

Amendments and Nonconformance
Penalties for Model Year 2027 and
Later Heavy-Duty Highway Engines
and Amendments to Inducement
Provisions for SCR-Equipped Diesel
Engines
Draft Regulatory Impact Analysis

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Engines: Draft Regulatory Impact
Analysis

Office of Transportation and Air Quality
U.S. Environmental Protection Agency

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Executive Summary

The U.S. Environmental Protection Agency (EPA) is proposing changes to the heavy-duty highway engine and vehicle emissions control program for oxides of nitrogen (NO_x), particulate matter (PM), hydrocarbons (HC), and carbon monoxide (CO).

This Draft Regulatory Impact Analysis (DRIA) is generally organized to provide overall background information, methodologies, and data inputs, followed by results of the various analyses. A summary of each chapter of the DRIA follows.

Chapter 1 presents an overview of the heavy-duty industry and a summary of average, banking, and trading (ABT) of emission credits in the EPA’s heavy-duty highway engine program.

Chapter 2 presents the EPA’s analysis of the national emissions impacts of the proposed amendments to the 2023 Final Rule for calendar years (CY) 2027 through 2055. The table below summarizes the projected national heavy-duty vehicle emission changes in U.S. tons in calendar years 2030, 2040, 2045, and 2055 from the proposed action.

Table ES-1: National Heavy-Duty Vehicle Emission Changes in U.S. Tons in Calendar Years 2030, 2040, 2045, and 2055 – Proposed Action Case Emissions Relative to No-Action Case

Pollutant	Increase in U.S. Short Tons			
	2030	2040	2045	2055
NO _x	30,626	39,819	37,917	36,673
VOC	84	122	118	116
Primary Total PM _{2.5}	29	49	47	46
CO	5,902	8,502	8,260	8,084

Chapter 3 presents the estimated costs associated with the emissions reduction technologies and program provisions applicable under this proposed rule. Consistent with the 2023 Final Rule, the EPA reports both technology costs and operating costs, and includes costs associated with emission-related warranty and regulatory useful life provisions. The table below summarizes per-engine cost savings of the proposed action.

*Table ES-2: Per-Engine Cost Savings Due to Reduced Emission-Related Warranty Period for MY 2027 by Regulatory Class and Fuel Type, 2024 Dollars**

Regulatory Class	Diesel	Gasoline	Compressed Natural Gas
Light HDE	\$6,152	\$2,783	
Medium HDE	\$4,130	\$2,838	
Heavy HDE	\$5,358		\$6,270
Urban Bus	\$6,004		\$6,878

* Blank cells indicate that there are no heavy-duty engines in a specific regulatory class for that fuel type; positive values indicate cost savings in expenditures.

Chapter 4 presents information on air quality, including a discussion of current air quality and air quality impacts from the proposed rule.

Chapter 5 summarizes health and welfare effects associated with exposure to pollutants emitted by mobile sources and impacted by this proposed rule and provides qualitative discussions of human health effects and select welfare effects.

Chapter 6 summarizes the estimated costs, cost savings, and non-monetized impacts of the proposed rule. The table below summarizes the present value and annualized value emission-related warranty savings, operating costs, and net savings of the proposed action. Several categories of costs and benefits remain unmonetized and are not reflected in the table.

*Table ES-3: Present Value and Annualized Value Emission-Related Warranty Savings, Operating Costs, and Net Savings of the Proposed Action Case Relative to the No-Action Case, Millions of 2024 Dollars**

Value Basis and Discount Rate	Emission-Related Warranty Savings	Operating Costs	Net Cost Savings
PV, 3%	\$37,000	-\$25,000	\$12,000
PV, 7%	\$24,000	-\$15,000	\$9,400
AV, 3%	\$1,900	-\$1,300	\$640
AV, 7%	\$2,000	-\$1,200	\$770

* Values show two significant figures; positive values indicate cost savings in expenditures.

Chapter 7 contains an overview of small entities in the heavy-duty engine (HDE) market and the EPA’s assessment that the proposed rule would not have a significant impact on a substantial number of small entities.

Please note that the EPA also proposes to establish nonconformance penalties (NCPs) for the model year (MY) 2027 and later NO_x standards for medium-heavy and heavy –heavy-duty engines. Technical information regarding the NCPs can be found in the Draft Technical Support Document accompanying this proposal which is available in the public docket for this action.¹

¹U.S. Environmental Protection Agency. Amendments and Nonconformance Penalties for Model Year 2027 and Later Heavy-Duty Highway Engines and Amendments to Inducement Provisions for SCR-Equipped Diesel Engines: Draft Technical Support Document - Nonconformance Penalty Analysis. June 2026. EPA-420-D-26-003.

Chapter 1 Industry Characterization and Use of Averaging, Banking, and Trading Provisions

1.1 Heavy-Duty Engine Industry

Currently, Cummins, Daimler Trucks North America (DTNA), Ford, General Motors, Hino, International, PACCAR, and Volvo Truck are the major heavy-duty engine manufacturers for the U.S. Some of these companies are “integrated manufacturers” that produce both engines and vehicles. Some of these integrated manufacturers also install engines supplied by an outside manufacturer. During the design stage, a vehicle manufacturer decides which engines it will make available in its vehicles. For some vehicle applications, only a single spark-ignition or compression-ignition engine model may be offered, whereas in other applications, the customer may be able to choose from a range of engines.

The light heavy-duty diesel vehicle market is a mix of vertically and non-vertically integrated vehicle and engine manufacturers. For example, General Motors and Ford currently supply their own diesel engines in light heavy-duty pick-up trucks for their respective companies, while Chrysler exclusively uses Cummins-supplied diesel engines in their Ram light heavy-duty pickup trucks.

The medium heavy-duty diesel vehicle market is unique, as it is made up of only a few manufacturers, with one engine manufacturer (Cummins) selling the majority of the diesel engines.

However, in the heavy heavy-duty vehicle market, there is a wider range of engines available to choose from for the same vehicle type. For example, an end-user can purchase a Western Star vehicle (produced by DTNA) with either a Cummins or a Detroit Diesel engine, or purchase a Peterbilt vehicle (produced by PACCAR) with either a Cummins or PACCAR engine. Engines produced by Cummins tend to be offered by all of the major heavy-duty truck manufacturers in at least some of their truck models.

Table 1-1. Heavy-Duty Engine Market for MY 2023.

Company	Market Share			
	Light HDE	Medium HDE	Heavy HDE	Spark-Ignition HDE
Cummins		92%	36%	
DTNA		3%	32%	
Ford Motor	53%	5%		75%
Isuzu Motors	22%			
International			4%	
PACCAR			12%	
Volvo Group			17%	
General Motors	25%			18%
Roush				4%
Stellantis				2%
Power Solutions International				1%

1.2 Averaging, Banking, and Trading of NO_x Emission Credits

Under the existing ABT regulations from the 2023 Final Rule,² which are consistent with previous ABT regulations, HDE manufacturers may generate NO_x emission credits and balance emissions across engine families within defined “averaging sets.” There are four averaging sets: Light HDE, Medium HDE, Heavy HDE, and Spark-Ignition HDE. Within an averaging set, credits generated by engines that over-comply with standards can be used to offset noncomplying engines in a given MY, or banked for use in future years, allowing manufacturers to produce engines that exceed the standards up to a Family Emission Limit (FEL) cap. In general, banked credits may also be traded between manufacturers. The credit values in Chapter 1 of this DRIA are rounded to the nearest megagram (Mg).³

1.2.1 NO_x Emissions Credit Generation

NO_x emissions credit generation has typically occurred prior to the start of new emissions standards as a way for manufacturers to spread the development costs for the engines meeting the new emissions standards.

² See 88 FR 4296 (Jan. 24, 2023).

³ As covered in 40 CFR 1068.11, “Emissions data,” which includes ABT credit information, cannot be treated as confidential business information.

1.2.1.1 Credits Generated in MYs 2004-2009

Table 1-2 summarizes NO_x credit balances, as of MY 2024, which reflect credits earned in MYs 2004-2009.

Table 1-2. Banked Credits as of MY 2024 Generated from MY 2004-2009 (Mg).

Manufacturer	Light HDE	Medium HDE	Heavy HDE
Cummins		10,230	2,129
Ford	284		
General Motors	4,360		
Isuzu	22	628	
International	1,120	766	60
Volvo Trucks			6,450
Westport Fuel Systems		577	1,161

1.2.1.2 Credits Generated in MYs 2010-2021

For MYs 2010 to 2021, when the MY 2010 NO_x standards were fully implemented, no NO_x credits were generated.

1.2.1.3 Credits Generated in MYs 2022-2024

Table 1-3 to Table 1-6 summarize the NO_x credits manufacturers generated ahead of the MY 2027 NO_x standards. The credits are separated by the transitional NO_x credits that are described in Chapter 1.2.3.1 of this DRIA.

*Table 1-3. MY 2022 Discounted Credits Pathway Earned (Mg).**

Manufacturer	Heavy HDE
Daimler Truck North America	3,103

*Credits include the 40% discount

*Table 1-4. MY 2023 Discounted Credits Pathway Earned, (Mg).**

Manufacturer	Light HDE	Medium HDE	Heavy HDE
Cummins		64	261
Daimler Truck North America			4,728
Ford	1,176	197	
International Motors	214		

*Credits include the 40% discount

Table 1-5. MY 2024 Discounted Credits Pathway Earned (Mg).*

Manufacturer	Light HDE	Medium HDE	Heavy HDE
Cummins		10	582
Daimler Truck North America			105
Ford	1,278		
General Motors	322		

*Credits include the 40% discount

Table 1-6. MY 2024 Partial Credits Pathway Earned (Mg).

Manufacturer	Medium HDE	Heavy HDE
Cummins	111	534
Daimler Truck North America		9,657
Ford	400	

1.2.2 Criteria Pollutant Emissions Credit Trading

Historically, there has been little trading between firms since the EPA implemented emissions credit regulations for criteria pollutants in 1985.⁴ Since MY 2012, only four trades between firms have occurred. These four pairs of trades involved a total of five companies. At least one trade was recorded in each of the Light HDE, Medium MDE, and Heavy HDE service classes. No trades have occurred for NO_x credits in the Spark-Ignition HDE service class. The total value of the NO_x credits for these four trades combined was approximately 2,200 Mg.

1.2.3 Overview of Averaging, Banking, and Trading Provisions in the 2023 Final Rule

The 2023 Final Rule included several updates to the ABT program. First, the 2023 Final Rule set FEL caps at 65 milligram (mg)/horsepower (hp)·hour (hr) for MYs 2027-2030 and 50 mg/hp·hr for MYs 2031 and later. The 2023 Final Rule also established a five-year credit life for any credits generated in MYs 2027 and later.⁵ The 2023 Final Rule established a transitional provision to allow up to five percent of Heavy HDE to be certified to MYs 2026 and earlier standards in MYs 2027-2029, but those engines must be offset with NO_x credits. Finally, the 2023 Final Rule included four transitional credit generation pathways for MYs prior to MY 2027.

This section describes the transitional credit pathways included in the 2023 Final Rule, and includes a summary of the NO_x credit balances HDE manufacturers have available as of the end of MY 2024. The EPA receives credit balances from manufacturers in September of each year

⁴ See 50 FR 10606 (Mar. 15, 1985).

⁵ The EPA first established the NO_x emission credit banking and trading flexibilities for heavy-duty engines in 1990, which included a three-year credit life. See 55 FR 30534 (July 26, 1990).

for the prior MY. So, as of the date of publication of this DRIA, the EPA has NO_x credit balances through MY 2024.

1.2.3.1 Transitional NO_x Credit Pathways

Transitional credits in the 2023 Final Rule were designed to provide manufacturers with flexibility as they transition to the new, more stringent NO_x standards that take effect in MY 2027. Under the 2023 Final Rule, credits generated before MY 2022 cannot be used for compliance with MYs 2027 and later standards. However, transitional credits generated for engines produced in MY 2022 through MY 2026 can be applied in MYs 2027 and later. The EPA selected MY 2022 for two reasons. First, allowing MY 2022 and later credits inherently precludes emission credits from the oldest MYs (*i.e.*, MY 2009 or prior). The MY 2009 and earlier credits were not generated with current emissions control technologies and are therefore quite distinct from credits generated under the MY 2022-2026 standards. Second, regarding both the oldest MY credits and those few credits generated in more recent years, allowing only MYs 2022 and later credits incentivizes manufacturers to maximize their development and introduction of the best available emissions control technologies before they are required to do so in MY 2027. The 2023 Final Rule provided four pathways for generating transitional credits, as described below:

1. Discounted Credits

- Can be generated from MYs 2022 through 2026 engines.
- Generated by certifying engines to the pre-2027 standards at a NO_x FEL below the current standard (200 mg/hp·hr).
- Credits are calculated based on the difference between the FEL and the standard, and they are discounted by 40 percent to account for these engines not meeting the new MYs 2027 and later requirements (most significantly the low-load cycle and off-cycle standards).
- Credits are based on the pre-2027 useful life periods.
- These credits can be used for compliance in MYs 2027-2029.

2. Partial Credits

- Can be generated from MYs 2024 through 2026 engines.
- Generated by certifying engines to a FEL below the current standard and meeting some of the new MY 2027 requirements (including the low-load cycle and off-cycle standards), but not the longer useful life and warranty periods of the 2023 Final Rule.
- Credits are not discounted, and they are based on the pre-2027 useful life periods.
- These credits can be used for compliance in MYs 2027-2032.

3. Full Credits

- Can be generated from MYs 2024 through 2026 engines.
- Generated by certifying engines to a FEL below the current standard and meeting all of the new MY 2027 requirements (including low-load cycle and off-cycle standards, longer useful life, and warranty).
- Credits are not discounted and are based on the longer useful life period.
- These credits can be used for compliance through MYs 2027-2032.

4. 2026 Service Class Pull-Ahead Credits

- Can be generated from MY 2026 engines.
- Generated by certifying all diesel-fueled Heavy HDE in MY 2026 to a FEL of 50 mg/hp·hr or less and meeting all MY 2027 requirements, including useful life.
- Credits have an extended credit life (usable through MY 2034) and can be transferred from the Heavy HDE to the Medium HDE averaging set (with a 10 percent discount applied if transferred).
- Engines using these credits in MYs 2027-2034 must also be certified to a FEL at or below 50 mg/hp·hr.

1.2.3.2 Manufacturer NO_x Credit Balances for 2024 (By Transitional Provision)

Table 1-7 and Table 1-8 include the manufacturer NO_x credit balances for MY 2024, broken out by the type of transitional credit provision under which they were earned. As of MY 2024, no manufacturer had generated “Full Credits.” Note that no manufacturer is utilizing the “2026 Service Class Pull-Ahead Credits” path, as this path requires certifying all diesel-fueled Heavy HDE in MY 2026 to a FEL at or below 50 mg/hp·hr and meeting all MY 2027 requirements. At the time of this proposed rule, each of the Heavy HDE manufacturers have a least one MY 2026 engine family with a FEL greater than 50 mg/hp·hr.

Table 1-7. Discounted Credits Pathway Banks (Mg).*

Manufacturer	Light HDE	Medium HDE	Heavy HDE
Cummins		74	843
Daimler Truck North America			7,937
Ford	2,454	198	
General Motors	536		

*Credits include the 40% discount

Table 1-8. Partial Credits Pathway Banks (Mg).

Manufacturer	Medium HDE	Heavy HDE
Cummins	111	470
Daimler Truck North America		9,657
Ford	400	
PACCAR		64

Chapter 2 Emissions Inventory Analysis

2.1 Introduction

This Chapter presents the EPA’s analysis of the national emissions impacts of the proposed amendments to the 2023 Final Rule⁶ for CYs 2027 through 2055.⁷ Specifically, the EPA has projected an emissions impact associated with the proposed revisions to emission-related warranty, regulatory useful life, and the five percent production volume allowance.

The EPA has not projected an emissions impact associated with the proposed NCPs, consistent with the approach taken in all past NCP rules. The EPA is not able to accurately project the degree to which firms may make use of the NCPs. The EPA’s expectation is that any use of the NCPs would be temporary and short-lived, given the nature of NCPs, which are a temporary bridge for any companies that need additional time to bring engines into compliance with the MY 2027 NO_x standards.

The EPA has also not projected an emissions impact associated with the proposed revisions to EPA’s selective catalytic reduction (SCR) inducement requirements for heavy-duty diesel engines. The inducement requirements finalized in the 2023 Final Rule, which the agency is proposing to amend in this action, would have mandated engine performance derates.

The proposed amendments to the SCR inducement requirements would reduce operator frustrations with SCR emission controls, but many uncertainties exist in terms of quantifying the potential impact. As described in section IV of the preamble to this proposal, diesel vehicle owners and operators have over a decade of experience using diesel exhaust fluid (DEF), refilling DEF is easy, and DEF is readily available at retail stores and diesel refueling stations nationwide, which suggests operator access and familiarity would not change DEF use relative to today. Also, in section IV of the preamble, the EPA summarized two recent studies on the impact of audible and visible signals used to prompt light-duty vehicle drivers to wear seatbelts.^{8,9}

In this proposal, the “no-action” case represents the 2023 Final Rule. It is unclear how owner or operator behavior would have changed in response to the speed restrictions that were set to apply starting in MY 2027 under the 2023 Final Rule. It is equally unclear how the proposed new audible signal schedule would change behavior relative to that no-action case.

⁶ “Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards” (the “2023 Final Rule”). 88 FR 4296 (Jan. 24, 2023).

⁷ The 2023 Final Rule inventory analysis included calendar years up to 2045. For the proposed amendments, the EPA extended analysis years to 2055 to better estimate the impact of fleet turnover further into the future.

⁸ Kidd, D. G., and Singer, J. (2019). The effects of persistent audible seat belt reminders and a speed-limiting interlock on the seat belt use of drivers who do not always use a seat belt. *Journal of Safety Research*: <https://www.iihs.org/research-areas/bibliography/ref/2185>.

⁹ Kidd, D. G., and O’Malley, S. (2023). Increasing seat belt use in the United States by promoting and requiring more effective seat belt reminder systems. *Traffic Injury Prevention*, 24(sup1), S80–S87: <https://doi.org/10.1080/15389588.2022.2134730>.

At this time, the EPA is not able to accurately project the degree to which SCR systems would be ineffective due to low DEF levels, low-quality DEF, or component-level tampering that can lead to improper DEF dosing, and therefore the Agency cannot project any associated increase in emissions. Additionally, the EPA is also unable to estimate whether the proposed removal of derates under this proposal would result in a reduction in emissions due to reduced user frustration and fewer instances of in-use tampering.

As described in detail in Chapter 2.2 of this DRIA, the onroad national inventories were estimated using a regulatory version of the EPA’s Motor Vehicle Emission Simulator (MOVES) model, known as MOVES5.R2,¹⁰ which was derived from the latest public version (MOVES5) with the updates described below. The onroad national emission inventories were developed using a single national modeling domain, referred to as “national-scale” in MOVES. Inputs developed to model the national emission inventories for the proposed action case are discussed in Chapter 2.2.2 of this DRIA. The national emissions inventory impacts for CYs 2030, 2040, 2045, and 2055 for the proposal are presented in Chapter 2.3.1 of this DRIA. In addition, the year-over-year national emissions results for CYs 2027 through 2055 are presented in Chapter 2.4 of this DRIA.

2.2 Model and Data Updates

To quantify the emissions impacts of the proposed amendments to the 2023 Final Rule, the EPA used a regulatory version of MOVES available at the time of the analysis, known as MOVES5.R2. This version does not contain any major algorithmic changes relative to the latest public version (MOVES5), making the two versions similar in terms of their modeling capabilities and outputs.

However, MOVES5.R2 incorporates several updates to vehicle population and activity based on the latest information. The EPA updated vehicle miles traveled (VMT) data for the 2023 and beyond using U.S. Federal Highway Administration’s (FHWA) Highway Statistics 2023.¹¹ The EPA also updated bus populations based on the School Bus Fleet Factbook¹² and the U.S. Federal Transit Administration’s National Transit Database.¹³ The activity projections were updated to reflect the Annual Energy Outlook 2025 (AEO 2025) reference case.¹⁴

¹⁰ See Chapter 2 of the “Revision of Tier 4 Criteria Pollutant Standards, Part 1: Amendments to Phase-In Schedule for Light-Duty and Medium-Duty Vehicles – Draft Regulatory Impact Analysis” EPA-420-D-26-001. May 2026.

¹¹ U.S. Department of Transportation Federal Highway Administration. (2023). Highway Statistics 2023. <https://www.fhwa.dot.gov/policyinformation/statistics/2023/>.

¹² Hugget. (2024). School Bus Fleet Factbook 2024. <https://schoolbusfleet.mydigitalpublication.com/fact-book-2024/>.

¹³ U.S. Department of Transportation Federal Transit Administration. (2024). National Transit Database. <https://www.transit.dot.gov/ntd>.

¹⁴ U.S. Energy Information Administration. (2025). Annual Energy Outlook. <https://www.eia.gov/outlooks/archive/aeo25/>.

In addition, MOVES5.R2 includes further updates to represent the U.S. without the EPA motor vehicle and engine greenhouse gas (GHG) standards, which were removed by the Agency's 2026 final rule "Rescission of the Greenhouse Gas Endangerment Finding and Motor Vehicle Greenhouse Gas Emission Standards Under the Clean Air Act" (the "EF/GHG Rescission Rule").¹⁵ MOVES5.R2 also removed relevant Inflation Reduction Act (IRA) tax credits,¹⁶ which were changed by the One Big Beautiful Bill Act (OBBA).¹⁷ To account for the absence of those standards and tax credits, projected electric vehicle adoption rates were adjusted.

All the updates to MOVES5.R2 described above apply to both the no-action and action cases for this proposal and are consistent with the action case for the EF/GHG Rescission Rule.¹⁸ The additional updates applied to MOVES in modeling the action case of this proposal are described in Chapter 2.2.2 of this DRIA.

2.2.1 Methodology Overview

The EPA used MOVES5.R2 to estimate the emissions impacts of the proposed amendments to the 2023 Final Rule. First, the EPA modeled a baseline (no-action) scenario that retains all provisions of the 2023 Final Rule. Then, the EPA modeled a control (action) scenario representing three of the program elements the Agency is proposing to revise as described in section III of the preamble: revisions to the emission-related warranty, the regulatory useful life, and the five percent production volume allowance. The emissions impacts of the proposed amendments were estimated by calculating the emissions difference between the no-action and the action cases. All model inputs, MOVES runspec files, analysis scripts, and the MOVES version used to generate the emissions inventories can be found in the docket for this rulemaking.¹⁹

The vehicle activity (*e.g.*, fleet age distributions, VMT by vehicle type and road type, vehicle speeds, off-network idling, hotelling hours, and start activity) and fuel inputs were kept the same for both the no-action and action cases using the default values in MOVES5.R2.

The MOVES emission rate inputs developed for modeling the proposed amendments are discussed in detail in the following section.

¹⁵ 91 FR 7686 (Feb. 18, 2026).

¹⁶ Public Law 117-169 (2022).

¹⁷ Public Law 119-21 (2025).

¹⁸ 91 FR 7686, February 18, 2026. Updated modeling assumptions and tools for 'Rescission of the Greenhouse Gas Endangerment Finding and Motor Vehicle Greenhouse Gas Emission Standards Under the Clean Air Act' Final Rule.

¹⁹ U.S. Environmental Protection Agency. (2026). Memo to docket EPA-HQ-OAR-2026-0728. MOVES Modeling-Related Data Files (MOVES Code, Input Databases and Runspecs) for the Amendments and Nonconformance Penalties for Model Year 2027 and Later Heavy-Duty Highway Engines and Amendments to Inducement Provisions for SCR-Equipped Diesel Engines: Draft Regulatory Impact Analysis (DRIA).

2.2.2 MOVES Emission Rates for Proposed Action Case

The 2023 Final Rule included multiple program elements that were modeled in MOVES, including duty-cycle standards, off-cycle standards, closed crankcase requirements, refueling standards, regulatory useful life, and emission-related warranty. The modeling methodologies accounted for the effect of these elements on vehicle emissions as described in the 2023 Final Rule RIA.²⁰ Under this proposal, the emission-related warranty and regulatory useful life provisions would be modified, and the other modeled provisions would remain unchanged from the 2023 Final Rule. The new MOVES emission rates for the proposed action case were developed by updating only those portions of the methodology affected by the proposed revisions to the emission-related warranty and the useful life provisions.²¹ In addition, the proposed amendments also include a five percent production allowance for heavy heavy-duty (HHD; Class 8 and urban bus regulatory classes) vehicles in MYs 2027, 2028, and 2029. To account for this allowance, MOVES emission rates are further adjusted by assuming that five percent of the HHD vehicle fleet in MYs 2027 through 2029 would have emission rates equivalent to MY 2026 vehicles. The production allowance does not apply to light heavy-duty (LHD, Class 4 and 5) and medium heavy-duty (MHD, Class 6 and 7) vehicles.

2.2.2.1 Emission Rates Based on Proposed Changes in Emission-Related Warranty and Useful Life

To estimate the emissions impact of proposed changes to emission-related warranty and useful life for HHD engines (Table 2-1), the EPA applied MOVES' existing age-effect methodology²² to adjust NO_x, HC, CO, and exhaust PM_{2.5} emission rates for the action case, reflecting the altered deterioration profiles under the proposed revisions. The resulting changes are treated as age-effect adjustments.

²⁰ U. S. Environmental Protection Agency. (2022). Regulatory Impact Analysis: Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards Regulatory Impact Analysis. EPA-420-R-22-035.

²¹ The proposed amendments would alter the modeling approaches described in sections 5.2.2.1.2 (Emission Rates Based on Final Changes in Warranty and Useful Life) and 5.2.2.1.3 (Summary of Diesel NO_x Running Emission Rates) of the 2023 Final Rule RIA. All the other parts of Chapter 5.2 in the 2023 Final Rule RIA remain unchanged.

²² The existing methodology is documented in Appendix B "Tampering and Mal-maintenance" of the reference "Exhaust Emission Rates for Heavy-Duty Onroad Vehicles in MOVES5 (EPA-420-R-24-015)." In MOVES, it is assumed that tampering and mal-maintenance effects are the dominant source of emissions deterioration of fleet-wide heavy-duty diesel emissions. Although MOVES does not explicitly account for normal deterioration of heavy-duty diesel emissions, such as due to catalyst aging, tampering and mal-maintenance effects assume emission increases due to aging and deterioration.

Table 2-1. Useful Life and Emission-Related Warranty Periods for Heavy-Duty Diesel Engines and Aftertreatment Systems in the No-Action and Action Cases.^a

Scenario	Applicable Model Years	Emission-Related Warranty (age, mileage)			Useful Life (age, mileage)		
		LHD	MHD	HHD/Urban Bus	LHD	MHD	HHD/Urban Bus
No-Action Case (2023 Final Rule)	2027+	10yr, 210k	10yr, 280k	10yr, 450k	15yr, 270k	12yr, 350k	11yr, 650k
Action Case	2027-2029	5yr, 50k	5yr, 100k	5yr, 100k	10yr, 110k	10yr, 185k	10yr, 435k
	2030+	5yr, 50k	5yr, 100k	5yr, 100k	15yr, 270k	12yr, 350k	11yr, 650k

^a The age effects for heavy-duty gasoline and natural gas (NG) vehicles in MOVES are estimated directly from emissions data or adapted from light-duty gasoline or heavy-duty diesel vehicles and are not tied to emission-related warranty and useful life periods. Thus, the emission rates for heavy-duty gasoline or NG engines were not adjusted to account for the proposed changes to emission-related warranty and useful life periods.

In this approach, MOVES models zero-mile emission rates for new vehicles/engines for each operating mode and maintains those rates until the age of the vehicle/engine reaches the end of the emission-related warranty period (Figure 2-1). Once the emission-related warranty period ends, emission rates increase linearly with age until the vehicle/engine reaches its regulatory useful life. At the end of the useful life, the emissions rates remain constant at a level calculated from the tampering and mal-maintenance (T&M) adjustment factor.²³

For the no-action and action cases, the EPA estimated the vehicle age at which heavy-duty diesel vehicles would reach the end of their emission-related warranty and useful life periods. Table 2-2 shows the calculations for the proposed action case. Row (A) shows the age limit of the standards for emission-related warranty and useful life periods. Row (B) shows the mileage limit of the standards. Row (C) shows the VMT per year,²⁴ which is used to calculate Row (D), the calculated age, rounded to the nearest whole number, when the mileage limit is reached. Row (E) is the smaller of the age at which the vehicle meets the end of its age limit, Row (A), or mileage limit, Row (D).

²³ For additional details on the development of tampering and mal-maintenance (T&M) adjustment factors, see Chapter 2.1.1.7 and Appendix B of “Exhaust Emission Rates for Heavy-Duty Onroad Vehicles in MOVES5” (EPA-420-R-24-015).

²⁴ The VMT per year used in Table 2-2 are the same values used to derive the vehicle age at the end of the emission-related warranty period and useful life in MOVES5.

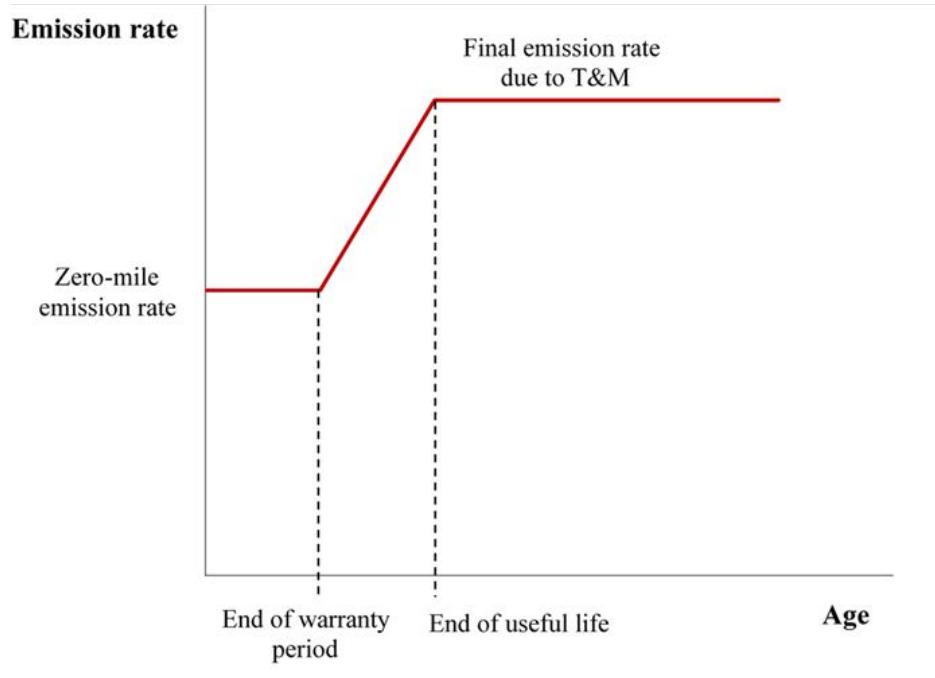


Figure 2-1. Methodology to Model the Effects of Tampering and Mal-Maintenance (T&M) on Emission Rates According to Emission-Related Warranty and Useful Life.

Table 2-2. Estimated Vehicle Age at the End of the Emission-Related Warranty Period and the Useful Life for Each Heavy-Duty Diesel Regulatory Class for the Proposed Action Case.

Row		Emission-Related Warranty				Useful Life			
		LHD	MHD	HHD	Urban Bus	LHD	MHD	HHD	Urban Bus
(A)	Age limit (years)	5	5	5	5	10 for MY 2027-2029; 15 for MY 2030+	10 for MY 2027-2029; 12 for MY 2030+	10 for MY 2027-2029; 11 for MY 2030+	10 for MY 2027-2029; 11 for MY 2030+
(B)	Mileage limit	50,000	100,000	100,000	100,000	110,000	185,000	435,000	435,000
(C)	Typical VMT/year	26,000	41,000	105,000	44,000	26,000	41,000	105,000	44,000
(D)	Calculated age when the mileage limit is reached	2	2	1	2	4 for MY 2027-2029; 10 for MY 2030+	5 for MY 2027-2029; 9 for MY 2030+	4 for MY 2027-2029; 6 for MY 2030+	10 for MY 2027-2029; 15 for MY 2030+
(E)	Estimated age (years)	2	2	1	2	4 for MY 2027-2029; 10 for MY 2030+	5 for MY 2027-2029; 9 for MY 2030+	4 for MY 2027-2029; 6 for MY 2030+	10 for MY 2027-2029; 11 for MY 2030+

Using the same process and same annual VMT estimate, similar calculations were performed for the no-action case. The resulting estimates of vehicle age at the end of the emission-related warranty and useful life periods are compared for the no-action and the proposed action cases in Table 2-3.

Table 2-3. Estimated Vehicle Age at the End of the Warranty Period and the Useful Life for Each Heavy-Duty Diesel Regulatory Class in the No-Action and Action Cases for MYs 2027 and Later.

Vehicle Age (years)	Emission-Related Warranty				Useful Life			
	LHD	MHD	HHD	Urban Bus	LHD	MHD	HHD	Urban Bus
No-Action Case (2023 Final Rule)	8	7	4	10	10	9	6	11
Action Case	2	2	1	2	4 for MY 2027-2029; 10 for MY 2030+	5 for MY 2027-2029; 9 for MY 2030+	4 for MY 2027-2029; 6 for MY 2030+	10 for MY 2027-2029; 11 for MY 2030+

The T&M adjustment factor is calculated as the sum of the product of the T&M frequency for each failure i , and the corresponding T&M emission effect, as shown in Equation 2-1.

Equation 2-1

$$f_{T\&M,p} = \sum_i (\text{T\&M frequency}_i \times \text{T\&M emission effect}_{p,i})$$

Where:

$f_{T\&M}$ = the tampering and mal-maintenance adjustment factor for pollutant p .

T&M frequency $_i$ = estimated fleet average frequency of a tampering and mal-maintenance failure i .

T&M emission effect $_i$ = estimated emission effect for pollutant p associated with tampering and mal-maintenance failure i .

The emission rate at the end of useful life is then calculated using Equation 2-2.²⁵

Equation 2-2

$$ER_{\text{End of useful life},p,r,o} = ER_{\text{zero mile},p,r,o} \times (1 + f_{T\&M,p})$$

Where:

$ER_{\text{useful life},p,r,o}$ = the heavy-duty diesel emission rate at the end of emission-related warranty for each pollutant, p , regulatory class, r , and operating mode, o .

$ER_{\text{zero mile}}$ = the zero-mile heavy-duty diesel emission rate for each pollutant, p , regulatory class, r , and operating mode, o .

$f_{T\&M}$ = the tampering and mal-maintenance adjustment factor for each pollutant p (Equation 2-1).

The EPA used both the T&M frequency values and T&M emission effects for HC, CO, and PM_{2.5} in MOVES5 for the no-action and action cases. For the NO_x T&M emissions effects, the EPA used the existing MOVES5 emission effects (HHD values shown in Table 2-4) for both the no-action and the action cases.

²⁵ The operating modes for heavy-duty vehicles in MOVES are defined in terms of power output (*i.e.*, Scaled Tractive Power) and vehicle speed. There are 23 operating mode bins for running and nine for starts. For additional details on MOVES definitions of operating mode and other terms in the equation, refer to "Exhaust Emission Rates for Heavy-Duty Onroad Vehicles in MOVES5 (EPA-420-R-24-015)."

Table 2-4. NO_x Tampering & Mal-Maintenance (T&M) Emission Effects.

	MY 2027-2028	MY 2029-2060
Timing Advanced	6%	6%
Timing Retarded	-20%	-20%
Injector Problem (all)	-1%	-1%
Puff Limiter Mis-set	0%	0%
Puff Limited Disabled	0%	0%
Max Fuel High	0%	0%
Clogged Air Filter	0%	0%
Wrong/Worn Turbo	0%	0%
Intercooler Clogged	3%	3%
Other Air Problem	0%	0%
Engine Mechanical Failure	-10%	-10%
Excessive Oil Consumption	0%	0%
Electronics Failed	0%	0%
Electronics Tampered	8%	8%
EGR Stuck Open	-20%	-20%
EGR Disabled/Low-Flow	5%	5%
NO _x Aftertreatment Sensor ^a	1629%	1643%
Replacement NO _x Aftertreatment Sensor ^a	1620%	1643%
NO _x Aftertreatment Malfunction ^a	3339%	3386%
PM Filter Leak	0%	0%
PM Filter Disabled	0%	0%
Oxidation Catalyst Malfunction/Remove	0%	0%

^a Values for HHD are shown. For detailed descriptions of these failure modes, refer to Appendix B in Exhaust Emission Rates for Heavy-Duty Onroad Vehicles in MOVES5.

Using the NO_x T&M emission effects, the EPA then calculated T&M adjustment factors $f_{T\&M,NOX}$ for each scenario using Equation 2-1 and the baseline T&M frequency values. For HC, CO, and PM_{2.5}, the EPA used the existing T&M adjustment factors $f_{T\&M,p}$ in MOVES5. Then, the EPA calculated the heavy-duty diesel emission rate for each pollutant, p, age, a, regulatory class, r, and operating mode, o, using Equation 2-3.

Equation 2-3

$$ER_{p,r,a,o} = ER_{zero\ mile,p,r,o} \times (1 + s_a \times f_{T\&M})$$

Where:

$ER_{p,r,a,o}$ = the heavy-duty diesel emission rate for each pollutant, p, regulatory class, r, age, a, operating mode, o.

$ER_{zero\ mile}$ = the zero-mile heavy-duty diesel emission rate for each pollutant, p, regulatory class, r, operating mode, o.

s_a = scaled age effect at age a.

$f_{T\&M}$ = the tampering and mal-maintenance adjustment factor (Equation 2-1).

The scaled age effect, s_a , is calculated using the age of the vehicle in comparison to the emission-related warranty and useful life requirements, as shown in Table 2-5. When the vehicle age is

between the end of the emission-related warranty and the useful life, s_a is interpolated between 0 and 1.

Table 2-5. Calculation of s_a .

s_a	Where:
0	Age \leq End of warranty age
$\frac{(\text{vehicle age} - \text{end of warranty age})}{(\text{useful life age} - \text{end of warranty age})}$	End of warranty age < Age < Useful life
1	Age \geq End of warranty age

As the final step, the age-adjusted emission rates calculated in Equation 2-3 were averaged according to the age ranges shown in Table 2-6 that are used to define emission rates in MOVES for LHD, MHD, HHD, and Urban Bus regulatory classes. The resulting age-adjusted running emissions have a relationship with vehicle age as shown in Figure 2-2 and Figure 2-3 for HHD NO_x emissions.²⁶

Table 2-6. MOVES ageGroupID Used to Define Running and Start Emission Rates.

ageGroupID	Lower bound (years)	Upper bound (years)
3	0	3
405	4	5
607	6	7
809	8	9
1014	10	14
1519	15	19
2099	20	40

2.2.2.2 Summary of Diesel NO_x Running Emission Rates

To compare the average running NO_x emission rates (g/mile) across vehicle age for both the no-action and action cases, Figure 2-2 and Figure 2-3 show the HHD diesel long-haul combination truck fleet rates for MY 2027 and 2030, respectively. The MOVES running emission rates for the action case reflect the adjustments made to model the proposed emission-related warranty and useful life provisions as discussed above in Chapter 2.2.2.1. The grams per mile average running emissions is also a function of the default activity assumptions in MOVES5.R2.

Figure 2-2 and Figure 2-3 show that at early ages (age 0 through age 5), the average NO_x emission rates for the action case are significantly higher than the no-action case. For example, as shown in Table 2-3, HHD regulatory class age effects apply starting at age 4 for the no-action case, but apply much earlier (at age 1) for the action case due to the proposed removal of longer

²⁶ The average emission rate accounts for the frequency of different operating modes according to MOVES estimate of in-use vehicle activity. The trend in individual operating modes will be slightly different than the average trend shown in Figure 2-2 and Figure 2-3. This is a feature of the method used to derive the aging effects, but the effect is averaged out when conducting emission inventory analysis.

emission-related warranty periods, resulting in higher NO_x emission rates at early ages. The figures also demonstrate that emissions deteriorate more quickly in the action case than the no-action case due to the T&M NO_x emission effect, as explained in Chapter 2.2.2.1.²⁷ Although not shown, the emission rate is constant from age 15 through age 40.

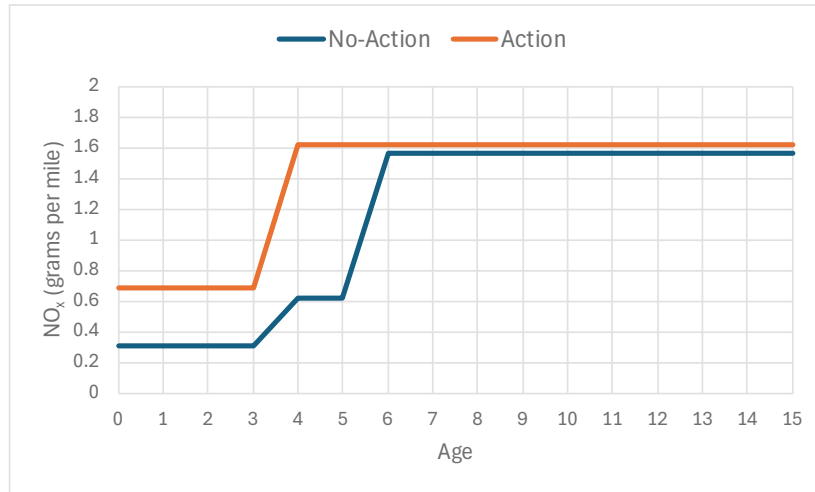


Figure 2-2. NO_x Emission Rates (g/mile) in MOVES for HHD Diesel Long-Haul Combination Trucks for the MY 2027 Fleet Across Vehicle Age for the No-Action and Action Cases.

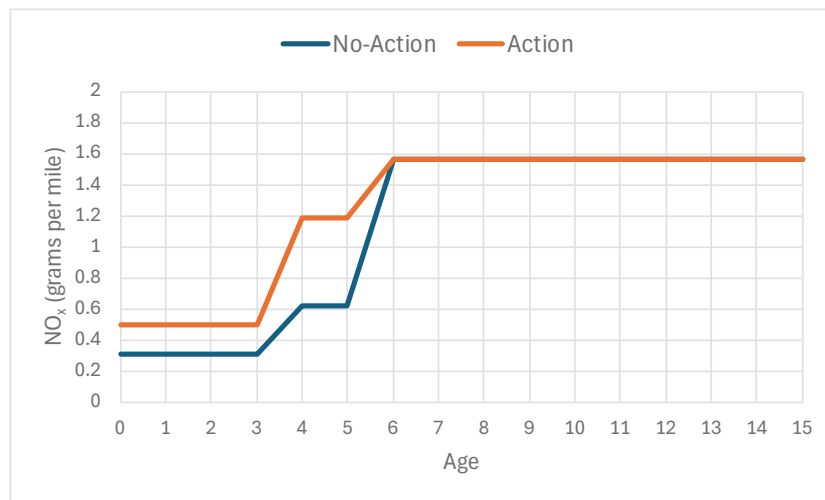


Figure 2-3. NO_x Emission Rates (g/mile) in MOVES for HHD Diesel Long-Haul Combination Trucks for the MY 2030 Fleet Across Vehicle Age for the No-Action and Action Cases.

²⁷ The MY 2027 HHD fleet is subject to the proposed three-year delay in useful life implementation and reaches its end of useful life at age 4 as shown in Figure 2-2 for the action case. In comparison, the end of useful life for both the MY 2030 HHD fleet and the no-action case is age 6 as shown in Figure 2-2 and Figure 2-3.

2.3 Emissions Impacts of the Proposed Rule

In Chapter 2.3.1, the EPA presents the emissions impacts of the proposed action case in selected CYs. For comparison, the EPA also presents the emission impacts of a request-for-comment case in Chapter 2.3.2 to evaluate the emissions sensitivity to potential additional changes in the useful life provisions.²⁸

More details about the impacts of the proposed action case can be found in Chapter 2.3.3 of this DRIA, where the emissions changes are categorized by vehicle fuel type and heavy-duty regulatory class.

2.3.1 Emissions Impacts of the Proposed Action Case

In Table 2-7 and Table 2-8, the EPA presents the estimated national emissions impacts of the proposal in four select CYs, in both absolute terms (U.S. Tons) and as percentage changes relative to the no-action case, respectively. The national (50 states and Washington D.C., excluding Puerto Rico and the Virgin Islands) highway heavy-duty vehicle emission inventory was generated using the national-scale option in MOVES5.R2 with the methodology and the model inputs as described in Chapter 2.2.²⁹ The carbon dioxide (CO₂) emissions are not affected by either the 2023 Final Rule or this proposal.

Table 2-7. National Heavy-Duty Vehicle Emissions Changes in U.S. Tons in CYs 2030, 2040, 2045, and 2055 — Proposed Action Case Emissions Relative to No-Action Case.

Pollutant	Increase in U.S. Short Tons			
	2030	2040	2045	2055
Oxides of Nitrogen (NO _x)	30,626	39,819	37,917	36,673
Volatile Organic Compounds (VOC)	84	122	118	116
Primary Total PM _{2.5}	29	49	47	46
Carbon Monoxide (CO)	5,902	8,502	8,260	8,084
Acetaldehyde	3	5	5	5
Benzene	0	0	0	0
Formaldehyde	2	3	3	3
Naphthalene	0	0	0	0

²⁸ Refer to section III.B in the preamble for this action for further details.

²⁹ Because of the differences in the control scenarios and the differences in the emission inventory methodology between the 2023 Final Rule and this proposal, no direct comparison should be made between the emission impacts of the 2023 Final Rule and the emissions impacts estimated in Table 2-7 and Table 2-8.

Table 2-8. National Heavy-Duty Vehicle Emissions Percentage Changes in CYs 2030, 2040, 2045, and 2055 — Proposed Action Case Emissions Relative to No-Action Case.

Pollutant	Percent Increase Relative to No-Action Case			
	2030	2040	2045	2055
Oxides of Nitrogen (NO _x)	4.2%	10.5%	11.3%	11.6%
Volatile Organic Compounds (VOC)	0.1%	0.2%	0.1%	0.1%
Primary Total PM _{2.5}	0.1%	0.3%	0.3%	0.3%
Carbon Monoxide (CO)	0.4%	0.6%	0.6%	0.4%
Acetaldehyde	0.2%	0.3%	0.2%	0.2%
Benzene	0.0%	0.0%	0.0%	0.0%
Formaldehyde	0.1%	0.2%	0.2%	0.1%
Naphthalene	0.0%	0.1%	0.1%	0.1%

In the 2023 Final Rule, the EPA projected nearly a 50 percent reduction in annual NO_x emissions in CY 2045 from vehicles subject to the MY 2027 and later standards and other requirements.³⁰ The NO_x emission reductions attributable to the lengthened emission-related warranty periods and longer useful life provisions were relatively small compared to the reductions from the more stringent standards and more representative test cycles also finalized in the 2023 Final Rule. While the EPA did not separately present the contributions from each program element in the 2023 Final Rule, the Agency updated our analysis in this proposed rule to assess the contributions of the program elements we are proposing to revise.

The EPA projects the proposed removal of lengthened emission-related warranty would increase NO_x emissions by 36,673 tons in CY 2055. As for the proposed three-year delay in the implementation of longer useful life periods, because it would apply only to MY 2027 through MY 2029 vehicles, and fleet turnover limits its influence, the EPA projects no impact on NO_x inventory in the analysis years, except for a small effect for urban buses.³¹ The proposed amendment to production volume allowance affects only up to five percent of U.S.-directed Heavy HDE production in MYs 2027 through 2029 and, therefore, is projected to increase NO_x emissions by just 0.04 percent in CY 2055. Accordingly, almost all NO_x emissions estimated in Table 2-7 are attributable to the removal of the longer emission-related warranty periods.

Using the same version of MOVES used for this proposal, the EPA estimates that the 2023 Final Rule, as amended by this proposal, would reduce the onroad heavy-duty NO_x inventory in 2055 by about 42 percent—over 260,000 tons of NO_x—compared to the 2055 heavy-duty NO_x inventory without the 2023 Final Rule.³² The proposed amendments would retain nearly 90 percent of the NO_x reductions originally projected to result from the 2023 Final Rule because the

³⁰ See Table VI-1 of the 2023 Final Rule (88 FR 4418, Jan. 24, 2023).

³¹ Because urban buses have lower annual VMT than other heavy-duty regulatory classes but a higher mileage limit (see Table 1-3), the shortened useful life for MYs 2027-2029 urban buses would contribute only about a 0.02 percent increase in heavy-duty NO_x inventory in CY 2040; no impact is projected for other analysis years.

³² Because this proposal and the 2023 Final Rule rely on different versions of MOVES that incorporate updated underlying data, the emissions estimates in this proposal are not directly comparable to those presented in the 2023 Final Rule.

more stringent standards and more representative test cycles finalized in the 2023 Final Rule remain in place.

2.3.2 Emissions Impacts of the Request-for-Comment Case

The EPA presents the national emission impacts of the request-for-comment case to evaluate the sensitivity due to potential additional changes in the useful life provisions. This case is included to estimate the emissions impacts of extending the pre-MY 2027 useful life provisions to all MY 2027 and later MYs as shown in Table 2-9. The emission-related warranty requirements are kept the same as in the proposed action case. The estimated vehicle age at the end of the emission-related warranty period and the useful life for each heavy-duty diesel regulatory class in the request-for-comment case for MYs 2027 and later is shown in Table 2-10.

Table 2-9. Useful Life and Emission-Related Warranty Periods for Heavy-Duty Diesel Engines and Aftertreatment Systems in the No-Action and Request-for-Comment Cases. ^a

Scenario	Applicable Model Years	Emission-Related Warranty (years, miles)			Useful Life (years, miles)		
		LHD	MHD	HHD/ Urban Bus	LHD	MHD	HHD/ Urban Bus
No-Action Case (2023 Final Rule)	2027+	10yr, 210k	10yr, 280k	10yr, 450k	15yr, 270k	12yr, 350k	11yr, 650k
Request-for-Comment Case	2027+	5yr, 50k	5yr, 100k	5yr, 100k	10yr, 110k	10yr, 185k	10yr, 435k

^a The age effects for heavy-duty gasoline and NG vehicles in MOVES are estimated directly from emissions data or adapted from light-duty gasoline or heavy-duty diesel vehicles and are not tied to emission-related warranty and useful life periods. Thus, the emission rates for heavy-duty gasoline or NG engines were not adjusted to account for the proposed changes to emission-related warranty and useful life periods.

Table 2-10. Estimated Vehicle Age at the End of the Emission-Related Warranty Period and the Useful Life for Each Heavy-Duty Diesel Regulatory Class in the No-Action and Request-for-Comment Cases for MYs 2027 and Later.

Vehicle Age (years)	Emission-Related Warranty				Useful Life			
	LHD	MHD	HHD	Urban Bus	LHD	MHD	HHD	Urban Bus
No-Action Case (2023 Final Rule)	8	7	4	10	10	9	6	11
Request-for-Comment Case	2	2	1	2	4	5	4	10

Table 2-11 and Table 2-12 summarize the emission impacts of the request-for-comment case (in U.S. Tons and as percent change relative to the no-action case, respectively) for four select CYs.

Table 2-11. National Heavy-Duty Vehicle Emissions Changes in U.S. Tons in CYs 2030, 2040, 2045, and 2055 – Request-for-Comment Case Emissions Relative to No-Action Case.

Pollutant	Increase in U.S. Short Tons			
	2030	2040	2045	2055
Oxides of Nitrogen (NO _x)	33,355	65,479	62,920	61,255
Volatile Organic Compounds (VOC)	92	204	198	194
Primary Total PM _{2.5}	32	84	81	79
Carbon Monoxide (CO)	6,519	14,183	13,788	13,509
Acetaldehyde	4	8	8	8
Benzene	0	0	0	0
Formaldehyde	2	5	5	5
Naphthalene	0	0	0	0

Table 2-12. National Heavy-Duty Vehicle Emissions Percentage Changes in CYs 2030, 2040, 2045, and 2055 – Request-for-Comment Case Emissions Relative to No-Action Case.

Pollutant	Increase as % of Baseline			
	2030	2040	2045	2055
Oxides of Nitrogen (NO _x)	4.6%	17.3%	18.8%	19.3%
Volatile Organic Compounds (VOC)	0.1%	0.3%	0.2%	0.2%
Primary Total PM _{2.5}	0.1%	0.5%	0.5%	0.4%
Carbon Monoxide (CO)	0.4%	1.1%	1.0%	0.7%
Acetaldehyde	0.2%	0.5%	0.4%	0.3%
Benzene	0.0%	0.0%	0.0%	0.0%
Formaldehyde	0.1%	0.3%	0.3%	0.2%
Naphthalene	0.0%	0.2%	0.2%	0.2%

2.3.3 Details of the Emissions Impacts of the Proposed Action Case

In this section, the EPA provides details of the national emission changes from the heavy-duty vehicles due to the proposed action case (previously summarized in Chapter 2.3.1 of this DRIA) for diesel fuel type and by heavy-duty vehicle regulatory class.³³

³³ Chassis certified Class 2b and 3 (LHD2b3) and gliders are not expected to be affected by either the 2023 Final Rule or this proposal. There are no changes in gasoline and CNG vehicle emissions due to the proposed amendments.

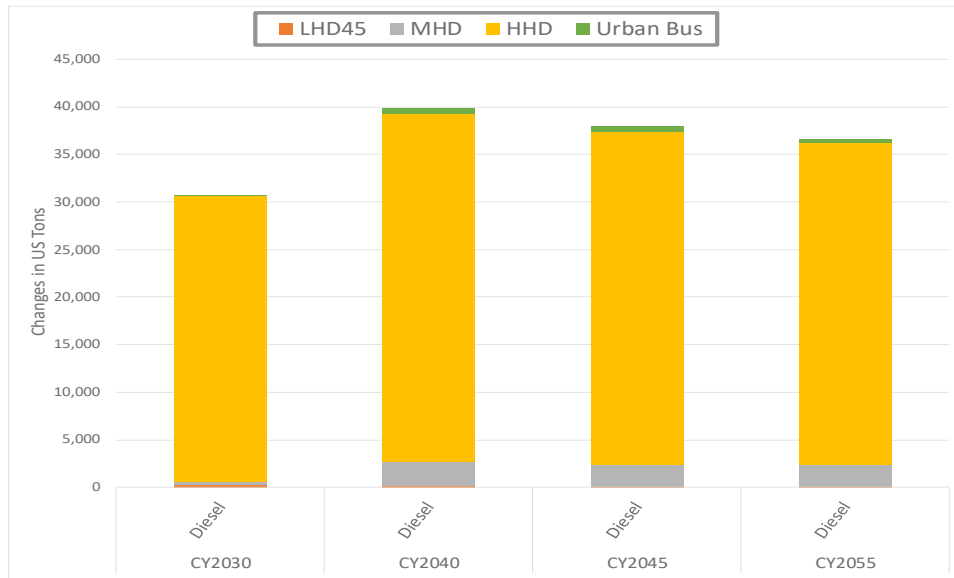


Figure 2-4. National NO_x Emissions Change from Heavy-Duty Diesel Vehicles in CYs 2030, 2040, 2045 and 2055 — by Heavy-Duty Regulatory Class.

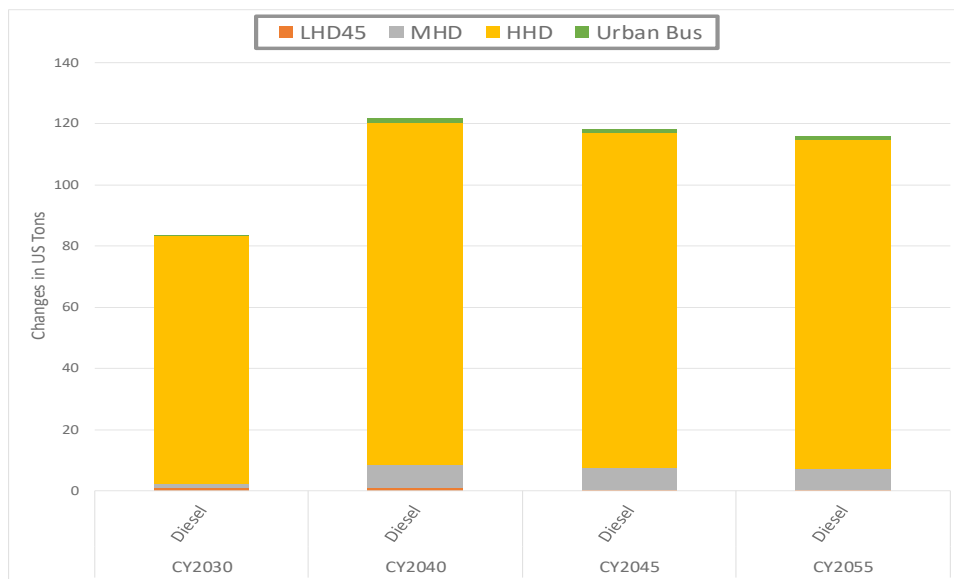


Figure 2-5. National VOC Emissions Change from Heavy-Duty Diesel Vehicles in CYs 2030, 2040, 2045, and 2055 — by Heavy-Duty Regulatory Class.

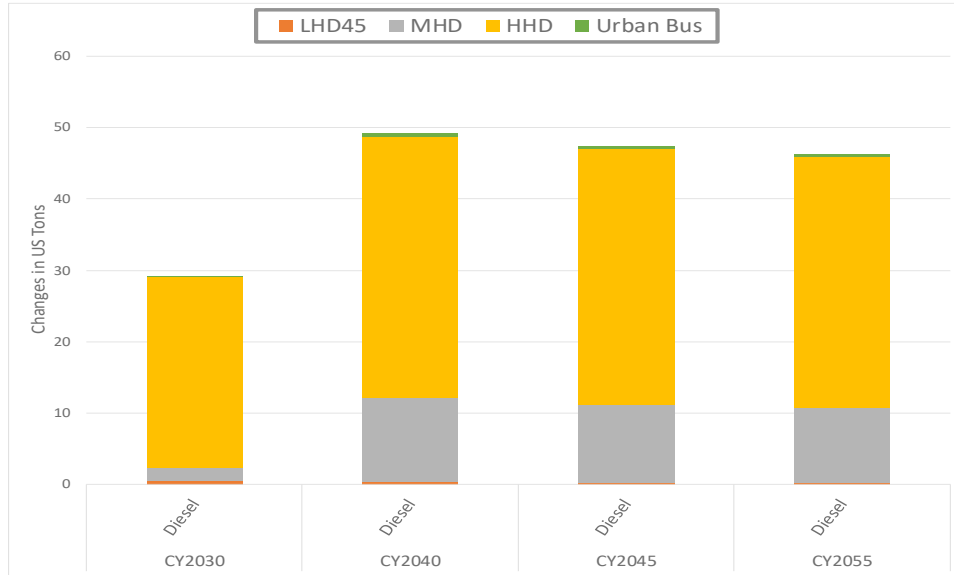


Figure 2-6. National Exhaust PM_{2.5} Emissions Change from Heavy-Duty Diesel Vehicles in CYs 2030, 2040, 2045, and 2055 — by Heavy-Duty Regulatory Class.

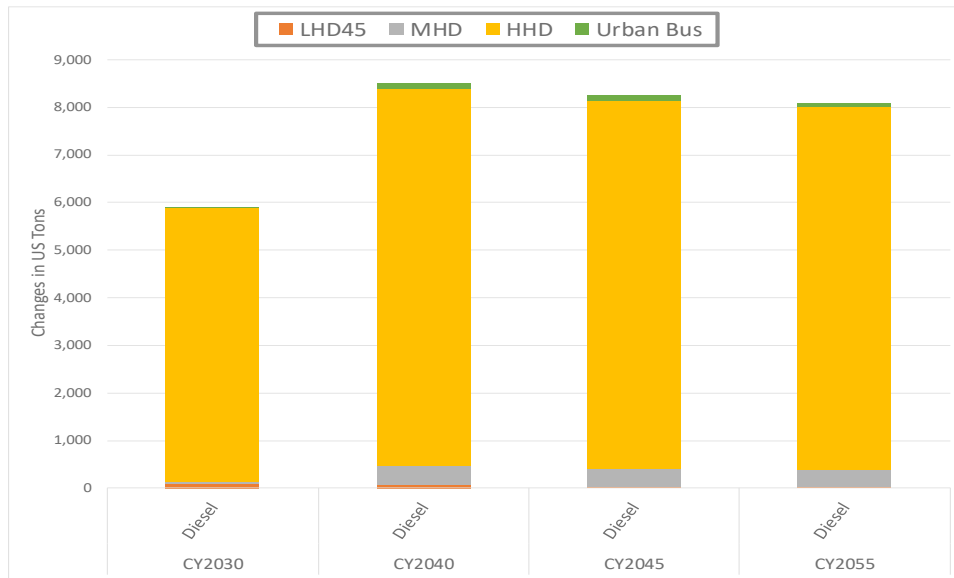


Figure 2-7. National CO Emissions Change from Heavy-Duty Diesel Vehicles in CYs 2030, 2040, 2045 and 2055 — by Heavy-Duty Regulatory Class.

2.4 Year-Over-Year Criteria Pollutant Emissions for Calendar Years 2027–2055

In this section, the EPA presents MOVES national emissions inventories (for selected criteria pollutants) across multiple CYs 2027–2055 for the no-action and action cases.

The national heavy-duty vehicle emissions inventories are summarized in Table 2-13 through Table 2-16 below for NO_x, VOC, PM_{2.5} (primary total), and CO, respectively, for the no-action and action cases. The same results are also displayed graphically in Figure 2-8 through Figure 2-11.

Table 2-13. National Heavy-Duty Vehicle NO_x Emissions (Annual U.S. Tons) for CYs 2027–2055.

Calendar Year	No-Action	Action	Increase Relative to No-Action Case (U.S. Tons)	Percent Increase Relative to No-Action Case
2027	992,118	1,001,707	9,589	1.0%
2028	894,484	913,020	18,536	2.1%
2029	806,391	833,211	26,820	3.3%
2030	727,207	757,833	30,626	4.2%
2031	651,774	700,926	49,152	7.5%
2032	587,087	652,396	65,309	11.1%
2033	547,003	608,083	61,081	11.2%
2034	512,759	564,742	51,984	10.1%
2035	482,291	525,676	43,385	9.0%
2036	454,842	497,242	42,401	9.3%
2037	431,421	472,624	41,203	9.6%
2038	409,756	450,380	40,623	9.9%
2039	393,543	433,678	40,135	10.2%
2040	378,849	418,668	39,819	10.5%
2041	365,836	405,411	39,575	10.8%
2042	355,547	394,863	39,316	11.1%
2043	346,360	385,261	38,902	11.2%
2044	340,171	378,563	38,392	11.3%
2045	334,824	372,741	37,917	11.3%
2046	330,908	368,458	37,550	11.3%
2047	325,811	363,081	37,271	11.4%
2048	323,706	360,746	37,040	11.4%
2049	322,102	358,966	36,864	11.4%
2050	320,013	356,699	36,686	11.5%
2051	319,238	355,750	36,512	11.4%
2052	318,432	354,863	36,431	11.4%
2053	317,724	354,225	36,501	11.5%
2054	317,214	353,845	36,631	11.5%
2055	317,327	353,999	36,673	11.6%

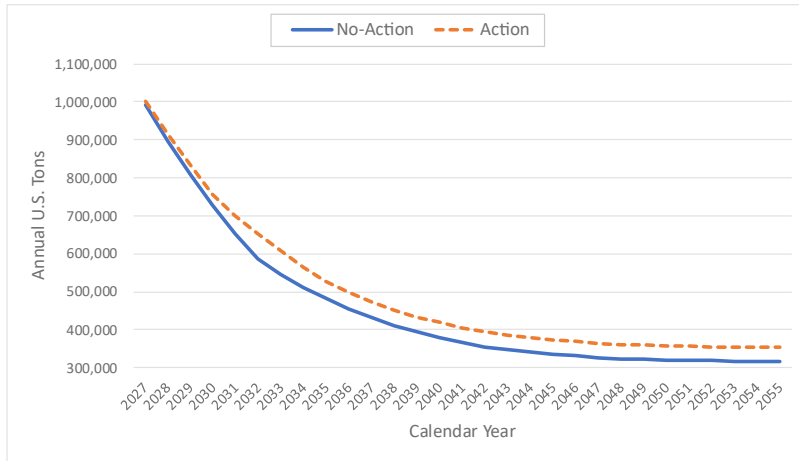


Figure 2-8. National Heavy-Duty Vehicle NO_x Emissions (Annual U.S. Tons) for CYs 2027–2055.

Table 2-14. National Heavy-Duty Vehicle VOC Emissions (Annual U.S. Tons) for CYs 2027–2055.

Calendar Year	No-Action	Action	Increase Relative to No-Action Case (U.S. Tons)	Percent Increase Relative to No-Action Case
2027	132,966	132,992	26	0.0%
2028	126,720	126,770	49	0.0%
2029	118,753	118,824	71	0.1%
2030	111,012	111,096	84	0.1%
2031	104,616	104,761	145	0.1%
2032	100,793	100,991	198	0.2%
2033	95,960	96,147	187	0.2%
2034	92,793	92,952	159	0.2%
2035	90,713	90,846	132	0.1%
2036	86,075	86,204	129	0.1%
2037	84,233	84,358	125	0.1%
2038	81,814	81,938	124	0.2%
2039	81,511	81,633	122	0.1%
2040	80,359	80,481	122	0.2%
2041	79,752	79,874	122	0.2%
2042	79,518	79,640	121	0.2%
2043	79,752	79,873	121	0.2%
2044	79,965	80,085	120	0.2%
2045	80,351	80,470	118	0.1%
2046	81,568	81,685	117	0.1%
2047	82,150	82,267	117	0.1%
2048	84,058	84,175	116	0.1%
2049	86,064	86,180	116	0.1%
2050	87,782	87,897	115	0.1%
2051	89,979	90,094	115	0.1%
2052	92,237	92,351	115	0.1%
2053	94,493	94,608	115	0.1%
2054	96,991	97,107	116	0.1%
2055	99,616	99,732	116	0.1%

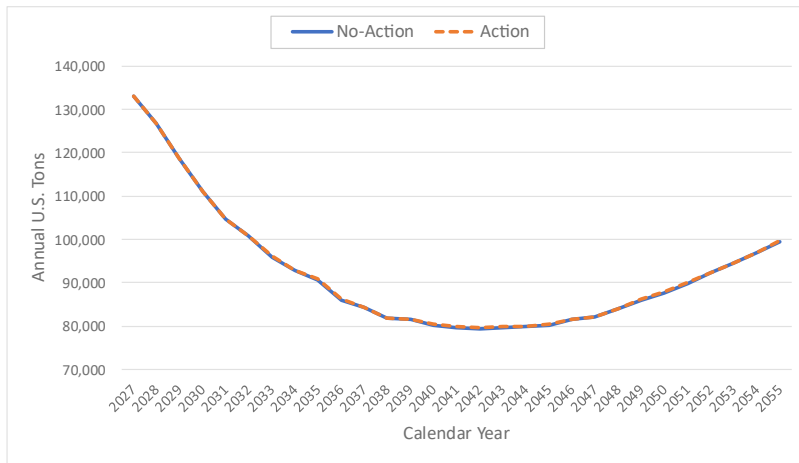


Figure 2-9. National Heavy-Duty Vehicle VOC Emissions (Annual U.S. Tons) for CYs 2027–2055.

Table 2-15. National Heavy-Duty Vehicle PM_{2.5} (Primary Total) Emissions (Annual U.S. Tons) for CYs 2027–2055.

Calendar Year	No-Action	Action	Increase Relative to No-Action Case (U.S. Tons)	Percent Increase Relative to No-Action Case
2027	31,348	31,356	9	0.0%
2028	28,738	28,755	17	0.1%
2029	26,672	26,697	25	0.1%
2030	24,997	25,026	29	0.1%
2031	23,383	23,436	54	0.2%
2032	22,160	22,235	75	0.3%
2033	21,150	21,225	75	0.4%
2034	20,490	20,557	67	0.3%
2035	19,781	19,838	56	0.3%
2036	19,191	19,246	55	0.3%
2037	18,726	18,777	52	0.3%
2038	18,165	18,216	51	0.3%
2039	18,033	18,082	50	0.3%
2040	17,810	17,859	49	0.3%
2041	17,613	17,662	49	0.3%
2042	17,445	17,493	49	0.3%
2043	17,303	17,351	48	0.3%
2044	17,201	17,249	48	0.3%
2045	17,117	17,164	47	0.3%
2046	17,075	17,122	47	0.3%
2047	16,836	16,882	47	0.3%
2048	16,904	16,950	46	0.3%
2049	17,000	17,046	46	0.3%
2050	17,080	17,126	46	0.3%
2051	17,191	17,237	46	0.3%
2052	17,301	17,347	46	0.3%
2053	17,415	17,461	46	0.3%
2054	17,535	17,581	46	0.3%
2055	17,664	17,711	46	0.3%

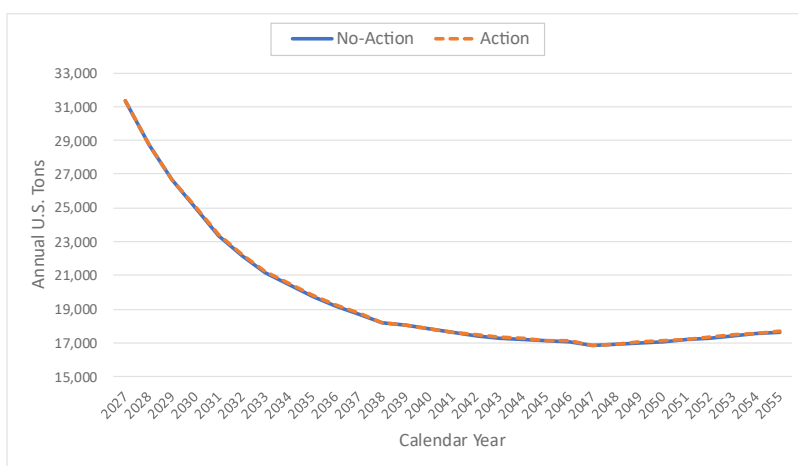


Figure 2-10. National Heavy-Duty Vehicle PM_{2.5} (Primary Total) Emissions (Annual U.S. Tons) for CYs 2027–2055.

Table 2-16. National Heavy-Duty Vehicle CO Emissions (Annual U.S. Tons) for CYs 2027–2055.

Calendar Year	No-Action	Action	Increase Relative to No-Action Case (U.S. Tons)	Percent Increase Relative to No-Action Case
2027	1,663,716	1,665,516	1,800	0.1%
2028	1,606,867	1,610,346	3,479	0.2%
2029	1,546,101	1,551,136	5,035	0.3%
2030	1,503,332	1,509,234	5,902	0.4%
2031	1,455,460	1,465,636	10,176	0.7%
2032	1,428,393	1,442,316	13,923	1.0%
2033	1,393,536	1,406,606	13,070	0.9%
2034	1,373,816	1,384,862	11,046	0.8%
2035	1,358,044	1,367,195	9,151	0.7%
2036	1,336,339	1,345,315	8,976	0.7%
2037	1,324,276	1,333,002	8,726	0.7%
2038	1,307,480	1,316,096	8,617	0.7%
2039	1,316,267	1,324,802	8,535	0.6%
2040	1,323,769	1,332,272	8,502	0.6%
2041	1,331,933	1,340,422	8,490	0.6%
2042	1,343,636	1,352,112	8,476	0.6%
2043	1,363,344	1,371,770	8,426	0.6%
2044	1,383,838	1,392,182	8,344	0.6%
2045	1,408,782	1,417,042	8,260	0.6%
2046	1,442,581	1,450,774	8,193	0.6%
2047	1,473,884	1,482,029	8,144	0.6%
2048	1,513,330	1,521,435	8,105	0.5%
2049	1,558,278	1,566,355	8,077	0.5%
2050	1,601,839	1,609,888	8,048	0.5%
2051	1,654,481	1,662,501	8,020	0.5%
2052	1,709,219	1,717,229	8,010	0.5%
2053	1,765,668	1,773,702	8,034	0.5%
2054	1,827,231	1,835,301	8,070	0.4%
2055	1,893,506	1,901,590	8,084	0.4%

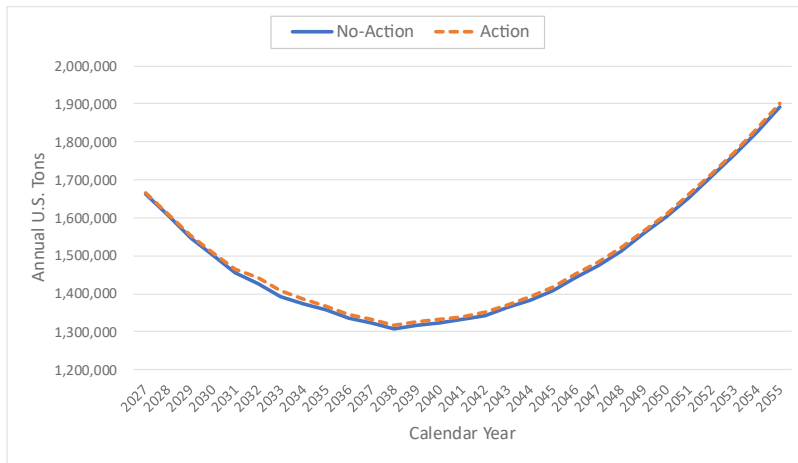


Figure 2-11. National Heavy-Duty Vehicle CO Emissions (Annual U.S. Tons) for CYs 2027–2055

Chapter 3 Program Cost Analysis

This Chapter presents the estimated costs associated with the emissions reduction- technologies and program provisions applicable under this proposed rule. Consistent with the 2023 Final Rule, the EPA reports both technology costs and operating costs, and includes costs associated with emission-related warranty and regulatory useful life provisions. Consistent with the EPA's inventory analysis presented in Chapter 2, the Agency has not projected costs for the proposed NCPs because we are not able to accurately project the degree to which firms may make use of the NCPs. Similarly, the EPA has not projected costs for the proposed revisions to the Agency's SCR inducement requirements for heavy-duty diesel engines because we are not able to accurately project the degree to which these proposed changes would result in different technology or operating costs relative to the requirements set to apply starting in MY 2027, which we are proposing to amend in this action. For example, on-highway vehicles and nonroad equipment generally already have hardware to generate audible and visible notifications but would require software changes to meet the proposed inducement requirements. Software changes are generally considered indirect costs related to production (*i.e.*, research and development). *See* more discussion about indirect costs in section 2.1.2.

The methods and cost elements follow the approach in the 2023 Final Rule, but key inputs have been updated as described below. For many of the costs that were modeled in the 2023 Final Rule, there are no cost impacts in this proposed rule. The cost categories that did have a cost impact in the proposed rule were the cost savings to manufacturers because of proposed shorter regulatory emission-related warranty periods, a slight decrease in DEF usage for vehicle operators, and increased engine emission repairs for vehicle operators. All costs are presented in 2024 dollars.

Direct manufacturing costs (DMC)

- Treatment of engine costs: For this proposed rule, all engine-related costs occur in the no-action case, and there are no incremental engine costs on a per-vehicle basis in the action case or request-for-comment case. The EPA derived no-action per-engine costs by summing the action case and no-action case per-engine costs used for the 2023 Final Rule and assigning that total to the no-action case for this proposed rule. This approach builds on the 2023 Final Rule's inclusion of baseline engine system costs to reflect interactions with emission-related warranty and useful life provisions.
- Exhaust aftertreatment, cylinder deactivation (CDA), and other technology costs: The EPA retains the technology cost basis from the 2023 Final Rule (*e.g.*, teardown-based costs for CDA and advanced diesel engine aftertreatment system from the engineering consulting firm FEV, and certification-based spark-ignition aftertreatment costs), but any engine costs are accounted for entirely in the no-action case for this proposed rule. The

2023 Final Rule's demonstrations and tables serve as the underlying source for package DMC values by regulatory class for each fuel type.

- Learning factors: The EPA applies the same seed volume factor used in the action case of the 2023 Final Rule to the no-action, action, and request-for-comment cases of this proposal to determine the learning factors for each regulatory class and fuel type. This follows the 2023 Final Rule methodology of projecting year-over-year technology cost evolution.

Indirect costs were estimated using Retail Price Equivalent (RPE) multipliers that were consistent with the 2023 Final Rule methodology and RTI International's factors derived from U.S. Securities and Exchange Commission financial filings. For the analysis in this proposed rule, the EPA applies uniform RPE markups equal to the values used in the action case of the 2023 Final Rule across all applicable categories.

- Regulatory useful life: For all scenarios, the EPA used the same values for useful life that were used in the 2023 Final Rule's action case. The EPA took this approach because the Agency believes that manufacturers have already designed their engines and incurred the research and development (R&D) costs to meet the longer useful life requirements in the no-action case and the proposal to delay the longer useful life for three MYs will not reduce the R&D costs that have already been incurred.
- Emission-related warranty: The EPA switches the 2023 Final Rule's action and no-action emission-related warranty values for this proposed amendment. For this proposed amendment, the action and request-for-comment case have the shorter emission-related warranty periods that match the existing MYs 2026 and earlier values.
- Extended emission-related warranty: The mileage values for the extended warranty cost calculations in this analysis were set equal to the base warranty values used in the 2023 Final Rule.

The EPA retains the operating cost categories from the 2023 Final Rule analysis, including DEF consumption changes for diesel engines, fuel costs, and emission related repair costs. The inputs as specified below were updated.

- Onboard refueling vapor recovery (ORVR)-related inputs: ORVR fuel change inputs are set to the same values as used in the action case of the 2023 Final Rule. This is consistent with the 2023 Final Rule's treatment of refueling control technologies and their implications for costs and emissions (*see* gasoline ORVR cost elements and the refueling standards discussion in the 2023 Final Rule). The same input values are used for all analysis cases in this DRIA: the no-action, proposed action, and request-for-comment cases.

- Fuel prices: Fuel price projections are updated in the no action, proposed action, and request-for-comment cases to the reference price case from the AEO 2025 for all operating cost calculations. AEO fuel prices were extended beyond 2050 to 2055 by linearly extrapolating the fuel prices from 2047 to 2050.

3.1 Technology Package Costs

3.1.1 Direct Manufacturing Costs

For this proposed rule, all engine-related costs occur in the no-action case. There are no incremental engine technology costs on a per-vehicle basis for the action case and request-for-comment case for these proposed amendments (that is, all cases are the same). The EPA took this approach for the purpose of this proposal because the Agency does not believe manufacturers will change their MY 2027 through MY 2029 technology designs in response to a shorter useful life for the action and request-for-comment cases. The EPA believes that manufacturers have already designed their engines for MY 2027 and that manufacturers are likely to maintain a steady technology design for MY 2028 and MY 2029. However, the EPA believes that if the regulatory useful life were permanently kept at the MY 2026 values, that manufacturers over time would optimize their systems to take cost out of the emissions controls. The EPA believes that this could come in two forms. First is that the EPA expects manufacturers could reduce the volume of the diesel oxidation catalyst (DOC), diesel particulate filter (DPF), and selective catalytic reduction (SCR) catalysts, and possibly reduce the platinum group metals (PGM) in the DOC. Second, manufacturers could remove technology from their aftertreatment. For example, if a manufacturer was relying on electric exhaust heaters (e-heaters) to heat up the aftertreatment, the manufacture could reduce the amount of heat provided by the system by reducing the number of e-heaters or reducing the power consumption of the e-heater. Both cases could result in a change in DMC. For this proposal, the EPA has not estimated the potential cost savings from the regulatory useful life permanently kept at the MY 2026 values.

The engine costs for this analysis are determined by summing the costs of the action and no-action case for each HDE. These costs were then converted into 2024 dollars using the conversion factors in Table 3-1 and the results are shown in Table 3-2.

Table 3-1. GDP Price Deflators^a Used to Adjust Costs to 2024 Dollars.

Cost Basis Year	Conversion Factor
2011	1.369
2012	1.344
2013	1.321
2014	1.299
2015	1.287
2016	1.275
2017	1.252
2018	1.224
2019	1.204
2020	1.189
2021	1.137
2022	1.061
2023	1.024
2024	1.000

^a Based on the National Income and Product Accounts, Table 1.1.9 Implicit Price Deflators for Gross Domestic Product, Bureau of Economic Analysis, U.S. Department of Commerce, July 30, 2025.

Costs are presented for MY 2027 vehicles in Table 3-2, but these costs continue for every MY going forward. Subsequent years have applied the appropriate learning factor that results in a decreasing cost over time on a per-engine basis.

Table 3-2. Technology Package Direct Manufacturing Costs for MY 2027 Per Engine by Regulatory Class and Fuel Type Per Vehicle, 2024 Dollars.^{a,b}

Regulatory Class	Diesel	Gasoline	CNG
Light HDE	\$6,788	\$4,031	
Medium HDE	\$6,704	\$4,031	
Heavy HDE	\$9,629		\$10,449
Urban Bus	\$6,841		\$7,837

^a Blank cells indicate that there are no HDEs in a specific regulatory class for that fuel type, *e.g.*, there are no Light HDE that run on CNG.

^b Values include the total of the base DMC for emissions control technology needed to meet the MY 2026 standards and the incremental DMC from the technology needed to meet the MY 2027 standards.

As was done in the 2023 Final Rule, the learning factors were applied on a technology package cost basis using MOVES projected sales volumes to determine first year sales and cumulative sales.³⁴ The analysis of the 2023 Final Rule used a seed volume factor of 3 for the action case to compute the learning factors for HDE in each regulatory class and fuel type. For the action, no-action and request-for-comment case a seed volume factor of 3 was used in combination with the MOVES projected sales volumes to produce the learning factors shown in Table 3-3. These learning effects are applied in same manner for the action, no-action and request-for-comment case.

³⁴ Chassis certified Class 2b and 3 (LHD2b3) and gliders are not expected to be affected by either the 2023 Final Rule or this proposal and are not included in this cost analysis.

Table 3-3. Learning Effects Applied to Direct Manufacturing Costs for HDE.

Model Year	Diesel				Gasoline		CNG	
	Medium HDE	Heavy HDE	Urban Bus	Light HDE	Light HDE	Medium HDE	Heavy HDE	Urban Bus
2027	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2028	0.949	0.948	0.948	0.954	0.944	0.948	0.950	0.951
2029	0.911	0.910	0.912	0.923	0.899	0.908	0.912	0.915
2030	0.880	0.879	0.886	0.904	0.861	0.873	0.883	0.890
2031	0.853	0.853	0.862	0.892	0.830	0.840	0.856	0.865
2032	0.830	0.831	0.840	0.887	0.803	0.812	0.832	0.840
2033	0.810	0.811	0.821	0.883	0.779	0.787	0.810	0.819
2034	0.793	0.794	0.804	0.880	0.757	0.765	0.790	0.800
2035	0.778	0.779	0.790	0.878	0.738	0.745	0.772	0.783
2036	0.764	0.765	0.776	0.875	0.721	0.727	0.756	0.767
2037	0.752	0.752	0.764	0.873	0.705	0.711	0.740	0.752
2038	0.740	0.740	0.753	0.871	0.691	0.696	0.725	0.737
2039	0.730	0.729	0.743	0.870	0.678	0.683	0.709	0.722
2040	0.720	0.719	0.734	0.868	0.666	0.671	0.693	0.707
2041	0.711	0.710	0.726	0.866	0.655	0.659	0.678	0.692
2042	0.703	0.701	0.718	0.864	0.645	0.649	0.663	0.679
2043	0.695	0.693	0.711	0.863	0.635	0.639	0.649	0.666
2044	0.688	0.686	0.705	0.861	0.626	0.630	0.636	0.653
2045	0.682	0.679	0.699	0.860	0.618	0.622	0.623	0.642
2046	0.675	0.672	0.694	0.858	0.610	0.614	0.612	0.631
2047	0.669	0.666	0.689	0.857	0.602	0.607	0.600	0.621
2048	0.664	0.660	0.684	0.855	0.595	0.600	0.590	0.611
2049	0.658	0.654	0.679	0.854	0.589	0.594	0.579	0.601
2050	0.653	0.649	0.675	0.852	0.582	0.588	0.569	0.592
2051	0.648	0.644	0.671	0.851	0.576	0.582	0.558	0.583
2052	0.643	0.639	0.668	0.850	0.570	0.576	0.548	0.574
2053	0.638	0.634	0.664	0.848	0.565	0.570	0.538	0.566
2054	0.633	0.629	0.661	0.847	0.560	0.565	0.529	0.557
2055	0.629	0.625	0.658	0.845	0.554	0.560	0.519	0.549

3.1.2 Indirect Costs

The indirect costs were calculated using the same methodology as the 2023 Final Rule, but the emission-related warranty costs were updated to align with the proposed changes to the warranty provisions for both the action and request-for-comment cases relative to the no-action case. The R&D costs are tied to the useful life provisions. For these cost calculations, the useful life provisions were kept the same between the no-action, action, and request-for-comment cases and remained at the 2023 Final Rule’s action case values. The EPA took this approach because the Agency believes that manufacturers have already designed their engines and incurred the R&D costs to meet the longer useful life requirements in the no-action case and the proposal to delay the useful life for three MYs will not reduce the R&D costs that have already been incurred. The EPA requests comment, including data, on revisions to R&D costs that the Agency should

consider for the request-for-comment case where useful life is changed indefinitely to the periods that apply for MYs 2026 and earlier values.

3.1.2.1 Emission-Related Warranty Costs

The proposed changes to the emission-related warranty between the action, no-action and request-for-comment cases are expected to change the contribution of warranty costs to indirect costs between scenarios. Examples of the contribution to MY 2027 indirect costs from emission-related warranty changes on a per-vehicle basis are presented in Table 3-4 for diesel engines, Table 3-5 for CNG engines, and Table 3-6 for gasoline engines. Each table shows the action case, no-action case, and the difference between them. The negative values when compared relative to the no-action case represent a cost savings to the indirect costs. The per-vehicle emission-related warranty cost saving in this proposed action does not exactly match the increase in the warranty costs from the 2023 Final Rule for several reasons. For this proposed rule, the EPA has determined the cost impacts in 2024 dollars, versus the 2017 dollars of the 2023 Final Rule. The emission-related warranty costs are a function of years the engine is under warranty, which is partially impacted by the annual VMT in MOVES. One of the changes to MOVES5.R2 (*see* Chapter 2.2 of this DRIA) was the use of updated activity data, which impacted the estimate of the number of years the engine is covered by the emission-related warranty. In this proposed rule, the EPA also did not account for an estimate of existing extended emission-related warranty packages in the action case to be consistent with the assumptions made in the inventory analysis in Chapter 1 of this DRIA. Finally, the method scales the emission-related warranty cost per year based on the direct manufacturing costs of the no-action case.

Table 3-4. MY 2027 Diesel-Fueled Engine Emission-Related Warranty Costs Per Vehicle by Regulatory Class and MOVES Vehicle Type for the Action and No-Action Cases, 2024 Dollars.^a

Regulatory Class	MOVES Vehicle Type	Action Case	No-Action Case	Relative to No-Action Case
Light HDE	Short-Haul Single Unit Trucks	\$2,380	\$8,630	-\$6,250
	Long-Haul Single Unit Trucks	\$1,504	\$6,315	-\$4,812
	Motor Homes	\$4,315	\$8,630	-\$4,315
Medium HDE	Other Buses	\$2,640	\$7,392	-\$4,752
	Transit Buses	\$2,640	\$7,392	-\$4,752
	School Buses	\$4,262	\$8,524	-\$4,262
	Refuse Trucks	\$3,547	\$8,524	-\$4,977
	Short-Haul Single Unit Trucks	\$4,262	\$8,524	-\$4,262
	Long-Haul Single Unit Trucks	\$2,970	\$8,317	-\$5,346
	Motor Homes	\$4,262	\$8,524	-\$4,262
	Short-Haul Combination Trucks	\$1,305	\$3,655	-\$2,350
	Long-Haul Combination Trucks	\$677	\$1,896	-\$1,219
Heavy HDE	Other Buses	\$3,792	\$12,243	-\$8,451
	School Buses	\$6,121	\$12,243	-\$6,121
	Refuse Trucks	\$5,095	\$12,243	-\$7,148
	Short-Haul Single Unit Trucks	\$6,121	\$12,243	-\$6,121
	Long-Haul Single Unit Trucks	\$4,266	\$12,243	-\$7,976
	Motor Homes	\$6,121	\$12,243	-\$6,121
	Short-Haul Combination Trucks	\$1,875	\$8,437	-\$6,562
	Long-Haul Combination Trucks	\$973	\$4,377	-\$3,404
Urban Bus	Transit Buses	\$2,694	\$8,698	-\$6,004

^a Negative values denote lower costs, *i.e.*, savings in expenditures.

Table 3-5. MY 2027 CNG-Fueled Engine Emission-Related Warranty Costs Per Vehicle by Regulatory Class and MOVES Vehicle Type for the Action and No-Action Cases, 2024 Dollars.^a

Regulatory Class	MOVES Vehicle Type	Action Case	No-Action Case	Relative to No-Action Case
Heavy HDE	Other Buses	\$4,115	\$13,285	-\$9,170
	School Buses	\$6,643	\$13,285	-\$6,643
	Refuse Trucks	\$5,529	\$13,285	-\$7,756
	Short-Haul Single Unit Trucks	\$6,643	\$13,285	-\$6,643
	Long-Haul Single Unit Trucks	\$4,629	\$13,285	-\$8,656
	Short-Haul Combination Trucks	\$2,035	\$9,156	-\$7,121
	Long-Haul Combination Trucks	\$1,055	\$4,749	-\$3,694
Urban Bus	Transit Buses	\$3,086	\$9,963	-\$6,878

^a Negative values denote lower costs, *i.e.*, savings in expenditures.

Table 3-6. MY 2027 Gasoline-Fueled Engine Emission-Related Warranty Costs Per Vehicle by Regulatory Class and MOVES Vehicle Type for the Action and No Action Cases, 2024 Dollars.^a

Regulatory Class	MOVES Vehicle Type	Action Case	No-Action Case	Relative to No-Action Case
Light HDE	Other Buses	\$794	\$2,540	-\$1,746
	Transit Buses	\$794	\$2,540	-\$1,746
	School Buses	\$2,308	\$5,125	-\$2,817
	Short-Haul Single Unit Trucks	\$1,414	\$4,523	-\$3,110
	Long-Haul Single Unit Trucks	\$893	\$2,857	-\$1,964
	Motor Homes	\$2,562	\$5,125	-\$2,562
Medium HDE	Other Buses	\$794	\$2,540	-\$1,746
	Transit Buses	\$794	\$2,540	-\$1,746
	School Buses	\$2,308	\$5,125	-\$2,817
	Short-Haul Single Unit Trucks	\$1,414	\$4,523	-\$3,110
	Long-Haul Single Unit Trucks	\$893	\$2,857	-\$1,964
	Motor Homes	\$2,562	\$5,125	-\$2,562

^a Negative values denote lower costs, *i.e.*, savings in expenditures.

3.1.2.2 Research and Development Costs

In the 2023 Final Rule, the EPA estimated that there would be additional R&D costs beyond what is captured in the RPE due to the longer useful life periods. The approach the EPA took scaled the R&D costs by the increase in useful life for the first three years of the standards. For this proposal, the EPA has kept the scalar the same as the 2023 Final Rule, with useful life for

the action, no-action, and request-for-comment cases. The EPA took this approach because the Agency believes that manufacturers have already designed their MY 2027 engines and incurred the R&D costs to meet the longer useful life requirements in the no-action case. Thus, the proposal to delay useful life will not reduce the R&D costs that have already been incurred. Similarly, the EPA believes that manufacturers' existing software to meet inducements requirements finalized in the 2023 Final Rule could be updated to address the proposal to modify the inducement requirements without changing the R&D costs that manufacturers have already incurred. The MY 2027 R&D costs on a per-vehicle basis by regulatory class are presented in Table 3-7 for diesel, CNG, and gasoline engines in the action case, no-action case, and the difference between them. Within a single regulatory class, the contributions to the indirect cost for R&D are the same across all MOVES vehicle types. Table 3-7 shows that the R&D contribution to indirect cost has no impact on costs between the action case and no-action case.

Table 3-7. MY 2027 R&D Costs Per Vehicle by Fuel Type and Regulatory Class for the Action and No-Action Cases, 2024 Dollars.

Fuel Type	Regulatory Class	Action Case	No Action Case	Relative to No Action Case
Diesel	Light HDE	\$833	\$833	\$0
	Medium HDE	\$634	\$634	\$0
	Heavy HDE	\$719	\$719	\$0
	Urban Bus	\$511	\$511	\$0
CNG	Heavy HDE	\$781	\$781	\$0
	Urban Bus	\$586	\$586	\$0
Gasoline	Light HDE	\$366	\$366	\$0
	Medium HDE	\$366	\$366	\$0

3.2 Operating Costs

The EPA has estimated two impacts on operating costs expected to be incurred by users of new MYs 2027 and later heavy-duty vehicles because of this proposed action case: decreased DEF consumption by diesel vehicles due to decreased DEF dose rates, and emission repair impacts. The EPA uses the same method to calculate operating costs in this analysis as was done in the 2023 Final Rule.

The EPA updated the fuel costs to use the reference case of AEO 2025. AEO 2025 projects fuel prices out to 2050; thus, to perform the cost analysis through 2055, an estimation of the fuel prices was necessary for 2051 through 2055. A linear extrapolation of fuel prices from 2047 to 2050 was used to compute fuel prices from 2051 to 2055. The operating costs the EPA estimates here are for the heavy-duty truck operation impacted by the proposed rule. These costs (and savings) are incurred by heavy-duty truck purchasers/owners. There are no impacts to fuel costs between the action and no-action case.

3.2.1 DEF Costs

The changes in DEF costs were computed in the same way as the 2023 Final Rule and are presented here for the lifetime of MY 2027 diesel vehicles.³⁵ Lifetime is defined as through the final year of this analysis, 2055. Table 3-8 and Table 3-9 show the lifetime DEF cost for each MOVES vehicle type and regulatory class for the action case, no-action case, and the difference between them for a 3 percent and 7 percent discount rate, respectively, for MY 2027. For MY 2027, the DEF costs are the same for the request-for-comment case and action-case, and the results are the same as in Table 3-8 and Table 3-9. The negative values for the difference between the action case or request-for-comment case and no-action case indicate a cost savings to vehicle operators due to reductions in DEF usage.

³⁵ In Chapter 7 of the RIA for the 2023 Final Rule, the final calculation of DEF consumption is to multiply the gallons of diesel fuel consumed by 5.18 percent to account for the baseline DEF consumption and add to that amount 527 gallons of DEF for each ton of NO_x reduced from the baseline. Both the gallons of diesel fuel consumed and the tons of NO_x reduced are taken directly from the year-over-year MOVES results.

Table 3-8. MY 2027 Lifetime (2027-2055) DEF Costs Per Diesel Vehicle by Regulatory Class and MOVES Vehicle Type for the Action and No-Action Cases, 3% Discounting in 2024 Dollars.

MOVES Vehicle Type	Light HDE	Medium HDE	Heavy HDE	Urban Bus
No-Action Case				
Short-Haul Single Unit Trucks	\$3,089	\$4,679	\$5,616	
Long-Haul Single Unit Trucks	\$4,227	\$6,393	\$7,670	
Motor Homes	\$1,411	\$2,053	\$2,431	
Other Buses		\$15,004	\$15,540	
Transit Buses		\$14,961		\$15,405
School Buses		\$4,030	\$4,240	
Refuse Trucks		\$9,854	\$10,266	
Short-Haul Combination Trucks		\$20,190	\$21,057	
Long-Haul Combination Trucks		\$45,315	\$46,221	
Action Case				
Short-Haul Single Unit Trucks	\$3,012	\$4,547	\$5,417	
Long-Haul Single Unit Trucks	\$4,121	\$6,207	\$7,399	
Motor Homes	\$1,393	\$2,028	\$2,385	
Other Buses		\$14,717	\$15,138	
Transit Buses		\$14,699		\$14,891
School Buses		\$3,962	\$4,143	
Refuse Trucks		\$9,611	\$9,944	
Short-Haul Combination Trucks		\$19,753	\$20,430	
Long-Haul Combination Trucks		\$44,681	\$45,238	
Difference from No-Action Case				
Short-Haul Single Unit Trucks	-\$77	-\$132	-\$199	
Long-Haul Single Unit Trucks	-\$106	-\$186	-\$272	
Motor Homes	-\$17	-\$25	-\$46	
Other Buses		-\$286	-\$401	
Transit Buses		-\$262		-\$513
School Buses		-\$69	-\$97	
Refuse Trucks		-\$244	-\$322	
Short-Haul Combination Trucks		-\$437	-\$627	
Long-Haul Combination Trucks		-\$634	-\$983	

Table 3-9. MY 2027 Lifetime (2027-2055) DEF Costs Per Diesel Vehicle by Regulatory Class and MOVES Vehicle Type for the Action and No-Action Cases, 7% Discounting in 2024 Dollars.

MOVES Vehicle Type	Light HDE	Medium HDE	Heavy HDE	Urban Bus
No-Action Case				
Short-Haul Single Unit Trucks	\$2,306	\$3,493	\$4,192	
Long-Haul Single Unit Trucks	\$3,209	\$4,854	\$5,824	
Motor Homes	\$904	\$1,316	\$1,558	
Other Buses		\$10,110	\$10,471	
Transit Buses		\$10,081		\$10,380
School Buses		\$2,716	\$2,857	
Refuse Trucks		\$7,057	\$7,352	
Short-Haul Combination Trucks		\$15,516	\$16,183	
Long-Haul Combination Trucks		\$33,150	\$33,812	
Action Case				
Short-Haul Single Unit Trucks	\$2,246	\$3,389	\$4,025	
Long-Haul Single Unit Trucks	\$3,126	\$4,707	\$5,595	
Motor Homes	\$891	\$1,297	\$1,522	
Other Buses		\$9,885	\$10,144	
Transit Buses		\$9,875		\$10,013
School Buses		\$2,662	\$2,778	
Refuse Trucks		\$6,866	\$7,085	
Short-Haul Combination Trucks		\$15,172	\$15,654	
Long-Haul Combination Trucks		\$32,651	\$32,995	
Difference from No-Action Case				
Short-Haul Single Unit Trucks	-\$60	-\$104	-\$166	
Long-Haul Single Unit Trucks	-\$83	-\$146	-\$229	
Motor Homes	-\$13	-\$19	-\$36	
Other Buses		-\$225	-\$328	
Transit Buses		-\$206		-\$367
School Buses		-\$54	-\$79	
Refuse Trucks		-\$192	-\$267	
Short-Haul Combination Trucks		-\$344	-\$529	
Long-Haul Combination Trucks		-\$498	-\$817	

3.2.2 Emissions Repair Costs

The emissions repair costs were computed in the same way as the 2023 Final Rule and are presented here for the lifetime of MY 2027 diesel, CNG, and gasoline vehicles. Lifetime is defined as through the final year of this analysis, 2055. However, the emission-related warranty period was changed for the action and request-for-comment cases to remain at MY 2026 levels. Thus, for each fuel type, the emission repair costs are the same for the request-for-comment case and the action case. This will have an impact on emission-related repair costs incurred by heavy-duty vehicle owners. The changes to the emissions warranty for the action case are described in Chapter 2.2.2 of this DRIA. The lifetime emissions repair costs for MY 2027 are presented below.

Table 3-10 and Table 3-11 show the lifetime emissions repair costs for each MOVES vehicle type and regulatory class for the action case, no-action case and the difference between them for diesel vehicles for a 3 percent and 7 percent discount rate, respectively, for MY 2027. For MY 2027 diesel vehicles, the emission repair costs are the same for the request-for-comment case and action case, and the results are the same as in Table 3-10 and Table 3-11.

Table 3-12 shows the lifetime emissions repair costs for each MOVES vehicle type and regulatory class at both a 3 percent and 7 percent discount rate for the action case, no-action case, and the difference between them for CNG vehicles for MY 2027. For MY 2027 CNG vehicles, the emission repair costs are the same for the request-for-comment case and action case, and the results are the same as in Table 3-12.

Table 3-13 shows the lifetime emissions repair costs for each MOVES vehicle type and regulatory class at both a 3 percent and 7 percent discount rate for the action case, no-action case, and the difference between them for gasoline vehicles for MY 2027. For MY 2027 gasoline vehicles, the emission repair costs are the same for the request-for-comment case and action case, and the results are the same as in Table 3-13.

Table 3-10. MY 2027 Lifetime (2027-2055) Emission Repair Costs Per Diesel Vehicle by Regulatory Class and MOVES Vehicle Type for the Action and No-Action Cases, 3% Discounting in 2024Ddollars. ^a

MOVES Vehicle Type	Light HDE	Medium HDE	Heavy HDE	Urban Bus
No-Action Case				
Short-Haul Single Unit Trucks	\$737	\$728	\$1,045	
Long-Haul Single Unit Trucks	\$1,649	\$1,073	\$1,472	
Motor Homes	\$637	\$629	\$903	
Other Buses		\$3,199	\$4,080	
Transit Buses		\$3,162		\$2,865
School Buses		\$966	\$1,387	
Refuse Trucks		\$1,393	\$2,001	
Short-Haul Combination Trucks		\$5,627	\$5,354	
Long-Haul Combination Trucks		\$17,302	\$21,415	
Action Case				
Short-Haul Single Unit Trucks	\$2,016	\$1,500	\$2,155	
Long-Haul Single Unit Trucks	\$3,651	\$2,888	\$4,147	
Motor Homes	\$910	\$899	\$1,291	
Other Buses		\$5,091	\$7,312	
Transit Buses		\$5,032		\$5,135
School Buses		\$1,482	\$2,129	
Refuse Trucks		\$2,705	\$3,885	
Short-Haul Combination Trucks		\$8,181	\$11,750	
Long-Haul Combination Trucks		\$19,991	\$28,712	
Difference from No-Action Case				
Short-Haul Single Unit Trucks	\$1,279	\$772	\$1,109	
Long-Haul Single Unit Trucks	\$2,002	\$1,814	\$2,675	
Motor Homes	\$273	\$270	\$387	
Other Buses		\$1,892	\$3,232	
Transit Buses		\$1,870		\$2,270
School Buses		\$517	\$742	
Refuse Trucks		\$1,312	\$1,884	
Short-Haul Combination Trucks		\$2,554	\$6,396	
Long-Haul Combination Trucks		\$2,689	\$7,297	

^a Blank cells indicate that there were no HDEs in a specific regulatory class for that MOVES vehicle type, e.g., there are no Transit Buses in the Heavy HDE regulatory class.

Table 3-11. MY 2027 Lifetime (2027-2055) Emission Repair Costs Per Diesel Vehicle by Regulatory Class and MOVES Vehicle Type for the Action and No-Action Cases, 7% Discounting in 2024 Dollars. ^a

MOVES Vehicle Type	Light HDE	Medium HDE	Heavy HDE	Urban Bus
No-Action Case				
Short-Haul Single Unit Trucks	\$406	\$401	\$576	
Long-Haul Single Unit Trucks	\$1,005	\$598	\$811	
Motor Homes	\$318	\$314	\$451	
Other Buses		\$1,696	\$2,081	
Transit Buses		\$1,677		\$1,462
School Buses		\$493	\$707	
Refuse Trucks		\$749	\$1,075	
Short-Haul Combination Trucks		\$3,856	\$3,367	
Long-Haul Combination Trucks		\$12,069	\$14,317	
Action Case				
Short-Haul Single Unit Trucks	\$1,410	\$976	\$1,401	
Long-Haul Single Unit Trucks	\$2,676	\$2,005	\$2,880	
Motor Homes	\$521	\$514	\$738	
Other Buses		\$3,192	\$4,585	
Transit Buses		\$3,155		\$3,220
School Buses		\$876	\$1,258	
Refuse Trucks		\$1,743	\$2,503	
Short-Haul Combination Trucks		\$6,104	\$8,768	
Long-Haul Combination Trucks		\$14,560	\$20,913	
Difference from No-Action Case				
Short-Haul Single Unit Trucks	\$1,004	\$575	\$825	
Long-Haul Single Unit Trucks	\$1,671	\$1,407	\$2,069	
Motor Homes	\$202	\$200	\$287	
Other Buses		\$1,496	\$2,504	
Transit Buses		\$1,479		\$1,758
School Buses		\$383	\$551	
Refuse Trucks		\$994	\$1,427	
Short-Haul Combination Trucks		\$2,248	\$5,401	
Long-Haul Combination Trucks		\$2,492	\$6,596	

^a Blank cells indicate that there were no HDEs in a specific regulatory class for that MOVES vehicle type, e.g., there are no Transit Buses in the Heavy HDE regulatory class.

Table 3-12. MY 2027 Lifetime (2027-2055) Emission Repair Costs Per CNG Vehicle by Regulatory Class and MOVES Vehicle Type for the Action and No-Action Cases, 3% and 7% Discounting in 2024 dollars. ^a

MOVES Vehicle Type	3% Discount Rate		7% Discount Rate	
	Heavy HDE	Urban Bus	Heavy HDE	Urban Bus
No-Action Case				
Other Buses	\$4,428		\$2,259	
School Buses	\$1,505		\$768	
Refuse Trucks	\$2,171		\$1,167	
Short-Haul Single Unit Trucks	\$1,134		\$625	
Long-Haul Single Unit Trucks	\$1,597		\$880	
Short-Haul Combination Trucks	\$5,810		\$3,654	
Long-Haul Combination Trucks	\$23,239		\$15,536	
Transit Buses		\$3,282		\$1,674
Action Case				
Other Buses	\$7,935		\$4,976	
School Buses	\$2,310		\$1,365	
Refuse Trucks	\$4,216		\$2,716	
Short-Haul Single Unit Trucks	\$2,338		\$1,521	
Long-Haul Single Unit Trucks	\$4,501		\$3,125	
Short-Haul Combination Trucks	\$12,750		\$9,514	
Long-Haul Combination Trucks	\$31,157		\$22,694	
Transit Buses		\$5,882		\$3,688
Difference from No-Action Case				
Other Buses	\$3,507		\$2,717	
School Buses	\$805		\$598	
Refuse Trucks	\$2,045		\$1,549	
Short-Haul Single Unit Trucks	\$1,204		\$896	
Long-Haul Single Unit Trucks	\$2,903		\$2,245	
Short-Haul Combination Trucks	\$6,941		\$5,861	
Long-Haul Combination Trucks	\$7,918		\$7,157	
Transit Buses		\$2,600		\$2,014

^a Blank cells indicate that there were no HDEs in a specific regulatory class for that MOVES vehicle type, e.g., there are no Transit Buses in the Heavy HDE regulatory class.

Table 3-13. MY 2027 Lifetime (2027-2055) Emission Repair Costs Per Gasoline Vehicle by Regulatory Class and MOVES Vehicle Type for the Action and No-Action Cases, 3% and 7% Discounting in 2024 Dollars.

MOVES Vehicle Type	3% Discount Rate		7% Discount Rate	
	Light HDE	Medium HDE	Light HDE	Medium HDE
No-Action Case				
Other Buses	\$2,632	\$2,632	\$1,558	\$1,558
Transit Buses	\$2,601	\$2,601	\$1,540	\$1,540
School Buses	\$581	\$581	\$296	\$296
Short-Haul Single Unit Trucks	\$526	\$526	\$302	\$302
Long-Haul Single Unit Trucks	\$1,285	\$1,285	\$832	\$832
Motor Homes	\$378	\$378	\$189	\$189
Action Case				
Other Buses	\$3,467	\$3,467	\$2,285	\$2,285
Transit Buses	\$3,427	\$3,427	\$2,258	\$2,258
School Buses	\$929	\$929	\$558	\$558
Short-Haul Single Unit Trucks	\$1,197	\$1,197	\$837	\$837
Long-Haul Single Unit Trucks	\$2,168	\$2,168	\$1,589	\$1,589
Motor Homes	\$540	\$540	\$309	\$309
Difference from No-Action Case				
Other Buses	\$835	\$835	\$727	\$727
Transit Buses	\$825	\$825	\$719	\$719
School Buses	\$348	\$348	\$262	\$262
Short-Haul Single Unit Trucks	\$671	\$671	\$536	\$536
Long-Haul Single Unit Trucks	\$883	\$883	\$757	\$757
Motor Homes	\$162	\$162	\$120	\$120

3.3 Program Costs

Using the cost elements outlined above, the EPA estimated the costs associated with the proposed rule as presented in the following tables. Costs are broken into two main categories: Technology Costs and Operating Costs. Technology costs are broken further into direct costs and the indirect costs elements (emission-related warranty costs, R&D costs, other indirect costs, and profits) to arrive at total technology costs incurred by manufacturers (*i.e.*, regulated entities). Operating costs are broken into DEF costs (diesel only), fuel costs, and emissions repair costs to arrive at total operating costs incurred by owners or operators of new MY 2027 and later heavy-duty vehicles. Section 3.3.1 presents the total technology costs for the proposed program and the updated costs for proposed request-for-comment case, both relative to the no-action case. Section 0 presents the operating costs, similarly grouped. Section 3.3.3 presents the total program costs relative to the no-action case for the proposed action case and request-for-comment case. Costs are presented in 2024 dollars in undiscounted annual values along with present and annualized values (PV and AV, respectively) at both 3 and 7 percent discount rates with discounted values discounted to the 2027 CY. The updated costs reflect the expected reduced emission-related warranty costs incurred by manufacturers, the increased emissions repair costs for vehicle operators, and a small reduction in costs from a reduction in DEF usage. The EPA expects in a

competitive market engine manufacturers will pass on some, if not all, of these cost savings to the purchaser of the vehicle, so that on net, the trucking industry, including vehicle owners, should realize the total projected cost savings of this action.

3.3.1 Total Technology Costs

Tables 2-14 and 2-15 show the impacts relative to the no-action case for direct manufacturing, emission-related warranty, R&D, profits, other indirect costs and total technology costs incurred by manufacturers. Values shown for a given CY are undiscounted values while discounted PV and AV are presented at both 3 and 7 percent discount rates with values discounted to 2027. All values are shown in 2024 dollars. Table 3-14 shows the total technology cost impacts for the proposed action case relative to the no-action case and Table 3-15 shows the total technology cost impacts for the request-for-comment case relative to the no-action case.

Table 3-14. Technology Cost Impacts of the Proposed Action Case Relative to the No-Action Case, Millions of 2024 Dollars.^a

Calendar Year	Direct Manufacturing Costs	Emission-Related Warranty Costs	R&D Costs	Other Indirect Costs	Profits	Total Technology Costs
2027	\$0	-\$2,400	\$0	\$0	\$0	-\$2,400
2028	\$0	-\$2,300	\$0	\$0	\$0	-\$2,300
2029	\$0	-\$2,200	\$0	\$0	\$0	-\$2,200
2030	\$0	-\$2,100	\$0	\$0	\$0	-\$2,100
2031	\$0	-\$2,000	\$0	\$0	\$0	-\$2,000
2032	\$0	-\$1,900	\$0	\$0	\$0	-\$1,900
2033	\$0	-\$1,900	\$0	\$0	\$0	-\$1,900
2034	\$0	-\$1,900	\$0	\$0	\$0	-\$1,900
2035	\$0	-\$1,900	\$0	\$0	\$0	-\$1,900
2036	\$0	-\$1,900	\$0	\$0	\$0	-\$1,900
2037	\$0	-\$1,900	\$0	\$0	\$0	-\$1,900
2038	\$0	-\$1,900	\$0	\$0	\$0	-\$1,900
2039	\$0	-\$1,900	\$0	\$0	\$0	-\$1,900
2040	\$0	-\$1,900	\$0	\$0	\$0	-\$1,900
2041	\$0	-\$1,900	\$0	\$0	\$0	-\$1,900
2042	\$0	-\$1,900	\$0	\$0	\$0	-\$1,900
2043	\$0	-\$1,800	\$0	\$0	\$0	-\$1,800
2044	\$0	-\$1,800	\$0	\$0	\$0	-\$1,800
2045	\$0	-\$1,800	\$0	\$0	\$0	-\$1,800
2046	\$0	-\$1,800	\$0	\$0	\$0	-\$1,800
2047	\$0	-\$1,800	\$0	\$0	\$0	-\$1,800
2048	\$0	-\$1,800	\$0	\$0	\$0	-\$1,800
2049	\$0	-\$1,800	\$0	\$0	\$0	-\$1,800
2050	\$0	-\$1,800	\$0	\$0	\$0	-\$1,800
2051	\$0	-\$1,800	\$0	\$0	\$0	-\$1,800
2052	\$0	-\$1,800	\$0	\$0	\$0	-\$1,800
2053	\$0	-\$1,800	\$0	\$0	\$0	-\$1,800
2054	\$0	-\$1,800	\$0	\$0	\$0	-\$1,800
2055	\$0	-\$1,800	\$0	\$0	\$0	-\$1,800
PV, 3%	\$0	-\$37,000	\$0	\$0	\$0	-\$37,000
PV, 7%	\$0	-\$24,000	\$0	\$0	\$0	-\$24,000
AV, 3%	\$0	-\$1,900	\$0	\$0	\$0	-\$1,900
AV, 7%	\$0	-\$2,000	\$0	\$0	\$0	-\$2,000

^a Values show two significant figures; negative values denote lower costs, *i.e.*, savings in expenditures.

Table 3-15. Technology Cost Impacts of the Request-for-Comment Case Relative to the No-Action Case, Millions of 2024 Dollars. ^a

Calendar Year	Direct Manufacturing Costs	Emission-Related Warranty Costs	R&D Costs	Other Indirect Costs	Profits	Total Technology Costs
2027	\$0	-\$2,400	\$0	\$0	\$0	-\$2,400
2028	\$0	-\$2,300	\$0	\$0	\$0	-\$2,300
2029	\$0	-\$2,200	\$0	\$0	\$0	-\$2,200
2030	\$0	-\$2,100	\$0	\$0	\$0	-\$2,100
2031	\$0	-\$2,000	\$0	\$0	\$0	-\$2,000
2032	\$0	-\$1,900	\$0	\$0	\$0	-\$1,900
2033	\$0	-\$1,900	\$0	\$0	\$0	-\$1,900
2034	\$0	-\$1,900	\$0	\$0	\$0	-\$1,900
2035	\$0	-\$1,900	\$0	\$0	\$0	-\$1,900
2036	\$0	-\$1,900	\$0	\$0	\$0	-\$1,900
2037	\$0	-\$1,900	\$0	\$0	\$0	-\$1,900
2038	\$0	-\$1,900	\$0	\$0	\$0	-\$1,900
2039	\$0	-\$1,900	\$0	\$0	\$0	-\$1,900
2040	\$0	-\$1,900	\$0	\$0	\$0	-\$1,900
2041	\$0	-\$1,900	\$0	\$0	\$0	-\$1,900
2042	\$0	-\$1,900	\$0	\$0	\$0	-\$1,900
2043	\$0	-\$1,800	\$0	\$0	\$0	-\$1,800
2044	\$0	-\$1,800	\$0	\$0	\$0	-\$1,800
2045	\$0	-\$1,800	\$0	\$0	\$0	-\$1,800
2046	\$0	-\$1,800	\$0	\$0	\$0	-\$1,800
2047	\$0	-\$1,800	\$0	\$0	\$0	-\$1,800
2048	\$0	-\$1,800	\$0	\$0	\$0	-\$1,800
2049	\$0	-\$1,800	\$0	\$0	\$0	-\$1,800
2050	\$0	-\$1,800	\$0	\$0	\$0	-\$1,800
2051	\$0	-\$1,800	\$0	\$0	\$0	-\$1,800
2052	\$0	-\$1,800	\$0	\$0	\$0	-\$1,800
2053	\$0	-\$1,800	\$0	\$0	\$0	-\$1,800
2054	\$0	-\$1,800	\$0	\$0	\$0	-\$1,800
2055	\$0	-\$1,800	\$0	\$0	\$0	-\$1,800
PV, 3%	\$0	-\$37,000	\$0	\$0	\$0	-\$37,000
PV, 7%	\$0	-\$24,000	\$0	\$0	\$0	-\$24,000
AV, 3%	\$0	-\$1,900	\$0	\$0	\$0	-\$1,900
AV, 7%	\$0	-\$2,000	\$0	\$0	\$0	-\$2,000

^a Values show two significant figures; negative values denote lower costs, *i.e.*, savings in expenditures.

3.3.2 Total Operating Costs

Table 3-16 shows the impacts of the proposed action case relative to the no-action case for emission repair costs, DEF costs, pre-tax fuel costs, and total operating costs incurred by owners or operators of new MYs 2027 and later heavy-duty vehicles. Values shown for a given CY are undiscounted values while discounted values are presented at both 3 and 7 percent discount rates.

All values are shown in 2024 dollars. Similar values for the request-for-comment case relative to the no-action case are shown in Table 3-17.

Note that values for DEF costs are shown as negative costs, or savings, due to reduced DEF consumption in the action case. With respect to the emission repair costs, there is an increased cost in the proposed action and request-for-comment cases relative to the no-action case. This is due to the reduced emission-related warranty for the action case and request-for-comment case relative to the no-action case. The proposed action case shows no impact on pre-tax fuel costs compared to the no-action case as the amount of fuel consumed for each scenario is the same as shown in Table 3-16 and similarly for the request-for-comment case as shown in Table 3-17.

Table 3-16. Operating Cost Impacts of the Proposed Action Case Relative to the No-Action Case, Millions of 2024 Dollars. ^a

Calendar Year	Emission Repair Costs	DEF Costs	Pre-tax Fuel Costs	Total Operating Costs
2027	\$63	-\$20	\$0	\$42
2028	\$430	-\$37	\$0	\$400
2029	\$870	-\$52	\$0	\$820
2030	\$1,200	-\$61	\$0	\$1,100
2031	\$1,300	-\$100	\$0	\$1,200
2032	\$1,500	-\$140	\$0	\$1,300
2033	\$1,600	-\$140	\$0	\$1,400
2034	\$1,600	-\$120	\$0	\$1,400
2035	\$1,600	-\$98	\$0	\$1,500
2036	\$1,600	-\$97	\$0	\$1,500
2037	\$1,600	-\$96	\$0	\$1,500
2038	\$1,600	-\$97	\$0	\$1,500
2039	\$1,600	-\$97	\$0	\$1,500
2040	\$1,600	-\$98	\$0	\$1,500
2041	\$1,600	-\$99	\$0	\$1,500
2042	\$1,600	-\$100	\$0	\$1,500
2043	\$1,600	-\$100	\$0	\$1,500
2044	\$1,600	-\$100	\$0	\$1,500
2045	\$1,600	-\$100	\$0	\$1,500
2046	\$1,600	-\$100	\$0	\$1,500
2047	\$1,600	-\$100	\$0	\$1,500
2048	\$1,600	-\$100	\$0	\$1,500
2049	\$1,600	-\$100	\$0	\$1,500
2050	\$1,600	-\$100	\$0	\$1,500
2051	\$1,600	-\$110	\$0	\$1,500
2052	\$1,600	-\$110	\$0	\$1,500
2053	\$1,600	-\$110	\$0	\$1,500
2054	\$1,600	-\$110	\$0	\$1,500
2055	\$1,600	-\$110	\$0	\$1,500
PV, 3%	\$27,000	-\$1,800	\$0	\$25,000
PV, 7%	\$16,000	-\$1,100	\$0	\$15,000
AV, 3%	\$1,400	-\$94	\$0	\$1,300
AV, 7%	\$1,300	-\$89	\$0	\$1,200

^a Values show two significant figures; negative values denote lower costs, *i.e.*, savings in expenditures.

Table 3-17. Operating Cost Impacts of the Request-for-Comment Case Relative to the No-Action Case, Millions of 2024 Dollars. ^a

Calendar Year	Emission Repair Costs	DEF Costs	Pre-tax Fuel Costs	Total Operating Costs
2027	\$63	-\$20	\$0	\$42
2028	\$430	-\$37	\$0	\$400
2029	\$870	-\$52	\$0	\$820
2030	\$1,200	-\$67	\$0	\$1,100
2031	\$1,300	-\$120	\$0	\$1,200
2032	\$1,500	-\$160	\$0	\$1,300
2033	\$1,600	-\$160	\$0	\$1,400
2034	\$1,600	-\$160	\$0	\$1,400
2035	\$1,600	-\$160	\$0	\$1,400
2036	\$1,600	-\$160	\$0	\$1,400
2037	\$1,600	-\$160	\$0	\$1,400
2038	\$1,600	-\$160	\$0	\$1,400
2039	\$1,600	-\$160	\$0	\$1,400
2040	\$1,600	-\$160	\$0	\$1,400
2041	\$1,600	-\$160	\$0	\$1,400
2042	\$1,600	-\$170	\$0	\$1,400
2043	\$1,600	-\$170	\$0	\$1,400
2044	\$1,600	-\$170	\$0	\$1,400
2045	\$1,600	-\$170	\$0	\$1,400
2046	\$1,600	-\$170	\$0	\$1,400
2047	\$1,600	-\$170	\$0	\$1,400
2048	\$1,600	-\$170	\$0	\$1,400
2049	\$1,600	-\$170	\$0	\$1,400
2050	\$1,600	-\$170	\$0	\$1,400
2051	\$1,600	-\$180	\$0	\$1,400
2052	\$1,600	-\$180	\$0	\$1,400
2053	\$1,600	-\$180	\$0	\$1,400
2054	\$1,600	-\$180	\$0	\$1,400
2055	\$1,600	-\$190	\$0	\$1,400
PV, 3%	\$27,000	-\$2,700	\$0	\$24,000
PV, 7%	\$16,000	-\$1,600	\$0	\$14,000
AV, 3%	\$1,400	-\$140	\$0	\$1,200
AV, 7%	\$1,300	-\$130	\$0	\$1,200

^a Values show two significant figures; negative values denote lower costs, *i.e.*, savings in expenditures.

3.3.3 Total Program Costs

Table 3-18 presents the year-over-year undiscounted emission-related warranty savings, total operating costs, and the sum of the two for the proposed action case relative to the no-action case. Table 3-19 shows the PV and AV at both 3 and 7 percent discount rates for the same savings and costs as in Table 3-18. Table 3-20 presents the year-over-year undiscounted emission-related warranty savings, operating costs, and the sum of the two for the request-for-comment case relative to the no-action case. Table 3-21 shows the PV and AV at both 3 and 7

percent discount rates for the same savings and costs as in Table 2-20. All values are shown in 2024 dollars.

Table 3-18. Year-Over-Year Total Technology and Operating Cost Savings Impacts of the Proposed Action Case Relative to the No-Action Case, Millions of 2024 Dollars. ^a

Calendar Year	Emission-Related Warranty Savings	Operating Costs	Net Cost Savings
2027	\$2,400	-\$42	\$2,400
2028	\$2,300	-\$400	\$1,900
2029	\$2,200	-\$820	\$1,300
2030	\$2,100	-\$1,100	\$940
2031	\$2,000	-\$1,200	\$770
2032	\$1,900	-\$1,300	\$600
2033	\$1,900	-\$1,400	\$480
2034	\$1,900	-\$1,400	\$430
2035	\$1,900	-\$1,500	\$370
2036	\$1,900	-\$1,500	\$350
2037	\$1,900	-\$1,500	\$370
2038	\$1,900	-\$1,500	\$380
2039	\$1,900	-\$1,500	\$380
2040	\$1,900	-\$1,500	\$370
2041	\$1,900	-\$1,500	\$360
2042	\$1,900	-\$1,500	\$350
2043	\$1,800	-\$1,500	\$340
2044	\$1,800	-\$1,500	\$330
2045	\$1,800	-\$1,500	\$320
2046	\$1,800	-\$1,500	\$300
2047	\$1,800	-\$1,500	\$290
2048	\$1,800	-\$1,500	\$280
2049	\$1,800	-\$1,500	\$300
2050	\$1,800	-\$1,500	\$310
2051	\$1,800	-\$1,500	\$320
2052	\$1,800	-\$1,500	\$330
2053	\$1,800	-\$1,500	\$340
2054	\$1,800	-\$1,500	\$350
2055	\$1,800	-\$1,500	\$360

^a Values show two significant figures; positive values indicate cost savings in expenditures.

Table 3-19. Present Value and Annualized Value Total Technology and Operating Cost Savings of the Proposed Action Case Relative to the No-Action Case, Millions of 2024 Dollars. ^a

Value Basis and Discount Rate	Emission-Related Warranty Savings	Operating Costs	Net Cost Savings
PV, 3%	\$37,000	-\$25,000	\$12,000
PV, 7%	\$24,000	-\$15,000	\$9,400
AV, 3%	\$1,900	-\$1,300	\$640
AV, 7%	\$2,000	-\$1,200	\$770

^a Values show two significant figures; positive values indicate cost savings in expenditures.

Table 3-20. Year-Over-Year Total Technology and Operating Cost Impacts of the Request-for-Comment Case Relative to the No Action-Case, Millions of 2024 Dollars. ^a

Calendar Year	Emission-Related Warranty Savings	Operating Costs	Net Cost Savings
2027	\$2,400	-\$42	\$2,400
2028	\$2,300	-\$400	\$1,900
2029	\$2,200	-\$820	\$1,300
2030	\$2,100	-\$1,100	\$940
2031	\$2,000	-\$1,200	\$780
2032	\$1,900	-\$1,300	\$620
2033	\$1,900	-\$1,400	\$500
2034	\$1,900	-\$1,400	\$470
2035	\$1,900	-\$1,400	\$430
2036	\$1,900	-\$1,400	\$410
2037	\$1,900	-\$1,400	\$430
2038	\$1,900	-\$1,400	\$450
2039	\$1,900	-\$1,400	\$450
2040	\$1,900	-\$1,400	\$440
2041	\$1,900	-\$1,400	\$420
2042	\$1,900	-\$1,400	\$420
2043	\$1,800	-\$1,400	\$410
2044	\$1,800	-\$1,400	\$400
2045	\$1,800	-\$1,400	\$380
2046	\$1,800	-\$1,400	\$370
2047	\$1,800	-\$1,400	\$350
2048	\$1,800	-\$1,400	\$350
2049	\$1,800	-\$1,400	\$370
2050	\$1,800	-\$1,400	\$380
2051	\$1,800	-\$1,400	\$390
2052	\$1,800	-\$1,400	\$410
2053	\$1,800	-\$1,400	\$410
2054	\$1,800	-\$1,400	\$420
2055	\$1,800	-\$1,400	\$430

^a Values show two significant figures; positive values indicate cost savings in expenditures.

Table 3-21. Present Value and Annualized Value Total Technology and Operating Cost Savings of the Request-for-Comment Case Relative to the No-Action Case, Millions of 2024 Dollars. ^a

Value Basis and Discount Rate	Emission-Related Warranty Savings	Operating Costs	Net Cost Savings
PV, 3%	\$37,000	-\$24,000	\$13,000
PV, 7%	\$24,000	-\$14,000	\$9,900
AV, 3%	\$1,900	-\$1,200	\$690
AV, 7%	\$2,000	-\$1,200	\$810

^a Values show two significant figures; positive values indicate cost savings in expenditures.

Chapter 4 Air Quality Impacts

This Chapter presents information on air quality, including a discussion of current air quality in Chapter 4.1 and a discussion of air quality impacts from the proposed rule in Chapter 4.2.

4.1 Current Air Quality

In this section, the EPA presents information related to current levels of air pollutants, visibility, and deposition amounts.

4.1.1 PM_{2.5}

The EPA has set National Ambient Air Quality Standards (NAAQS) to protect against adverse health effects caused by PM exposure. There are two primary NAAQS for PM_{2.5}: an annual standard and a 24-hour standard, and there are two secondary NAAQS for PM_{2.5}: an annual standard and a 24-hour standard. The initial PM_{2.5} standards were set in 1997 and revisions to the standards have been finalized since.

There are areas of the country that are currently in nonattainment for the annual and 24-hour primary PM_{2.5} NAAQS. As of February 28, 2026, more than 19 million people lived in the two areas that are designated as nonattainment for the 1997 annual PM_{2.5} NAAQS. Also, as of February 28, 2026, more than 29 million people lived in the eight areas that are designated as nonattainment for the 2006 24-hour PM_{2.5} NAAQS, and more than 20 million people lived in the five areas designated as nonattainment for the 2012 annual PM_{2.5} NAAQS. In total, there are currently 10 PM_{2.5} nonattainment areas with a population of more than 30 million people.³⁶ Nonattainment areas for the PM_{2.5} NAAQS, as of February 28, 2026, are pictured in Figure 4-1.

³⁶ The population total is calculated by summing, without double counting, the 1997, 2006, and 2012 PM_{2.5} nonattainment populations contained in the Criteria Pollutant Nonattainment Summary report (<https://www.epa.gov/green-book/green-book-data-download>).

**Counties Designated Nonattainment
for PM-2.5 (1997, 2006, and/or 2012 Standards)**

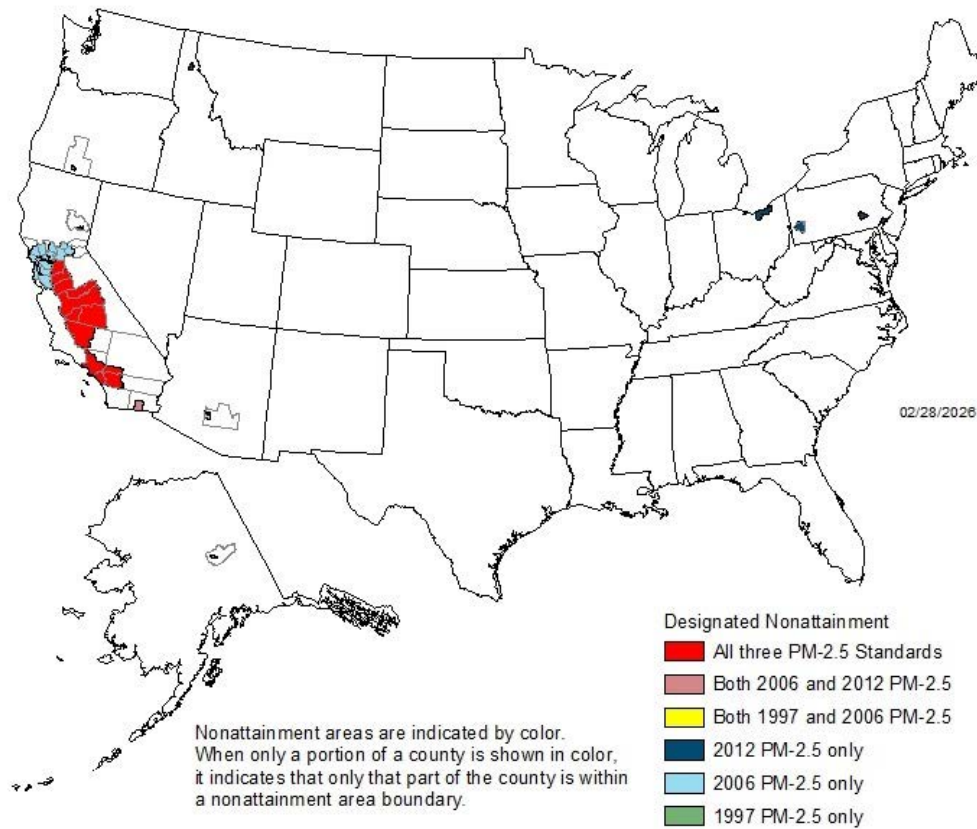


Figure 4-1. Counties Designated Nonattainment for PM_{2.5} (1997, 2006, and/or 2012 standards).

4.1.2 Ozone

The EPA has set NAAQS to protect against adverse health effects caused by ozone exposure. The primary NAAQS for ozone, established in 2015³⁷ and retained in 2020,³⁸ is an 8-hour standard with a level of 0.07 ppm.³⁹ The EPA is also implementing the previous 8-hour ozone primary standard, set in 2008 at a level of 0.075 ppm. As of February 28, 2026, there were 34 ozone nonattainment areas for the 2008 primary ozone NAAQS, with a total population of more than 90 million (*see* Figure 4-2); there were 45 ozone nonattainment areas for the 2015 primary

³⁷ 80 FR 65292 (Oct. 26, 2015).

³⁸ 85 FR 87256 (Dec. 31, 2020).

³⁹ *See* <https://www.epa.gov/ground-level-ozone-pollution/ozone-national-ambient-air-quality-standards-naaqs>.

ozone NAAQS, with a total population of more than 115 million (*see* Figure 4-3). In total, as of February 28, 2026, there are more than 119 million people living in ozone nonattainment areas.⁴⁰

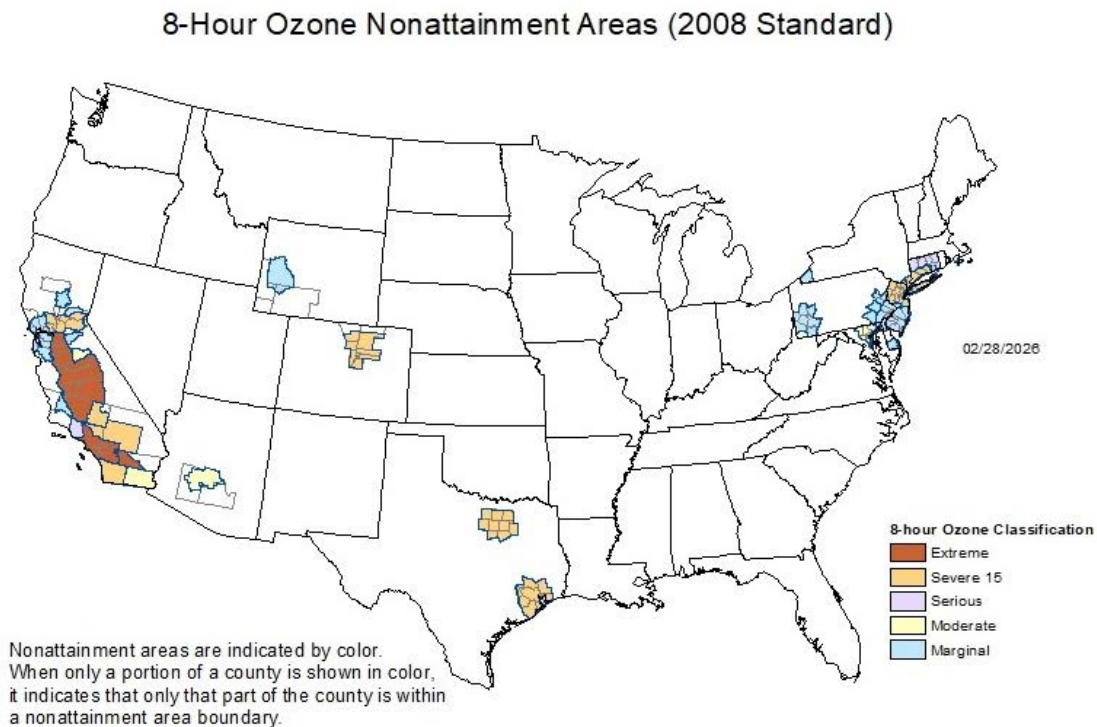
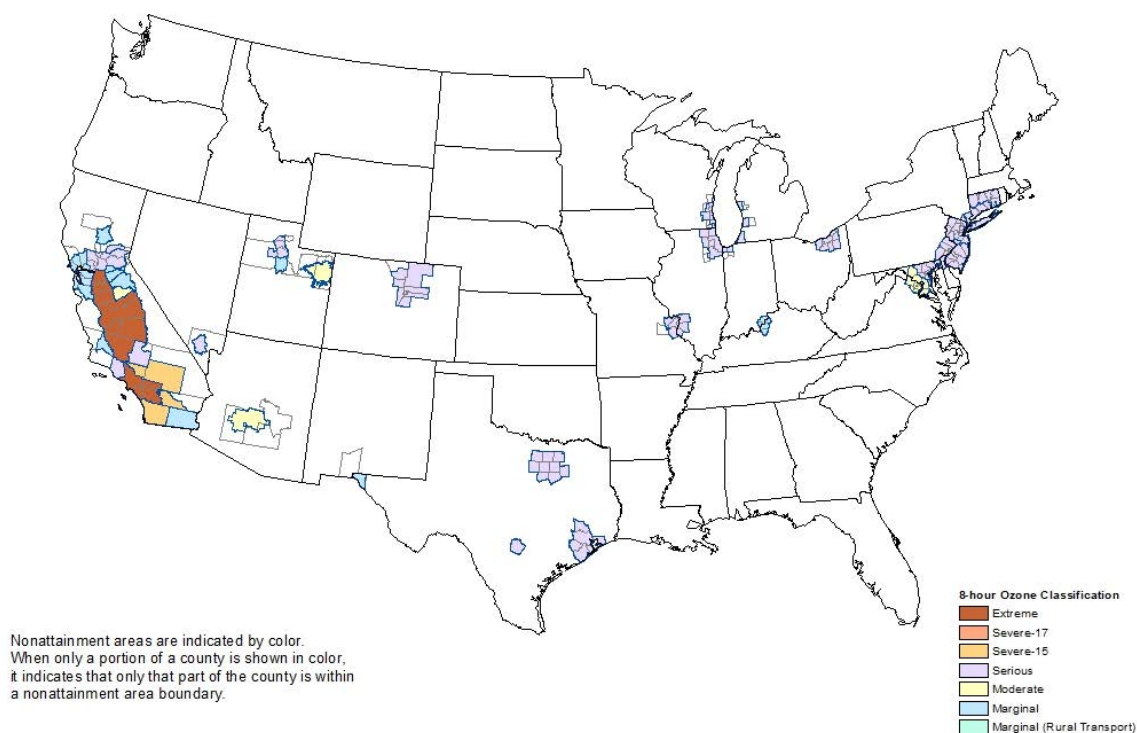


Figure 4-2. 8-Hour Ozone Nonattainment Areas (2008 Standard).

⁴⁰ The total population is calculated by summing, without double counting, the 2008 and 2015 ozone nonattainment populations contained in the Criteria Pollutant Nonattainment Summary report (<https://www.epa.gov/green-book/green-book-data-download>).



For the Ozone-8Hr (2015) Louisville, KY-IN nonattainment area, the Ohio portion was redesignated on July 5, 2022. The Kentucky portion has not been redesignated. The Kentucky portion of the Louisville area was reclassified from Marginal to Moderate on November 7, 2022. The entire area is not considered in maintenance until all states in a multi-state area are redesignated.

Figure 4-3. 8-Hour Ozone Nonattainment Areas (2015 Standard).

4.1.3 NO₂

The EPA has set NAAQS to protect against adverse health effects caused by NO₂ exposure.⁴¹ In 2010, the EPA established requirements for monitoring NO₂ near roadways expected to have the highest concentrations of NO₂ within large cities. Monitoring within this near-roadway network began in 2014, with additional sites deployed in the following years. At present, there are no nonattainment areas for NO₂.

4.1.4 CO

The EPA has set NAAQS to protect against adverse health effects caused by CO exposure.⁴² There are currently no CO nonattainment areas; as of September 27, 2010, all CO nonattainment areas had been redesignated to attainment.

⁴¹ See <https://www.epa.gov/no2-pollution/primary-national-ambient-air-quality-standards-naaqs-nitrogen-dioxide>.

⁴² See <https://www.epa.gov/naaqs/carbon-monoxide-co-air-quality-standards>.

4.1.5 Air Toxics

Gasoline and diesel vehicle emissions contribute to ambient levels of air toxics that are known or suspected human or animal carcinogens, or that have noncancer health effects, such as immunological and respiratory outcomes. These compounds include, but are not limited to, benzene, 1,3-butadiene, formaldehyde, acetaldehyde, acrolein, polycyclic aromatic hydrocarbon (PAH)/polycyclic organic matter (POM), and naphthalene. Of these, formaldehyde is the largest contributor to cancer risk in the U.S., according to the 2020 Air Toxics Screening Assessment (AirToxScreen).⁴³ These compounds have been identified as national or regional risk drivers or contributors and pose potential health concerns for millions of Americans.⁴⁴

The levels of air toxics to which people are exposed vary depending on where people live and work and the kinds of activities in which they engage, as discussed in detail in the EPA's 2007 Mobile Source Air Toxics Rule.⁴⁵ According to the EPA's 2020 National Emissions Inventory (NEI), mobile sources were responsible for 29 percent of outdoor anthropogenic air toxics emissions. In addition to direct emissions of air toxics, mobile sources also emit precursors that contribute significantly to secondary formation of air toxics. For example, mobile sources were responsible for 16 percent of primary anthropogenic emissions of formaldehyde in 2020 based on the NEI, and they also contribute to formaldehyde precursor emissions.⁴⁶ Benzene is also a large contributor to cancer risk, and mobile sources account for 62 percent of average exposure concentrations.

4.1.6 Deposition

Over the past two decades, the EPA has undertaken numerous efforts to reduce nitrogen and sulfur deposition across the U.S. Analyses of monitoring data for the U.S. show that deposition of nitrogen and sulfur compounds has decreased over the last 25 years. At 34 long-term monitoring sites in the eastern U.S., where data are most abundant, average total nitrogen deposition decreased by 43 percent between 1989-1991 and 2014-2016.⁴⁷ Although total nitrogen deposition has decreased over time, many areas continue to be negatively impacted by deposition.

4.1.7 Visibility

As of February 28, 2026, over 30 million people live in areas that are designated nonattainment for the PM_{2.5} NAAQS. Overall, the evidence is sufficient to conclude that a causal relationship

⁴³ U.S. Environmental Protection Agency. (2020). AirToxScreen Risk Drivers.

<https://www.epa.gov/system/files/documents/2024-08/2020-airtoxscreen-risk-drivers.pdf>.

⁴⁴ See <https://www.epa.gov/AirToxScreen/2020-airtoxscreen-assessment-results#about>.

⁴⁵ U.S. Environmental Protection Agency. (2007). Control of Hazardous Air Pollutants from Mobile Sources Regulatory Impact Analysis. <https://nepis.epa.gov/Exe/ZyPDF.cgi/P1004LNN.PDF?Dockey=P1004LNN.PDF>.

⁴⁶ Cook, R; Phillips, S; et al. (2020). Contribution of mobile sources to secondary formation of carbonyl compounds. *Journal of the Air and Waste Management Association*.

⁴⁷ U.S. Environmental Protection Agency. (2018). Report on the Environment: acid deposition technical documentation. <https://cfpub.epa.gov/roe/indicator.cfm?i=1>.

exists between PM and visibility impairment.⁴⁸ Thus, the populations who live in nonattainment areas and travel to these areas will likely experience visibility impairment. Additionally, while visibility trends have greatly improved in Mandatory Class I Federal areas, these areas continue to suffer from some visibility impairment.^{49,50, 51} In summary, visibility impairment is experienced throughout the U.S., in multi-state regions, urban areas, and remote Mandatory Class I Federal areas.

4.2 Impacts of this Proposed Rule on Air Quality

Chapter 2 of this DRIA presents projections of the emissions reductions that would no longer occur under the proposed amendments. When feasible and appropriate, the EPA conducts full-scale photochemical air quality modeling to accurately project levels of criteria and air toxic pollutants. For this proposal, however, the EPA did not conduct air quality modeling to determine how these emissions increases could change the ambient concentrations of air pollutants. Making predictions about air quality based solely on emissions changes is extremely difficult because the atmospheric chemistry related to ambient concentrations of PM_{2.5}, ozone, and air toxics is very complex, and the emissions changes are spatially variable.

However, full-scale air quality modeling was conducted for the 2023 Final Rule (further detailed in Chapter 6 of the 2023 Final Rule RIA). The results of that full-scale air quality modeling demonstrated overall air quality improvements, including significant reductions in ozone concentrations, due to the 2023 Final Rule standards. Ozone and annual PM_{2.5} design values were projected to decrease by a population-weighted average of 2.23 ppb and 0.04 µg/m³ in 2045, respectively. Concentrations of NO₂ and CO were also projected to decrease. The EPA expected that reductions in directly emitted PM_{2.5} or NO₂ as a result of the 2023 Final Rule would also contribute to reductions in ambient concentrations near roadways.

Considering the projected increase in total onroad emissions from the proposed rule, the modeled air quality improvements from the 2023 Final Rule standards would not be fully realized. The magnitudes of the onroad emissions increases from the proposed amendments are significantly smaller than the onroad emissions reductions that were modeled for the 2023 Final Rule, so the resulting changes in ambient concentrations of air pollutants are also expected to be relatively smaller than what was previously modeled (*see* Chapter 2.3.1 of this DRIA for more information on the emissions impacts of this proposal). The EPA expects that the increased vehicle emissions

⁴⁸ U.S. Environmental Protection Agency. (2019). Integrated Science Assessment (ISA) for Particulate Matter. EPA/600/R-19/188, 2019.

⁴⁹ *See* <https://www.epa.gov/visibility/regional-haze-program>.

⁵⁰ U.S. Environmental Protection Agency. (2018). Report on the Environment: regional haze. <https://cfpub.epa.gov/roe/indicator.cfm?i=21>.

⁵¹ Mandatory Class I Federal areas are the 156 national parks and wilderness areas where State and Federal agencies work to improve visibility. 42 U.S.C. § 7491.

would slightly reduce the estimated overall air quality improvements of the 2023 Final Rule on ambient levels of ozone, PM_{2.5}, NO₂, and other traffic-related pollutants.

Chapter 5 Health and Welfare Effects of Proposed Rule Related to Changes in Air Quality

As described in Chapter 3 of this DRIA, the proposal would result in changes in emissions of pollutants that contribute to ambient concentrations of PM_{2.5}, ozone, NO₂, CO, and air toxics. There are a broad range of health risks and welfare effects associated with exposure to these pollutants, including premature mortality, non-fatal illnesses, and other adverse effects, including ecosystem effects. This air pollution affects people nationwide and those who live or work near transportation corridors. Detailed information on the health and welfare effects associated with exposure to pollutants emitted by mobile sources and impacted by this proposed rule can be found in sections II.B–C of the 2023 Final Rule preamble and Chapter 4 of the 2023 Final Rule RIA.

The EPA sometimes performs air quality modeling to conduct a full assessment of the PM_{2.5}-related and ozone-related human health benefits of the Agency's regulatory actions. As mentioned in Chapter 3.2 of this DRIA, the EPA did not conduct air quality modeling for this proposal.

Historically, the EPA estimated the monetized benefits of avoided PM_{2.5}- and ozone-related impacts, which accounted for most, if not all, of the monetized benefits of many air regulations—even when the regulation was not regulating PM_{2.5} or ozone. The Office of Management and Budget (OMB), in its annual report of the Benefits and Costs of Federal Regulations, routinely provides estimates that the monetized benefits from reducing PM_{2.5} and/or ozone exceed hundreds of millions or even billions of dollars and result in most of the monetized benefits from Federal regulations.

In previous RIAs, the EPA's approach to estimating the impacts to human health of the changes in concentrations of ozone and PM_{2.5} relied substantially on information from the Integrated Science Assessments (ISAs) for ozone and particulate matter.^{52,53} These documents synthesize the toxicological, clinical, and epidemiological evidence to determine whether PM and ozone are causally related to an array of adverse human health outcomes associated with either acute (*i.e.*, hours or days-long) or chronic (*i.e.*, years-long) exposure; for each outcome, the ISA reports this relationship to be causal, likely to be causal, suggestive of a causal relationship, inadequate to infer a causal relationship, or not likely to be a causal relationship. The ISAs reflect the EPA's most up-to-date evaluation of the strength and limitations of the available scientific evidence and clearly identify the health and welfare endpoints for which the evidence is strongest. The EPA

⁵² U.S. Environmental Protection Agency. (2020). Integrated Science Assessment (ISA) for Ozone and Related Photochemical Oxidants. EPA/600/R-20/012. <https://assessments.epa.gov/risk/document/&deid=348522>.

⁵³ U.S. Environmental Protection Agency. (2019). Integrated Science Assessment (ISA) for Particulate Matter. EPA/600/R-19/188. <https://assessments.epa.gov/risk/document/&deid=347534>.

continues to focus on these endpoints in considering how regulatory actions may impact public health and welfare. Historically, the EPA has estimated the incidence of air pollution effects for those health endpoints that the ISA classified as either causal or likely-to-be-causal and these endpoints are shown in Table 5-1. The table below omits welfare effects such as acidification and nutrient enrichment.

Table 5-1. Health Effects of Ambient Ozone and PM_{2.5}.

Category	Effect	Causal / Likely-to-be-causal	More Information
Premature mortality from exposure to PM _{2.5}	Adult premature mortality based on cohort study estimates and expert elicitation estimates (age 65-99 or age 30-99)	✓	PM ISA
	Infant mortality (age <1)	✓	PM ISA
Nonfatal morbidity from exposure to PM _{2.5}	Heart attacks (age > 18)	✓	PM ISA
	Hospital admissions—cardiovascular (ages 65-99)	✓	PM ISA
	Emergency department visits— cardiovascular (age 0-99)	✓	PM ISA
	Hospital admissions—respiratory (ages 0-18 and 65-99)	✓	PM ISA
	Emergency room visits—respiratory (all ages)	✓	PM ISA
	Cardiac arrest (ages 0-99; excludes initial hospital and/or emergency department visits)	✓	PM ISA
	Stroke (ages 65-99)	✓	PM ISA
	Asthma onset (ages 0-17)	✓	PM ISA
	Asthma symptoms/exacerbation (6-17)	✓	PM ISA
	Lung cancer (ages 30-99)	✓	PM ISA
	Allergic rhinitis (hay fever) symptoms (ages 3-17)	✓	PM ISA
	Lost work days (age 18-65)	✓	PM ISA
	Minor restricted-activity days (age 18-65)	✓	PM ISA
	Hospital admissions—Alzheimer’s disease (ages 65-99)	✓	PM ISA
	Hospital admissions—Parkinson’s disease (ages 65-99)	✓	PM ISA
	Other cardiovascular effects	✓	PM ISA
	Other respiratory effects	✓	PM ISA
	Other nervous system effects	✓	PM ISA
	Cancer	✓	PM ISA
	Reproductive and developmental effects	—	PM ISA
Metabolic effects	—	PM ISA	
Mortality from exposure to ozone	Premature respiratory mortality based on short-term study estimates (0-99)	✓	Ozone ISA
	Premature respiratory mortality based on long-term study estimates (age 30–99)	✓	Ozone ISA
Nonfatal morbidity from exposure to ozone	Hospital admissions—respiratory (ages 0-99)	✓	Ozone ISA
	Emergency department visits—respiratory (ages 0-99)	✓	Ozone ISA
	Asthma onset (0-17)	✓	Ozone ISA
	Asthma symptoms/exacerbation (asthmatics age 2-17)	✓	Ozone ISA
	Allergic rhinitis (hay fever) symptoms (ages 3-17)	✓	Ozone ISA
	Minor restricted-activity days (age 18–65)	✓	Ozone ISA
	School absence days (age 5–17)	✓	Ozone ISA
	Metabolic effects (e.g., diabetes)	✓	Ozone ISA

For regulatory analyses, the EPA estimated changes in health effects in response to modeled air quality changes for most health endpoints identified as causal or likely-to-be-causal in Table 5-1. Some endpoints were not quantified due to data availability limitations, such as for other

cardiovascular/respiratory/nervous system effects. The environmental Benefits Mapping and Analysis Program—Community Edition (BenMAP-CE) software program was used to quantify counts of premature deaths and illnesses attributable to photochemical modeled changes in annual mean PM_{2.5} and summer season average ozone. This approach to estimating health impacts involved two major steps: (1) developing spatial fields of air quality across the U.S. for the baseline and regulatory scenarios using nationwide photochemical source apportionment modeling and related analyses; and (2) using these spatial fields in BenMAP-CE to quantify selected endpoints under each scenario and each year as compared to the baseline in that year while accounting for the changes in population size, income growth, and baseline incidence and prevalence rates.

Figure 5-1 summarizes the key data inputs and modeling steps for estimating the health impacts of a regulatory impact analysis using PM_{2.5} inputs as an example.

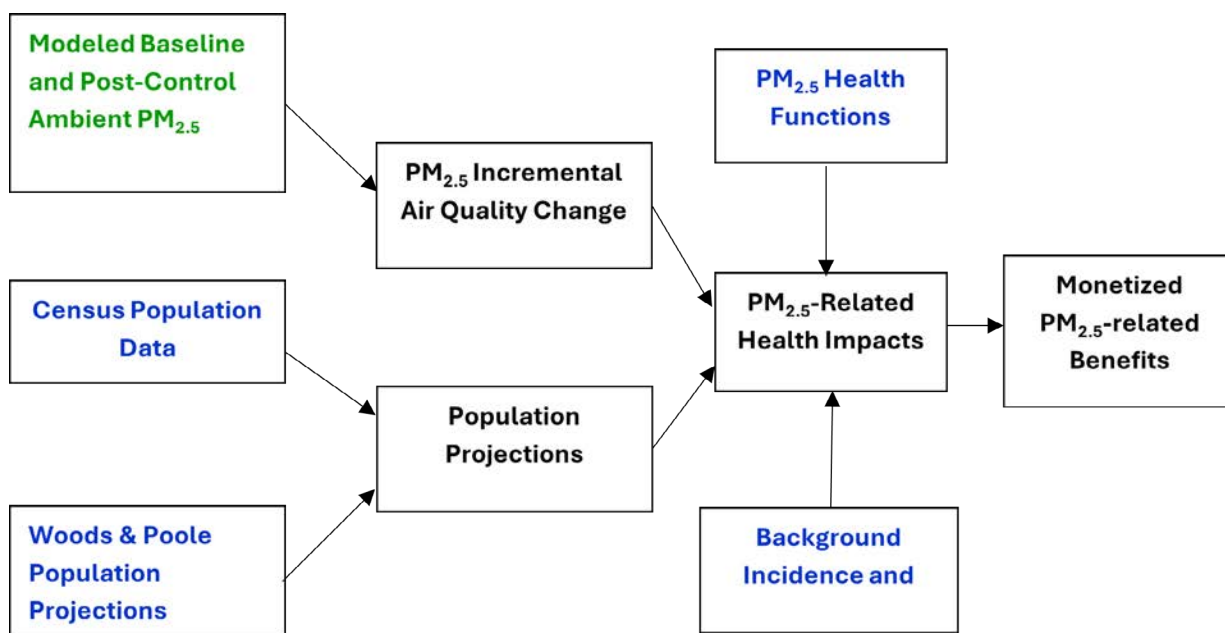


Figure 5-1. Data Inputs and Outputs for the BenMAP-CE Model Using PM_{2.5} as an Example.

As the diagram above illustrates, the approach for estimating PM_{2.5} and ozone benefits included health effect risk estimates from epidemiologic studies, population data, population growth estimates, economic data for monetizing risk reductions, and assumptions regarding the future state of the world (*e.g.*, on-the-books regulations). Each of these inputs has unique uncertainties associated with it. When the uncertainties from each stage of the analysis are compounded, even small uncertainties can have large effects on the total quantified benefits. Where possible, the EPA in the past has attempted to quantitatively assess uncertainty in each input parameter. In some cases, quantitative analysis has not been possible due to lack of data, so the EPA instead

characterized the sensitivity of the results to alternative plausible input parameters. And, for some inputs into the benefits analysis, such as the air quality data, the EPA lacked the data to perform either a quantitative uncertainty analysis or sensitivity analysis.

Throughout prior RIAs, the EPA acknowledged these significant uncertainties around input parameters and employed various techniques for characterizing the resulting uncertainty in estimates of regulatory impacts. For example, the EPA has estimated the fraction of avoided health effects occurring at various concentration ranges, conducted sensitivity analyses, and employed alternate concentration-response assumptions to show how much estimates could vary depending on which assumptions and inputs were used in primary estimates versus sensitivity estimates.

Chapter 6 of the EPA Health Benefits TSD, Estimating PM_{2.5}- and Ozone-Attributable Health Benefits: 2024 Update, details the Agency's approach to characterizing uncertainty associated with the estimation of PM_{2.5} and ozone benefits in both quantitative and qualitative terms.⁵⁴ Some of the key types of uncertainty highlighted in this chapter include:

- Statistical uncertainty around the risk estimate
- Uncertainty around low concentration exposures and the potential for thresholds
- Uncertainty in exposure estimates
- Co-pollutant confounding
- Confounding by other individual risk factors
- Effect modification
- Application of risk estimates to other locations and populations
- Uncertainties regarding at-risk populations
- Baseline incidence rate uncertainties
- Economic valuation estimate uncertainties (*e.g.*, income elasticity of willingness to pay, statistical estimates of VSL, Alzheimer's and Parkinson's onset lifetime costs)
- Unquantified uncertainties (*e.g.*, causality determination, estimating and assigning exposures in epidemiology studies, risk attributable to long-term and short-term exposures, shape of the concentration-response relationship)

Despite substantial investments by the EPA in approaches to characterizing uncertainties, the RIAs have still tended to focus on point estimates for PM_{2.5} and ozone-related benefits.

⁵⁴ U.S. Environmental Protection Agency. (2024). Estimating PM_{2.5}- and Ozone-Attributable Health Benefits: 2024 Update. <https://www.epa.gov/system/files/documents/2024-06/estimating-pm2.5-and-ozone-attributable-health-benefits-tsd-2024.pdf>.

Frequently, the EPA has utilized more than one epidemiologic study to estimate mortality impacts because these estimates drive overall benefits for a given regulatory action due to the large monetary value assigned to such impacts. Risk estimates using the top epidemiologic studies sometimes differ by a factor of two or more. Presenting multiple estimates drawn directly from the primary literature is one way to convey the prevailing uncertainty. While this leads to an estimated range of benefits, it is not a range that reflects the true uncertainties in the underlying parameters supporting each study, either for mortality or for other effects. Because of the significant impacts of environmental regulations on the U.S. economy, it is essential that the EPA has confidence in the estimated benefits of an action, and their underlying uncertainties, prior to utilizing these estimates in a regulatory context.

A 2024 Scientific Advisory Board (SAB) reviewed the EPA’s methods for estimating the health effects of PM_{2.5} and clearly and repeatedly recommended that the Agency improve the Agency’s approach to characterizing and presenting the uncertainty in estimating the health effects of PM_{2.5}.⁵⁵ A Tier 1 SAB recommendation was that the EPA present a single probabilistic mortality estimate based on pooled risk estimates with associated uncertainty ranges rather than present multiple estimates of mortality outcomes from the epidemiologic studies. The EPA was encouraged to explore meta-analysis methods or other forms of information synthesis, and support research and development of modified methods as needed.

The OMB “2017 Report to Congress on the Benefits and Costs of Federal Regulations”⁵⁶ listed six key assumptions underpinning PM_{2.5} health effect estimation which introduce substantial uncertainties in the health effect estimates:

- That inhalation of fine particles is causally associated with premature death at concentrations near those experienced by most Americans on a daily basis;
- That the concentration-response function for fine particles and premature mortality is approximately linear, even for concentrations below the levels established by the NAAQS;
- That all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality;
- That the forecasts for future emissions and associated air quality modeling accurately predict both the baseline (state of the world absent a rule) and the air quality impacts of the rule being analyzed;

⁵⁵ U.S. Environmental Protection Agency. (2024). Review of BenMAP and Benefits Methods. EPA/SAB/24/003. https://sab.epa.gov/ords/sab/r/sab_apex/sab/advisoryactivitydetail?p18_id=2617&clear=18&session=15054897040198#report.

⁵⁶ See the OMB “2017 Report to Congress on Benefits and Costs of Federal Regulations and Agency Compliance with the Unfunded Mandates Reform Act” for a fuller discussion on uncertainties. https://trumpwhitehouse.archives.gov/wp-content/uploads/2019/12/2019-CATS-5885-REV_DOC-2017Cost_BenefitReport11_18_2019.docx.pdf.

- That benefits-per-ton (BPT) approaches, when used to estimate benefits, are based on regional or national-level analysis that may not reflect local variability in population density, meteorology, exposure, baseline health incidence rates, or other local factors; and
- That the estimated value of mortality risk reductions is an accurate reflection of what people would be willing to pay for incremental reductions in mortality risk from air pollution exposure, and that these values are constant across the life-cycle.

To the extent that any of these assumptions are incorrect, the benefit estimates will change, though the magnitude and direction of change are not known with certainty. The EPA is interested in improving understanding in each of these six areas. The EPA understands that additional research is needed and will begin to develop approaches that reduce these uncertainties. The EPA will seek peer review for new methods developed from this work consistent with the OMB's Peer Review Guidance.⁵⁷

In particular, the EPA is interested in reevaluating the validity of the approach for estimating the benefits of air quality improvements relative to the NAAQS for PM_{2.5} and ozone. These standards, which have been set at a level which the Administrator judges to be requisite to protect public health or welfare with an adequate margin of safety, are widely understood to represent the divide between clean air and air with an unacceptable level of pollution. Even in instances in which an assumption is found to be justified based on scientific evidence, the EPA is interested in reevaluating the Agency's approach to characterizing and communicating underlying uncertainty to the public.

In the past, the EPA has explored a variety of approaches to shed light on how the estimated benefits of an action relate to the level of the NAAQS. For example, in estimating PM benefits, the EPA has employed techniques such as cutpoint analyses and Lowest Measured Level analyses, noting that the Agency is most confident in the magnitude of the risks projected at PM_{2.5} concentrations that coincide with the bulk of the observed PM_{2.5} concentrations in the epidemiological studies that are used to estimate the benefits.⁵⁸ However, such approaches address only a few of the sources of uncertainty that influence PM-related air quality benefits.

The limitations of reduced-form approaches, such as the BPT approach, are even more pronounced than photochemical modeling/BenMAP-CE approaches due to: (1) the compounding effects of emissions reductions typically occurring across many geographic areas simultaneously, with varying proximity to population centers; (2) differing atmospheric transformation pathways for NO_x, VOCs, and secondary PM_{2.5}; and (3) region-specific photochemical and meteorological

⁵⁷ Office of Management and Budget. (2005). Memorandum M-05-03, Memorandum for the Heads of Executive Departments and Agencies: Issuance of OMB's Final Information Quality Bulletin for Peer Review. <https://www.federalregister.gov/documents/2005/01/14/05-769/final-information-quality-bulletin-for-peer-review>.

⁵⁸ U.S. Environmental Protection Agency. (2019). Regulatory Impact Analysis for the Repeal of the Clean Power Plan, and the Emission Guidelines for Greenhouse Gas Emissions from Existing Electric Utility Generating Units. https://www.epa.gov/sites/default/files/2019-06/documents/utilities_ria_final_cpp_repeal_and_ace_2019-06.pdf.

conditions. Using a national BPT estimate implicitly assumes uniform marginal health benefits for each ton of reduced emissions, an assumption not supported given heterogeneity in exposure patterns and atmospheric chemistry. As more areas achieve or maintain attainment with the NAAQS, the uncertainties associated with low-concentration health effects grow, and marginal benefits become more difficult to characterize with precision.

Therefore, it may be appropriate for the EPA to separate exposures and impacts above the level of the standard from those occurring at lower ambient concentrations. The EPA will investigate this prior to estimating these impacts in a regulatory analysis even for informational purposes.

5.1 Human Health Effects

The human health effects of increased emissions of directly emitted PM_{2.5}, as well as NO_x (which is a precursor to ambient PM_{2.5}), and ground-level ozone resulting from NO_x and VOC emissions, were not quantified for this rule. A qualitative description of related human health effects is provided instead.

5.1.1 NO_x-Related Health Effects

The Integrated Science Assessment for Oxides of Nitrogen – Health Criteria (“NO_x ISA”) reviewed evidence from epidemiologic and laboratory studies on the health effects of exposure to NO_x, concluding that there is a causal relationship between respiratory health effects and short-term exposure to NO₂.⁵⁹ Epidemiologic and experimental studies encompassed several endpoints, including emergency department visits and hospitalizations, respiratory symptoms, airway hyperresponsiveness, airway inflammation, and lung function. The NO_x ISA also concluded that the relationship between short-term NO₂ exposure and premature mortality was “suggestive but not sufficient to infer a causal relationship,” because it is difficult to attribute the mortality risk effects to NO₂ alone. Although the NO_x ISA stated that studies consistently reported a relationship between NO₂ exposure and mortality, the effect was generally smaller than that for other pollutants such as PM. NO_x emissions are also a precursor to PM_{2.5} and ozone and affect human health through these additional pathways.

5.1.2 Ozone-Related Health Effects

Following a comprehensive review of toxicological, clinical, and epidemiological evidence, the Integrated Science Assessment for Ozone and Related Photochemical Oxidants (“Ozone ISA”)⁵² found both short-term (*i.e.*, less than one month) and long-term (*i.e.*, one month or longer) ozone exposure to be related to an array of adverse human health effects. For each effect, the Ozone ISA reports relationships to be causal, likely to be causal, suggestive of a causal relationship, inadequate to infer a causal relationship, or not likely to be a causal relationship. This assessment

⁵⁹ U.S. Environmental Protection Agency. (2016). Integrated Science Assessment for Oxides of Nitrogen - Health Criteria. EPA/600/R-15/068. <https://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=310879>.

is based on the body of scientific evidence, which can include observational human studies, experimental human exposure studies, animal model studies, and mechanistic studies.

The Ozone ISA found short-term exposure to ozone to be causally related to respiratory effects, including respiratory mortality, and likely to be causally related to metabolic effects. For short-term exposure, evidence was suggestive of a causal relationship for cardiovascular and nervous system effects as well as total mortality. The Ozone ISA reported that long-term exposure to ozone is likely-to-be-causally related to respiratory effects, including respiratory mortality. Evidence on metabolic, cardiovascular, reproductive, and nervous system effects as well as total mortality was suggestive of a causal relationship with long-term ozone exposure.

When adequate data and resources are available, the EPA has generally quantified health effects which the Ozone ISA classified as causally related or likely-to-be-causally related to short- or long-term ozone exposure. Health effects classified as suggestive-of-causality or weaker have not historically been quantified. Historically, quantified health effects include premature respiratory mortality, hospital admissions and emergency department visits, asthma onset and related symptoms (chest tightness, cough, shortness of breath, and wheeze), allergic rhinitis symptoms, and restricted activity days and school absences. The EPA did not quantify or monetize the disbenefits associated with changes in the incidence of the listed health effects of this rule.

5.1.3 PM_{2.5}-Related Health Effects

PM_{2.5} describes an array of pollutants from human and natural sources with diameters that are generally 2.5 micrometers and smaller. This includes directly emitted PM_{2.5} as well as PM_{2.5} formed through atmospheric chemical reactions of precursor pollutants, including NO_x.

Following a comprehensive review of toxicological, clinical, and epidemiological evidence, the Integrated Science Assessment for Particulate Matter (“PM ISA”)⁵³ and the Supplement to the Integrated Science Assessment for Particulate Matter (“PM ISA Supplement”)⁶⁰ found PM_{2.5} to be related to an array of adverse human health effects. For each effect, the PM ISA and PM ISA Supplement report relationships to be causal, likely to be causal, suggestive of a causal relationship, inadequate to infer a causal relationship, or not likely to be a causal relationship. This assessment is based on the body of scientific evidence, which can include observational human studies, experimental human exposure studies, animal model studies, and mechanistic studies.

The PM ISA and PM ISA Supplement found acute and chronic exposures to PM_{2.5} to be causally related to cardiovascular effects and total mortality (*i.e.*, premature death), and respiratory effects as likely-to-be-causally related. Chronic exposures to PM_{2.5} were also determined to be likely-to-

⁶⁰ U.S. Environmental Protection Agency. (2022). Supplement to the 2019 Integrated Science Assessment for Particulate Matter (Final Report). EPA/600/R-22/028. <https://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=354490>.

be-causally related to nervous system effects and cancer, with the latter determination based primarily on evidence from studies of lung cancer incidence as well as decades of research on the mutagenicity and carcinogenicity of PM. Evidence was suggestive of a causal relationship for reproductive and developmental effects, pregnancy and birth outcomes, and metabolic effects.

When adequate data and resources are available, the EPA has generally quantified health effects which the PM ISA and PM ISA Supplement classified as causally related or likely-to-be-causally related to PM_{2.5} exposure. Health effects classified as suggestive-of-causality or weaker have not historically been quantified. Historically, quantified health effects include premature mortality, heart attacks, cardiovascular hospital admissions, cardiovascular emergency department visits, respiratory hospital admissions, respiratory emergency room visits, cardiac arrest, stroke, asthma onset, asthma symptoms/exacerbation, lung cancer, allergic rhinitis (hay fever) symptoms, lost workdays, and minor restricted-activity days. The EPA did not quantify or monetize the disbenefits associated with changes in the incidence of the listed health effects for this rule.

5.2 Welfare Effects

Due to operational constraints and data limitations, most benefits analyses focus on human health effects expected to occur because of changes in primary and secondary pollutant concentrations resulting from the rulemaking. However, the benefits of reductions in emissions of air pollutants include additional effects that include, but are not limited to: effects on soils, water, crops, vegetation, manmade materials, animals, wildlife, weather, visibility, and climate, damage to and deterioration of property, and hazards to transportation, as well as effects on economic values and on personal comfort and well-being, whether caused by transformation, conversion, or combination with other pollutants.⁶¹ In this section, the EPA provides qualitative discussions of select welfare effects.

5.2.1 Ozone Welfare Effects

5.2.1.1 Vegetation and Ecosystem Effects

Exposure to ozone has been found to be associated with a wide array of vegetation and ecosystem effects in the published literature.⁵² Sensitivity to ozone is highly variable across species, with over 66 vegetation species identified as “ozone-sensitive,” many of which occur in State and national parks and forests. These effects include those that cause damage to, or impairment of, the intended use of the plant or ecosystem. Such effects are considered adverse to public welfare and can include reduced growth and/or biomass production in sensitive trees, reduced yield and quality of crops, visible foliar injury, changes to species composition, and changes in ecosystems and associated ecosystem services.⁵²

⁶¹ 42 U.S.C. § 7602(h).

5.2.1.2 Animal Welfare Effects

While effects can be context- and species-specific, a large body of scientific evidence links ozone exposure to health effects in animals. When exploring environmental pathways through which environmental effects of ozone may impact animals, the Ozone ISA found a likely-to-be-causal relationship between ambient ozone concentrations and alterations of herbivore growth and reproduction.⁵² In addition, many animal toxicological studies served as evidence for determining the causality of relationships between human exposure to ozone and human health effects, including respiratory and metabolic effects. The Ozone ISA states, “[a] large body of experimental animal toxicological studies demonstrates (short- and long-term) ozone-induced changes in measures of lung function, inflammation, increased airway responsiveness, and impaired lung host defense”.⁵² Additionally, animal studies report relationships between short-term ozone exposure and metabolic effects in various stocks and strains of animals across multiple laboratories.⁵²

5.2.2 PM_{2.5} Welfare Effects

5.2.2.1 Visibility Effects

Reducing secondary formation of PM_{2.5} would improve levels of visibility in the U.S. because suspended particles and gases degrade visibility by scattering and absorbing light.⁵³ Fine particles with significant light-extinction efficiencies include sulfates, nitrates, organic carbon, elemental carbon, and soil. Visibility has direct significance to people’s enjoyment of daily activities and their overall sense of wellbeing. Good visibility increases the quality of life where individuals live and work, and where they engage in recreational activities. Particulate sulfate is the dominant source of regional haze in the eastern U.S. and particulate nitrate is an important contributor to light extinction in California.⁵³ Previous analyses show that visibility benefits can be a significant welfare benefit category.⁶²

5.2.2.2 Animal Welfare Effects

While effects can be context- and species-specific, a large body of scientific evidence links PM_{2.5} exposure to health effects in animals. The PM ISA⁵³ and PM ISA Supplement⁶⁰ evaluated exposures to PM_{2.5} and an array of health markers described in animal toxicological studies. Animal toxicological studies have found evidence that PM_{2.5} induces changes in measurements including, but not limited to, breathing patterns, airway irritation, impaired heart function, changes in blood pressure, oxidative stress, reproductive outcomes, and other outcomes. However, neither the PM ISA nor the PM ISA Supplement provide a causality determination of the causality of PM_{2.5} affecting animal health.

⁶² U.S. Environmental Protection Agency. (2012). Regulatory Impact Analysis for the Final Revisions to the National Ambient Air Quality Standards for Particulate Matter. EPA-452/R-12-005. <https://www3.epa.gov/ttnecas1/regdata/RIAs/finalria.pdf>.

Chapter 6 Comparison of Benefits and Costs

This section summarizes the estimated costs, cost savings, and non-monetized impacts of the proposed rule. Operating costs and reduced warranty costs are presented in Chapter 2 of this DRIA. The sum of compliance costs and cost savings associated with the proposed rule yields net compliance cost savings. As noted in Chapter 4 of this DRIA, the EPA did not quantify or monetize the health disbenefits associated with emissions increases. The quantified and monetized net benefits associated with the proposed rule are therefore the net cost savings, which are presented in 2024 dollars.

6.1 Methods

The EPA presents costs and cost savings using three different methods:

CY costs and cost savings from 2027 to 2055. Costs and cost savings in these years are not discounted.

The PV of the stream of costs and cost savings, which represents costs and cost savings that are projected to occur from 2027 to 2055, discounted back to 2027 assuming end of year discounting. PVs are estimated using both a 3-percent and 7-percent discount rate.

The equivalent AV of costs and cost savings, representing a flow of constant annual values that, had they occurred in each year from 2027 to 2055, would yield an equivalent PV to the PV described above (using either a 3-percent or 7-percent discount rate). Each AV represents a typical cost/cost savings for each year of the analysis and is presented in 2024 dollars.

6.2 Results

Table 6-1 presents the costs, cost savings, and non-monetized impacts of the proposed rule. Monetized costs and cost savings are presented in undiscounted annual terms, in PV terms, and in AV terms.

Table 6-1. Costs and Benefits of the Proposed Action Case Relative to the No-Action Case, Millions of 2024 Dollars.^a

Calendar Year	Emission-Related Warranty Savings	Operating Costs	Net Cost Savings
2027	\$2,400	-\$42	\$2,400
2028	\$2,300	-\$400	\$1,900
2029	\$2,200	-\$820	\$1,300
2030	\$2,100	-\$1,100	\$940
2031	\$2,000	-\$1,200	\$770
2032	\$1,900	-\$1,300	\$600
2033	\$1,900	-\$1,400	\$480
2034	\$1,900	-\$1,400	\$430
2035	\$1,900	-\$1,500	\$370
2036	\$1,900	-\$1,500	\$350
2037	\$1,900	-\$1,500	\$370
2038	\$1,900	-\$1,500	\$380
2039	\$1,900	-\$1,500	\$380
2040	\$1,900	-\$1,500	\$370
2041	\$1,900	-\$1,500	\$360
2042	\$1,900	-\$1,500	\$350
2043	\$1,800	-\$1,500	\$340
2044	\$1,800	-\$1,500	\$330
2045	\$1,800	-\$1,500	\$320
2046	\$1,800	-\$1,500	\$300
2047	\$1,800	-\$1,500	\$290
2048	\$1,800	-\$1,500	\$280
2049	\$1,800	-\$1,500	\$300
2050	\$1,800	-\$1,500	\$310
2051	\$1,800	-\$1,500	\$320
2052	\$1,800	-\$1,500	\$330
2053	\$1,800	-\$1,500	\$340
2054	\$1,800	-\$1,500	\$350
2055	\$1,800	-\$1,500	\$360
PV, 3%	\$37,000	-\$25,000	\$12,000
PV, 7%	\$24,000	-\$15,000	\$9,400
AV, 3%	\$1,900	-\$1,300	\$640
AV, 7%	\$2,000	-\$1,200	\$770

Non-Monetized Impacts^b

Disbenefits to human health and the environment from increased exposure to ambient PM_{2.5}, ozone, NO₂ and air toxics (*see* Chapter 4)

^a Values show two significant figures; totals may not sum due to rounding. Positive values indicate cost savings in expenditures.

^b Several categories of costs and benefits remain unmonetized and are not reflected in the table.

Chapter 7 Regulatory Flexibility Analysis

The Regulatory Flexibility Act (RFA), as amended by the Small Business Regulatory Enforcement Fairness Act of 1996 (SBREFA), generally requires an agency to prepare a regulatory flexibility analysis for any rule subject to notice-and-comment rulemaking requirements under the Administrative Procedure Act or any other statute. This requirement does not apply if the agency certifies that the rule will not have a significant economic impact on a substantial number of small entities. This chapter contains an overview of small entities in the HDE market and the EPA's assessment that the proposed rule would not have a significant impact on a substantial number of small entities.

Under the RFA,⁶³ a small entity is defined as: (1) a business that meets the definition for small business based on the SBA's size standards; (2) a small governmental jurisdiction that is a government of a city, county, town, school district, or special district with a population of less than 50,000; or (3) a small organization that is any not-for-profit enterprise which is independently owned and operated and is not dominant in its field.

This analysis considers small business entities that are subject to the regulations the EPA proposes to revise. Small governmental jurisdictions and small not-for-profit organizations would not be subject to the proposed rule as they have no certification or compliance requirements.

This regulatory flexibility analysis was performed using data on small entities assembled for the EPA's Final Rule: Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards, finalized in December 2022. Chapter 11 of the Regulatory Impact Assessment for that rule describes how the Agency identified the small entities in each of the relevant NAICS categories and the results of applying that methodology.⁶⁴

7.1 NAICS Categories and SBA Sizes of Small Businesses Potentially Affected by the Proposal

The regulated entities that are subject to the regulations the EPA is proposing to revise in this action are expected to have registered under the North American Industry Classification System (NAICS) codes shown in Table 7-1. The small business size standards that qualify the regulated entities as "small entities" are also set out in Table 7-1.

⁶³ 5 U.S.C. 601 et seq.

⁶⁴ See Chapter 11, Small Business Analysis, in Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards Draft Regulatory Impact Analysis, EPA-420-D-22-001, March 2022, finalized December 2022, EPA-420-R-22-035.

Table 7-1. Primary Small Business NAICS Categories Affected by This Proposed Rule. ^a

NAICS Code ^b	NAICS Title	Defined by SBA as a small business if less than or equal to: ^c
336120	Heavy-Duty Truck Manufacturing	1,500 employees
336390	Other Motor Vehicle Parts Manufacturing	1,000 employees
333618	Other Engine Equipment Manufacturing	1,500 employees
336999	All Other Transportation Equipment Manufacturing	1,000 employees

^a According to SBA’s regulations (13 CFR Part 121), businesses with no more than the listed number of employees or dollars in annual receipts are considered “small entities” for RFA purposes.

^b North American Industry Classification System, United States, 2022. A copy of this document can be found in the docket for this proposal. *See also:* NAICS Association. NAICS & SIC Identification Tools: <https://www.naics.com/search>.

^c U.S. Small Business Administration. (2023). Table of Small Business Size Standards Matched to North American Industry Classification System Codes: https://www.sba.gov/sites/default/files/2023-06/Table%20of%20Size%20Standards_Effective%20March%2017%2C%202023%20%282%29.pdf. A copy of this document can be found in the docket for this proposal

7.2 Description of Small Businesses Potentially Affected by the Proposal

There are four categories of highway heavy-duty engine and vehicle entities that would be subject to the proposed rule:

- Heavy-duty engine manufacturers: these are companies that have been developing, testing, and certifying engines for many years in compliance with EPA rulemakings adopted under the CAA. The heavy-duty engine manufacturers that certify engines to EPA’s program include no small entities.
- Heavy-duty conventional vehicle manufacturers that manufacture and certify a complete or incomplete vehicle and its associated engines. These companies are not small entities.
- Alternative fuel engine converters: these are companies that convert compression-ignition or spark-ignition heavy-duty engines to use alternative fuels. The EPA identified two small alternative fuel engine converters.
- Independent Commercial Importers: these are companies that import heavy-duty engines into the United States. None of these companies are small.

We note that in the 2023 Final Rule, the EPA described secondary vehicle manufacturers that manufacture vehicles of their own design using certified engines or certified incomplete vehicles produced by a different company. The 2023 Final Rule estimated there were 249 small entity secondary vehicle manufacturers and that those vehicle manufacturers are not subject to the proposed regulations because the incomplete vehicles they are finishing are already certified. We further note that the amendments in this proposed rule would not require these manufacturers to

modify their vehicle designs to accommodate the proposed new requirements and therefore the proposed rule would not have an adverse economic impact on their companies.

7.3 Potential Impacts on Small Entities

The EPA considered the following potential impacts on small entities.

7.3.1 Warranty and Useful Life Periods

This action proposes to shorten emission-related warranty periods and delay increased regulatory useful life periods. All entities, including all small entities, in the four industries (engine manufacturers, vehicle manufacturers, alternative fuel converters, and commercial importers) are expected to see a decrease in regulatory burden as a result of the proposed changes to warranty and useful life.

7.3.2 SCR inducements

The EPA is proposing to revise the requirements for SCR inducement in newly manufactured diesel-fueled highway engines and vehicles (*i.e.*, light- and medium-duty vehicles and heavy-duty engines) and nonroad engines and equipment. This would affect only diesel engine manufacturers, and none of those companies meet the SBA criteria as a small business.

7.3.3 NCPs

The EPA is proposing to make NCPs available, which would allow manufacturers to continue to sell their current products while they complete the development of engines that are compliant with the MY 2027 standards. The EPA is proposing that the NCPs would be available only for diesel-fueled Medium HDE and Heavy HDE categories, and no small manufacturers produce engines in those categories.

7.3.4 Other Regulatory Amendments

The proposal includes amendments that the EPA projects would not add meaningful costs for any manufacturers. Those proposed amendments would improve access to an existing production volume allowance and clarify and streamline various other test procedures and compliance provisions.

7.4 Conclusion

For the above reasons, the EPA does not anticipate that there would be a significant adverse economic impact on directly regulated small entities as a result of these revisions. In making this determination, the impact of concern for this proposal is any significant adverse economic impact on small entities that are directly affected by the proposal.