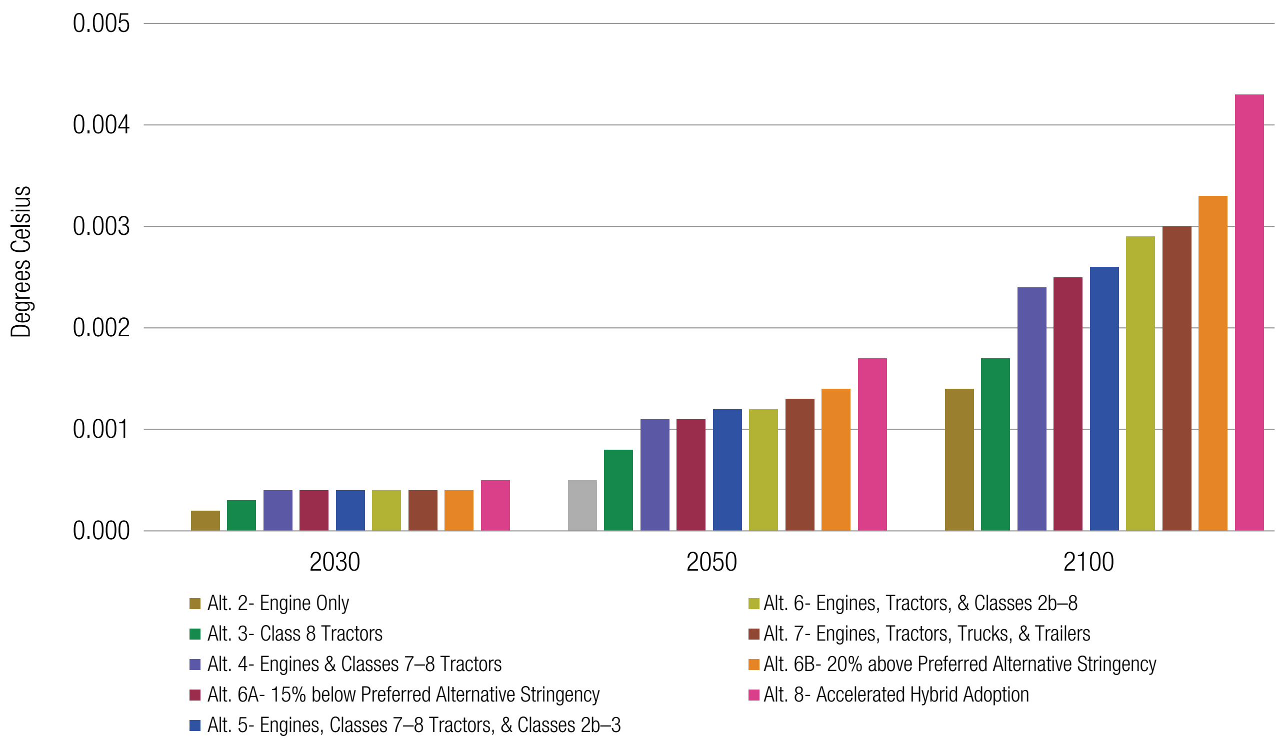
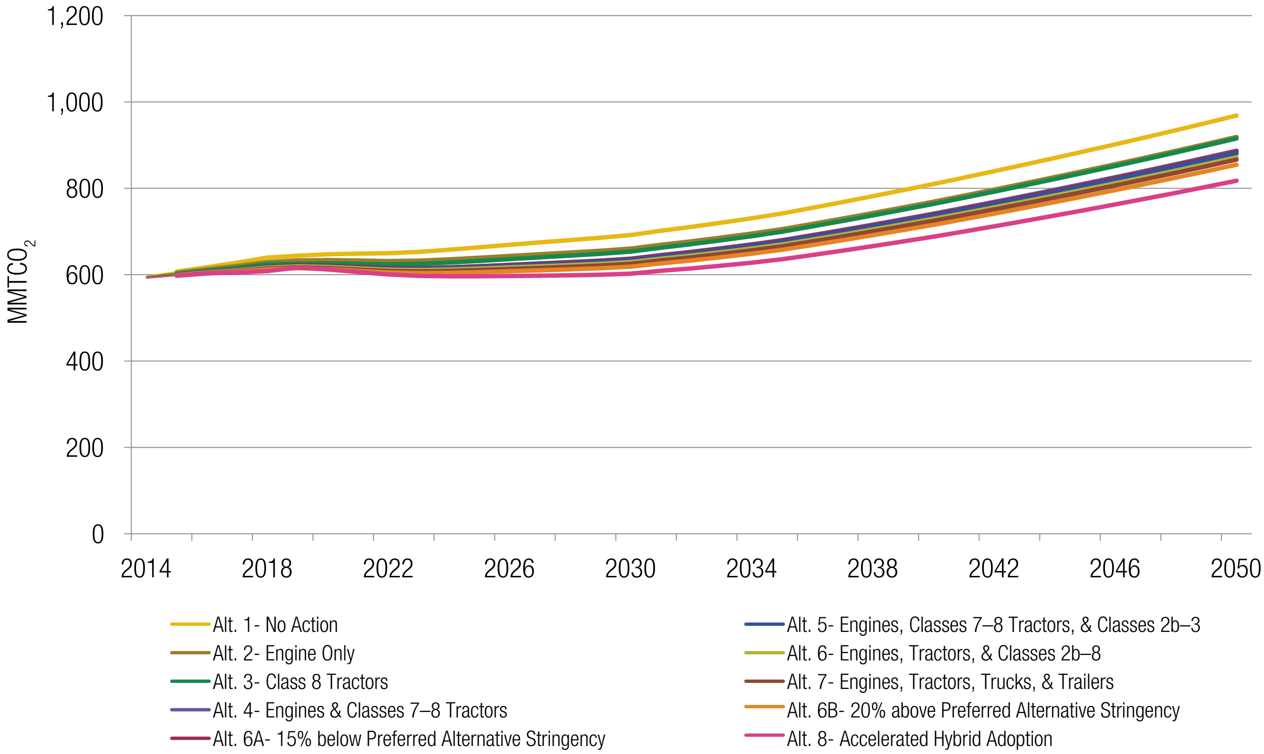


Figure S-14. Projected Greenhouse Gas Emissions from HD Vehicles by Alternative, Cumulative Impacts



- Projected sea-level rise in 2100 ranges from 14.72 inches (37.40 centimeters) under the No Action Alternative to 14.71 inches (37.36 centimeters) under Alternative 8. Thus, the action alternatives will result in a maximum reduction of sea-level rise equal to 0.016 inch (0.04 centimeter) by 2100 from the level projected under the No Action Alternative.
- For 2090, the reduction in global mean precipitation (percent change) for the action alternatives, as compared to the No Action Alternative, ranges from 0.00% to 0.01%.

Cumulative Effects

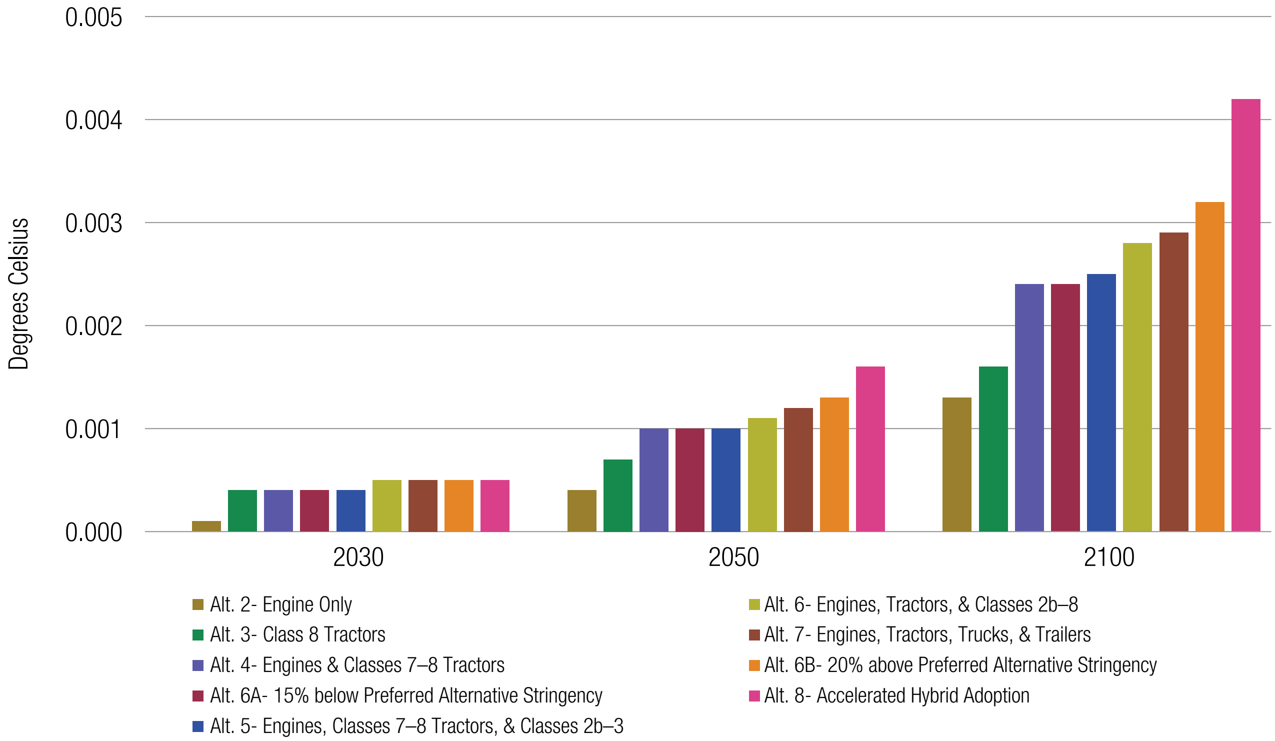
Greenhouse Gas Emissions

- Compared with projected global emissions of 4,294,482 $MMTCO_2$ from 2014 through 2100, the incremental impact of this rulemaking is expected to reduce global CO_2 emissions by about 0.1 to 0.2 percent from their projected levels under the No Action Alternative. *See* Figure S-14.
- Projections of total emission reductions over the 2014 through 2100 period due to the HD standards and other reasonably foreseeable future actions (*i.e.,* forecasted fuel efficiency increases resulting from market-driven demand) range from 3,500 to 10,600 $MMTCO_2$.

CO_2 Concentration, Global Mean Surface Temperature, Sea-Level Rise, and Precipitation

- Estimated CO_2 concentrations in the atmosphere for 2100 range from 676.8 ppm under Alternative 8 (Accelerated Hybrid Option) to 677.8 ppm under the No Action Alternative.
- For 2100, the reduction in temperature increase for the action alternatives in relation to the No Action Alternative is about 0.002 to 0.007 ° F (0.001 to 0.004 °C). *See* Figure S-15.

Figure S-15. Reduction in Global Mean Temperature Compared with the No Action Alternative, Cumulative Impacts



- Projected sea-level rise in 2100 ranges from 13.16 inches (33.42 centimeters) under the No Action Alternative to 13.15 inches (33.39 centimeters) under Alternative 8. Thus, the action alternatives will result in a maximum reduction of sea-level rise equal to 0.01 inch (0.03 centimeter) by 2100 from the level that could occur under the No Action Alternative.

Readers interested in further details about the direct, indirect, and cumulative climate impacts should consult Sections 3.4 and 4.4 of this EIS.

Health, Societal, and Environmental Impacts of Climate Change

The magnitude of the changes in climate effects that would be produced by the most stringent alternative is 1 ppm less of CO_2, less than one hundredth of a degree difference in temperature, one hundredth of one percent change in the rate of precipitation increase, and less than one-half millimeter of sea-level rise. These changes are too small to address quantitatively in terms of their impacts on health, society, and the environment. Given the enormous resource values at stake, these distinctions could be important, but they are too small for current quantitative techniques to resolve. For detailed discussion of the impacts of climate change on various resource sectors, *see* Section 4.5 of this EIS.

The changes in non-climate impacts (such as ocean acidification by CO_2) associated with the alternatives have also been assessed qualitatively. A reduction in the rate of increase in atmospheric CO_2, which all the action alternatives would provide to some extent, would reduce the ocean acidification effect and the CO_2 fertilization effect. For additional discussion of non-climate environmental impacts, *see* Section 3.5 of this EIS.