5 Emissions Impacts

5.1 Executive Summary

5.2 Introduction

5.2.1 Scope of Analysis

The proposed standards affect both diesel- and gasoline-fueled heavy-duty vehicles. This analysis accounts for the direct downstream/tailpipe reduction of greenhouse gas (GHG) as well upstream (fuel production and distribution) reductions of GHGs and non-GHGs. Total GHG impacts will also be determined by any VMT rebound effects, changes in fleet turnover, and changes in fuel consumption globally due to reduced petroleum prices. See Chapter 9 for a further discussion of these aspects of the analysis. The agencies also expect this proposal to impact downstream and upstream emissions of non-GHG air pollutants.

Emissions estimates for the three greenhouse gases carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are presented herein. Inventories for the non-GHG pollutants 1,3-butadiene, acetaldehyde, acrolein, benzene, carbon monoxide (CO), formaldehyde, oxides of nitrogen (NO_X), particulate matter below 2.5 micrometers ($PM_{2.5}$), oxides of sulfur (SOx), and volatile organic compounds (VOC) are also presented.

5.2.2 Downstream Contributions

The largest source of GHG and other air pollutant reductions from this proposal is from tailpipe emissions produced during vehicle operation. Absolute reductions from tailpipe emissions are projected to grow over time as the fleet turns over to vehicles affected by the standards, meaning the benefit of the program will continue to grow as long as the older vehicles in the fleet are replaced by newer, lower CO_2-emitting vehicles.

As described herein, the downstream reductions in emissions due to the program are anticipated to be achieved through improvements in engine efficiency, road load reduction, and APU use during extended idling.

Changes in downstream GHG and other emissions at the fleet level will be affected by whether the regulations affect the timing of fleet turnover and total VMT, as discussed in section 8 of the preamble. If the regulations spur firms to increase their purchase of new vehicles before efficiency standards are in place ("pre-buy") or to delay their purchases once the standards are in place to avoid higher costs, then there will be a delay in achieving the full GHG and other emission reductions from improved fuel economy across the fleet. If the lower per-mile costs associated with higher fuel economy lead to an increase in VMT (the "rebound effect"), then total emission reductions will also be reduced. Chapter 9 of this draft RIA provides more detail on how the rebound effect is calculated in EPA's analysis. The analysis discussed in this chapter incorporates the rebound effect into the estimates, though fleet turnover impacts are not estimated.

In addition, EPA also recognizes that this regulation will lower the world price of oil (the "monopsony" effect, further discussed in Chapter 9 of the DRIA). Lowering oil prices could lead to an uptick in oil consumption globally, resulting in a corresponding increase in GHG emissions in other countries. This global increase in emissions could slightly offset some of the emission reductions achieved domestically as a result of the regulation. EPA does not provide quantitative estimates of the impact of the regulation on global petroleum consumption and GHG emissions in this DRIA.

5.2.3 Upstream Contributions

In addition to downstream emission reductions, reductions are expected in the emissions associated with the processes involved in getting fuel to the pump, including the extraction and transportation of crude oil, the production, and the distribution of finished gasoline and diesel. Changes are anticipated in upstream emissions due to the expected reduction in the volume of fuel consumed. Less fuel consumed means less fuel transported, less fuel refined, and less crude oil extracted and transported to refineries. Thus, there should be reductions in the emissions associated with each of these steps in the fuel production and distribution process. Any changes in downstream reductions associated with changes in fleet turnover, VMT, and global petroleum consumption should be reflected in a corresponding change in upstream emissions associated with petroleum processing and distribution.

5.2.4 Global Warming Potentials

Throughout this document, in order to refer to the four inventoried greenhouse gases on an equivalent basis, Global Warming Potentials (GWPs) are used. In simple terms, GWPs provide a common basis with which to combine several gases with different heat trapping abilities into a single inventory (Table 5-1). When expressed in CO_2 equivalent (CO_2 EQ) terms, each gas is weighted by its heat trapping ability relative to that of carbon dioxide. The GWPs used in this chapter are drawn from publications by the Intergovernmental Panel on Climate Change (IPCC).[1]

The global warming potentials (GWP) used in this analysis are consistent with the 2007 Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4). At this time, the 1996 IPCC Second Assessment Report (SAR) global warming potential values have been agreed upon as the official U.S. framework for addressing climate change and are used in the official U.S. greenhouse gas inventory submission to the United Nations climate change framework. This is consistent with the use of the SAR global warming potential values in current international agreements.

Table 5-1 Global Warming Potentials for the Inventory GHGs

Gas	Global Warming potential (CO_2 Equivalent)
CO_2	1
CH_4	25
N_2O	298

5.3 Program Analysis and Modeling Methods

5.3.1 Models Used

The Motor Vehicle Emissions Simulator, more commonly called MOVES[2], EPA's official mobile source emission inventory model, was the primary tool used to calculate downstream emissions inventories. The 2010-December-21 version of MOVES was used along with the 2010-May-15 default database. Some post-processing was done to MOVES output to ensure proper calculation of emissions inventories for each scenario.

This proposal affects heavy-duty vehicles. In MOVES, which categorizes vehicle types by their use, these vehicle types are represented by combination tractors, single unit tractors, refuse trucks, motor homes, transit buses, intercity buses, school buses, and light commercial trucks.

Upstream emissions were calculated using the same tools as were used for the Renewable Fuel Standard 2 (RFS2) rule analysis,[3] but for the current analysis it was assumed that all impacts are related to changes in volume of gasoline and diesel produced and consumed, with no changes in volumes of ethanol or other renewable fuels such as biodiesel. This assumption is reasonable because EISA mandates that a certain volume of renewable fuels be blended into the fuel supply, regardless of the quantity of conventional liquid fuels consumed. The estimate of emissions associated with production of gasoline and diesel from crude oil is based on emission factors in the "Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation" model (GREET) developed by DOE's Argonne National Lab, and are consistent with those used for the Light Duty Greenhouse Gas rulemaking.[4, 5] The actual calculation of the emission inventory impacts of the decreased gasoline production is done in EPA's spreadsheet model for upstream emission impacts. This model uses the decreased volumes of the crude based fuels and the various crude production and transport emission factors from GREET to estimate the net emissions impact of fuel use changes. As just noted, the analysis for this rulemaking assumes that all changes in volumes of fuel used affect only gasoline and diesel, with no effects on use of ethanol, or other renewable fuels.

5.3.2 Description of Scenarios

5.3.2.1 Reference Case

The reference case assumes no action. Since MOVES2010 vehicle sales and activity data were developed from AEO2006, EPA first updated these data using sales and activity estimates from AEO2010. EPA also updated the fuel supply information in MOVES to reflect a 100% E10 "gasoline" fuel supply to reflect the Renewable Fuels Standard.[6] The tables which were modified and included as user input tables for the run were fuelsupply, fuelformulation, sourcetypeyear, and hpmsvtypeyear. MOVES2010 defaults, including all emission rates, were used for all other parameters to estimate the reference case emissions inventories.

For extended idling emission inventories, MOVES defaults were post-processed to account for increased use of APUs for model year 2010 and later, which is not assumed in default MOVES. For all alternatives, the agencies assumed that about 30 percent of all combination long-haul tractors between model years 2010 through 2013 use an auxiliary power unit (APU) during extended idling. For alternatives where combination long-haul trucks are regulated, the agencies assumed that 100 percent of those trucks model year 2014 and later use APUs during extended idling. For alternatives where combination long-haul trucks are not regulated, the agencies assumed that 30 percent of those trucks model year 2014 and later use APUs during extended idling. A diesel fuel consumption rate of 0.2 gallons per hour for APUs was assumed. We also considered that diesel APUs are regulated as non-road small engines for criteria (non-GHG) pollutants. Assuming that these APUs emit criteria pollutants at the standard[7], Table 5-2 shows the emission rate of APUs, given an extended idle load demand of 4.5 kW (6 hp).

Table 5-2 Estimated emission rates of non-GHG pollutants from APUs

Pollutant	Emission rate [g/hour]
CO	36
NOx + NMHC	33.6
PM	1.8

EPA developed more user input data for MOVES runs to estimate control case inventories. The fuel supply update used in the reference case was also used in all the alternatives since this fuel supply is the baseline for all future scenarios and is not affected by this proposal. To account for improvements of engine and vehicle efficiency, EPA developed several user inputs to run the alternatives in MOVES. Since MOVES does not calculate emissions based on engine FTP cycle results, EPA used the percent reduction in engine CO_2 emissions expected from the proposal to develop energy inputs for the control case runs. Also, EPA used the percent reduction in aerodynamic drag coefficient and tire rolling resistance coefficient expected from each alternative to develop road load inputs.

5.3.2.2 Control Case/Proposal

This case represents the proposed rules. Table 5-3 and Table 5-4 describe the estimated expected changes in engine emissions and vehicle technologies from this proposal, which were input into MOVES for estimating control case emissions inventories.

Table 5-3 Estimated reductions in engine CO_2 emission rates from this proposal

GVWR class	Fuel	Model years	CO_2 Reduction from reference case
HHD (8a-8b)	Diesel	2014-2016	3%
		2017+	6%
MHD (6-7) and LHD 4-5	Diesel	2014-2016	5%
		2017+	9%
	Gasoline	2016+	5%

Table 5-4 Estimated reductions in rolling resistance and aerodynamic drag coefficients from reference case for Alternative 6 (model years 2014 and later)

Truck type	Reduction in tire rolling resistance coefficient from 2010 MY	Reduction in aerodynamic drag coefficient from 2010 MY
Combination long-haul	8.4%	7.2%
Combination short-haul	7.0%	5.3%
Straight trucks, refuse trucks, motor homes, transit buses, and other vocational trucks	10.0%	0%

Since nearly all 2b/3 pickup trucks and vans will be certified on a chassis dynamometer, the CO_2 reductions for these vehicles will not be represented as engine and road load reduction components, but total vehicle CO_2 reductions. These estimated reductions are described in Table 5-5.

Table 5-5 Estimated total vehicle CO_2 reductions for 2b/3 pickup trucks and vans

GVWR class	Fuel	Model years	CO_2 Reduction from reference case
LHD 2b-3	Gasoline	2014	1.5%
		2015	2%
		2016	4%
		2017	6%
		2018+	10%
	Diesel	2014	2.3%
		2015	3%
		2016	6%
		2017	9%
		2018+	15%

It was assumed that 100 percent of Class 7/8 combination long-haul tractors model year 2014 and later use APUs during extended idling.

5.3.3 Calculation of Downstream Emissions

5.3.4 Calculation of Upstream Emissions

The term "upstream emissions" refers to air pollutant emissions generated from all crude oil extraction, transport, refining, and finished fuel transport, storage, and distribution. As shown above in Table XX this includes all stages prior to the final filling of vehicle fuel tanks at retail service stations. The details of the assumptions, data sources, and calculations that were used to estimate the emission impacts presented here can be found in the Technical Support Document and the docket memo, "Calculation of Upstream Emissions for the GHG Vehicle Rule", initially created for use in the Light Duty Greenhouse Gas rulemaking.[8] The results of this analysis are shown in Table XX.

5.4 Greenhouse Gas Emission Impacts

5.4.1 Downstream and Fuel Consumption

Table 5-6 Downstream GHG impacts in 2030

POLLUTANT	CALENDAR YEAR 2030	% CHANGE VS. 2030 REFERENCE
Δ CO_2 (metric tons)	-58,232,453	-9.33%
Δ CH_4 (metric tons CO_2EQ)	274	0.35%
Δ N_2O (metric tons CO_2EQ)	2,478	0.36%
Δ Total CO_2EQ (metric tons)	-58,229,701	-9.31%
Δ Gasoline Fuel (billion gallons)	-0.569	-10.3%
Δ Diesel Fuel (billion gallons)	-8.45	-8.2%

5.4.2 Upstream Emissions

Table 5-7 Upstream GHG impacts in 2030

POLLUTANT	CALENDAR YEAR 2030	% CHANGE VS. 2030 REFERENCE
CO_2 (metric tons)	-12,650,952	-9.3%
CH_4 (metric tons CO_2EQ)	-1,954,275	-9.3%
N_2O (metric tons CO_2EQ)	-61,090	-9.3%
Total CO_2EQ (metric tons)	-14,666,317	-9.3%

5.4.3 Total Program Impact

5.5 Non-Greenhouse Gas Emission Impacts

5.5.1 Downstream Impacts of Program

Table 5-8 Downstream impacts for key non-GHG pollutants (U.S. short tons)

POLLUTANT	CALENDAR YEAR 2030	% CHANGE VS. 2030 REFERENCE
Δ Carbon Monoxide	-53709	-2.0%
Δ Oxides of Nitrogen	-231631	-20.6%
Δ Benzene	-339	-13.5%

Δ 1,3-Butadiene	0.5	0.1%
Δ Formaldehyde	-6,227	-44.5%
Δ Acetaldehyde	-1,899	-38.0%
Δ Acrolein	-261	-37.9%
Δ Oxides of Sulfur	-480	-9.5%
Δ Volatile Organic Compounds	-25,121	-17.7%
Δ Particulate Matter (below 2.5 micrometers)	2279.38	16.26%

5.5.2 Upstream Impacts of Program

Non-GHG fuel production and distribution emission impacts of the program were estimated in conjunction with the development of life cycle GHG emission impacts, and the GHG emission inventories discussed above. The basic calculation is a function of fuel volumes in the analysis year and the emission factors associated with each process or subprocess. In general this life cycle analysis uses the same methodology as the Renewable Fuel Standard (RFS2) rule. It relies partially on the "Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation" (GREET) model, developed by the Department of Energy's Argonne National Laboratory (ANL), but takes advantage of additional information and models to significantly strengthen and expand on the GREET analysis.

Updates and enhancements to the GREET model assumptions include updated crude oil and gasoline transport emission factors that account for recent EPA emission standards and modeling, such as the Tier 4 diesel truck standards published in 2001 and the locomotive and commercial marine standards finalized in 2008. In addition, GREET does not include air toxics. Thus emission factors for the following air toxics were added: benzene, 1,3-butadiene, formaldehyde, acetaldehyde, and acrolein. These upstream toxics emission factors were calculated from the 2002 National Emissions Inventory (NEI), a risk and technology review for petroleum refineries, speciated emission profiles in EPA's SPECIATE database, or the Mobile Source Air Toxics rule (MSAT) inventory for benzene; these pollutant tons were divided by refinery energy use or gasoline distribution quantities published by the DOE Energy Information Administration (EIA) to get emission factors in terms of grams per million BTU of finished gasoline and diesel.

Results of these emission inventory impact calculations relative to the reference case for 2030 are shown in Table 5-9 for the criteria pollutants and individual air toxic pollutants.

The program is projected to provide reductions in all pollutants associated with gasoline production and distribution as the projected fuel savings reduce the quantity of gasoline needed.

Table 5-9 Upstream impacts for key non-GHG pollutants (U.S. short tons)

POLLUTANT	CALENDAR YEAR 2030	% CHANGE VS. 2030 REFERENCE
Δ 1,3-Butadiene		
Δ Acetaldehyde		

Δ Acrolein		
Δ Benzene		
Δ Carbon Monoxide		
Δ Formaldehyde		
Δ Oxides of Nitrogen		
Δ Particulate Matter (below 2.5 micrometers)		
Δ Oxides of Sulfur		
Δ Volatile Organic Compounds		

5.5.3 Total Program Impact

5.6 Assessment of the Impact of Credit Programs

5.6.1 Appendix: Emission Rates

References

[1] Intergovernmental Panel on Climate Change. Chapter 2. Changes in Atmospheric Constituents and in Radiative Forcing. September 2007. http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-chapter2.pdf . Docket ID: EPA-HQ-OAR-2009-0472-0117
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[3] U.S. EPA. Draft Regulatory Impact Analysis: Changes to Renewable Fuel Standard Program. Chapters 2 and 3.May 26, 2009. Docket ID: EPA-HQ-OAR-2009-0472-0119
[4] Argonne National Laboratory. The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) Model versions 1.7 and 1.8. http://www.transportation.anl.gov/modeling_simulation/GREET/. Docket ID: EPA-HQ-OAR-2009-0472-0215
[5] U.S. EPA. 2008. RFS2 Modified version of GREET1.7 Upstream Emissions Spreadsheet, October 31, 2008. Docket ID: EPA-HQ-OAR-2009-0472-0191
[6] http://www.epa.gov/otaq/fuels/renewablefuels/index.htm
[7] Tier 4, less than 8 kW nonroad compression-ignition engine exhaust emissions standards assumed for APUs: http://www.epa.gov/otaq/standards/nonroad/nonroadci.htm
[8] Craig Harvey, EPA, “Calculation of Upstream Emissions for the GHG Vehicle Rule.” 2009. Docket ID: EPA-HQ-OAR-2009-0472-0216