

Greenhouse Gas Emissions Standards for Heavy-Duty Vehicles – Phase 3

Overview Briefing of the Final Rule for National Association of Clean Air Agencies (NACAA)

US EPA, OFFICE OF TRANSPORTATION AND AIR QUALITY

APRIL 15, 2024



Agenda

- Background: Authority, Need, and Phases 1 and 2 GHG Rules
- Scope, Highlights, Changes from Proposal
- Final Standards, Compliance Flexibilities, Program Elements
- Emission Impacts, Benefits, and Costs

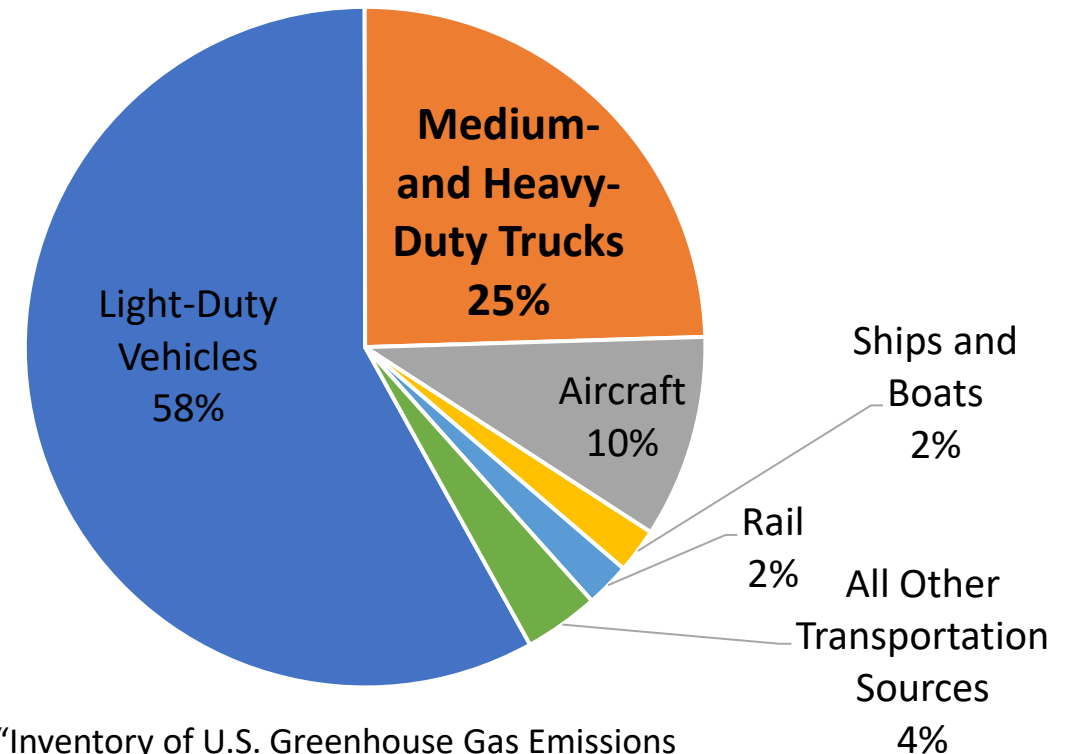
Background: Key Statutory Provisions and Importance of Reducing HD Air Pollution



Clean Air Act Statutory Authority

- Section 202(a)(1) of the Clean Air Act (CAA) requires the EPA to “by regulation prescribe (and from time to time revise) . . . standards applicable to the emission of any air pollutant from any class or classes of new motor vehicles or new motor vehicle engines. . . , which in his judgment cause, or contribute to, air pollution which may reasonably be anticipated to endanger public health or welfare.”
- Standards take effect "after such period as the Administrator finds necessary to permit the development and application of the requisite technology, giving appropriate consideration to the cost of compliance within such period."
- **EPA also must consider issues of technological feasibility, compliance cost, and lead time. EPA may consider other factors.**

HD is the 2nd largest source of GHG emissions in the transportation sector, and a significant source of local & regional air pollution



“Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2020,” EPA 430-R-22-003

Background: HD GHG Phases 1 and 2 Program Highlights

- Standards set by heavy-duty regulatory categories, e.g., tractors, vocational vehicles, large pickups/vans
- Phase 1 vehicle standards implemented 2014 through 2018; Phase 2 program started in 2021, fully phase in by 2027

Combination Tractors



Vocational Vehicles



Large Pickups & Vans



When designing program in 2016, EPA envisioned these technologies *could* be used to meet Phase 2:

- Engine, transmission, and driveline improvements
- Extended and workday idle reduction technologies
- Aerodynamic devices
- Lower rolling resistance tires
- Automatic tire inflation systems
- Weight reduction
- Engine stop start
- Powertrain hybridization
- Combustion optimization
- Improved air handling
- Reduced friction within the engine
- Improved emissions after-treatment technologies
- Engine waste heat recovery

Scope of the Phase 3 Final Rule

HD GHG Phase 3

Vocational Vehicles



Short-haul Tractors



Long-haul Tractors



Light- and Medium-Duty Multi-Pollutant Final Rule

Light-Duty



Medium-Duty



Regulatory Classes for Heavy-duty Vehicles

Weight Class	GWVR (lb)	Examples	EPA Regulatory Classification / Averaging Sets
2b	8501 – 10000	Crew Size Pickup Full Size Pickup Step Van Utility Van	Light HDV: All Class 2b-5 vocational vehicles (SI engine, CI engine, and no engine)
3	10001 – 14000	City Delivery Mini Bus Walk In	
4	14001 – 16000	City Delivery Conventional Van Landscape Utility Large Walk In	
5	16001 – 19500	Bucket City Delivery Large Walk In	
6	19501 – 26000	Beverage Rack School Bus Single Axle Van Stake Body	
7	26000 – 33000	City Transit Bus Furniture High Profile Semi Home Fuel Medium Semi Tractor Refuse Tow	Medium HDV: All Class 7 vehicles, including Class 7 tractors (unless a Class 7 vocational is certified with <i>Heavy HDE</i>)
8	33001 +	Cement Mixer Dump Fire Truck Fuel Heavy Semi Tractor Refrigerated Van Semi Sleeper Tour Bus	Heavy HDV: All Class 8 vehicles, including Class 8 hybrids and Class 8 tractors (unless a Class 8 vocational is certified with <i>Medium HDE</i>)

See 40 CFR 1037.105(h) (custom-chassis categories), 1037.140 (classification), 1037.230 (regulatory subcategories), 1037.740 (averaging sets).
 Vehicle example images from: <https://afdc.energy.gov/data/10381>



The Clean Trucks Plan

EPA's Clean Trucks Plan represents the **most protective set of EPA regulations ever for the on-road sector**, significantly reducing pollution, protecting public health, and responding to the urgency of climate change.

The Heavy-Duty GHG Phase 3 final rule signed in March 2024 completes the Clean Trucks Plan.

It follows the completion of these two rules:

- The **Control of Air Pollution from Heavy-Duty Engines and Vehicles** signed in December 2022, which focuses on reducing emissions that form smog and soot and will apply to heavy-duty engines and vehicles beginning in model year 2027.
- The **Multi-Pollutant Emission Standards for Model Years 2027 and Later for Light- and Medium-Duty Vehicles** rule that was signed in March 2024 addresses greenhouse gas emissions and emissions that form smog and soot from commercial pickup trucks and vans, in addition to light-duty vehicles.



HD GHG Phase 3 Highlights

- Achievable and flexible **greenhouse gas standards for model years 2027-2032** that completes the Clean Trucks Plan
- Will deliver **one billion metric tons of net CO₂ emission reductions** between 2027 and 2055
- Projected increased use of ZEVs and advanced ICE vehicle technologies will **decrease criteria pollutants and air toxics from vehicles and refineries**
 - Reduced pollution (e.g., PM_{2.5}, NO₂) near roadways, where over 72 million people live, including communities with EJ concerns
- **\$13 billion in annualized net benefits** to society from climate and public health benefits and savings for truck owners and operators



HD GHG Phase 3 Highlights

- **Technology-neutral, performance-based standards**
 - Manufacturers can meet the standards with a **variety of technologies, including:**
 - Advanced internal combustion engine vehicles
 - Hybrid vehicles
 - Plug-in hybrid vehicles
 - Battery electric vehicles
 - Hydrogen fuel cell vehicles
- Final standards will **save vehicle owners billions of dollars**
 - Heavy-duty industry will see **annualized savings of \$3.5 billion, compared to annualized costs of \$1.1 billion**
 - With vehicle purchase tax credits provided under the IRA, typical buyers in 2032 will save money on the upfront cost of the vehicles and recoup any additional costs in:
 - 2-4 years for vocational vehicles and day cabs
 - 5 years for sleeper cabs



Changes from the Proposal

- Delivers **greater reductions over time than the proposed rule**, while still allowing:
 - **More time in the early years of the program** for technology and infrastructure development and deployment
 - Less stringent starting point and more gradual phase-in
 - Day cab program starts one year later (2028); heavy-heavy vocational vehicles start two years later (2029)
 - **More flexibilities for manufacturers**
 - Maintains the Phase 2 program's advanced technology credit multiplier in 2027 (we proposed to eliminate for PHEVs and BEVs)
 - Provides an interim, transitional flexibility during 2027 through 2032 that will allow manufacturers broader use of credits for heavy-duty vehicles across averaging sets
- Greater reductions from the final rule are driven by **more stringent standards in 2032 for several vehicle categories**
 - More stringent for light- and medium-heavy vocational vehicles and day cab tractors
 - Same stringency for sleeper cab tractors
 - Less stringent only for heavy-heavy vocational vehicles
- **EPA commitment to monitor technology and infrastructure development** to ensure successful implementation
 - **Ongoing engagement with stakeholders**
 - **Periodic reports beginning as early as 2026**
 - Will help inform EPA about whether any potential adjustments to the program are warranted



Updates for the Final Rule Analyses

- Updated technical analysis from the NPRM, based on best available data informed by:
 - **Public comments**
 - Extensive **collaboration with DOT, DOE, and National Laboratories** on new studies to inform our updates of battery costs, critical materials & supply chain, infrastructure, grid impacts, and IRA incentives
- Additional updates include
 - No Action reference case updated to reflect waiver for enforcement of Advanced Clean Trucks rule in California and seven other states, as well as HD ZEV adoption elsewhere
 - BEV and FCEV component costs
 - Component efficiency and sizing
 - EVSE costs
 - Dwell times and EVSE sizing
 - Diesel fuel, hydrogen fuel, depot charging costs, public charging costs
 - Addition of cost considerations including Federal Excise tax, sales tax, insurance
 - Additional technology pathways that include advanced vehicle technologies, hybrids, plug-in hybrids, CNG vehicles, and hydrogen-fueled ICE vehicles



Phase 3 Builds off Phase 2's Program Structure

- **Phase 3 standards maintain the flexible structure** created in EPA's Phase 2 GHG program, which is designed to reflect the diverse nature of the heavy-duty industry
- **Performance-based and technology-neutral** standards are first differentiated between tractors and vocational vehicles
 - Vocational vehicles are divided into 23 different subcategories for setting standards – 8 are for specialized vehicles
 - For tractors, standards are divided into 10 different subcategories for standards
 - In total, there are 33 unique HD vehicle subcategories for standards for each model year of the program
- CO₂ Emissions Averaging, Banking and Trading (ABT) program
 - Allows emissions credits to be generated and used to meet the standards
 - 5-year credit life, 3-year deficit carry forward



Final Phase 3 Standards and Requirements

- We made **numerous changes** to the final program based on our review of public comments on the proposal and our updated technical assessment, including:
 - **More time in the early years of the program**
 - Day cab program starts one year later (2028); heavy-heavy vocational vehicles start two years later (2029)
 - **Lower starting point and more gradual phase-in**
 - Less stringent standards for all vehicle categories in MY 2027-2030
 - MY 2031 also less stringent for sleeper cab tractors
 - Less stringent every year for heavy-heavy vocational
 - **Emission credit program changes**
 - Interim, transitional flexibility during 2027 through 2032 that will allow broader use of credits generated from heavy-duty vehicles across averaging sets
 - Maintains the Phase 2 program's advanced technology credit multiplier in 2027 (which we proposed to eliminate for PHEVs and BEVs), but with additional guardrails to constrain the use and life of these credits
 - **Stronger end-point standards for key truck categories**
 - MY 2032 and beyond standards for light and medium-duty vocational vehicles and day cab tractors more stringent than proposed

Stringency of Standards for the Final Rule

% Reduction from the Phase 2 CO₂ Standards

Model Year:	2027	2028	2029	2030	2031	2032
Light Heavy-Duty Vocational: Final Rule	17%	22%	27%	32%	46%	60%
Proposal	22%	28%	34%	39%	45%	57%
Medium Heavy-Duty Vocational: Final Rule	13%	16%	19%	22%	31%	40%
Proposal	19%	21%	24%	27%	30%	35%
Heavy Heavy-Duty Vocational: Final Rule			13%	15%	23%	30%
Proposal	16%	18%	19%	30%	33%	40%
Day Cab Tractors: Final Rule		8%	12%	16%	28%	40%
Proposal	10%	12%	15%	20%	30%	34%
Sleeper Cab Tractors: Final Rule				6%	12%	25%
Proposal				10%	20%	25%

Stronger standards in long term vs proposal

Stronger standards in long term vs proposal



More time in early years for technology and infrastructure development and deployment



Compliance Flexibilities

- **Advanced Technology Credit Multipliers**
 - Retained the multipliers for BEVs, PHEVs, and FCEVs through MY 2027 **as adopted in Phase 2**
 - **Added important guardrails** to restrict how multiplier credits can be used for MYs 2027-2029 and expire any remaining multiplier credits in MY 2030
 - Overall, **this approach is more protective than the proposal** to eliminate MY 2027 PHEV and BEV multipliers, especially in the later years of the program
- **Transitional Averaging, Banking, and Trading Provisions for MYs 2027-2032**
 - **Allow credit exchanges across HD vehicle averaging sets**
 - Light HDV credits to Medium HDV and Heavy HDV, Medium HDV credits to Light HDV and Heavy HDV, and Heavy HDV credits to Light HDV and Medium HDV
 - Can exchange any credits earned in MY 2027 to 2032 but can only exchange credits banked from MY 2026 and earlier if they were earned with Phase 2 advanced technology vehicles
 - Allow credits earned from Medium-Duty Vehicles (MDV) certified under 40 CFR part 86 to transfer into Light HDV or Medium HDV averaging sets
 - Credit transfers from MDV are limited to credits earned in MYs 2027-2032; no credits from MY 2026 or earlier can transfer to HD vehicle averaging sets

Durability Monitoring and Warranty Requirements for Advanced Technologies



- Battery durability monitoring requirements for battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs)
 - Includes new 40 CFR 1037.115(f) that require manufacturers to **install a customer-accessible state of health (SOH) monitor** for the battery
 - The SOH monitor estimates, monitors, and communicates the vehicle's state of certified energy (SOCE)
 - For BEVs we did not finalize a specific test procedure to determine usable battery energy (UBE)
 - For PHEVs manufacturers would use the existing powertrain test procedures defined in 40 CFR 1036.545 to determine UBE or developed their own procedure that meets the requirements in 40 CFR 1037.115(f)
- Final rule also includes **warranty requirements for BEV and fuel cell electric vehicles (FCEVs)**; and clarifies how warranty applies to hybrid vehicles



Post-Rule Commitment

- EPA carefully assessed the technologies and infrastructure and concluded **they will support the feasibility of the final standards.**
- EPA commits to **actively engage with a range of stakeholders** to monitor both manufacturer compliance and the heavy-duty ZEV infrastructure.
- EPA will **coordinate with DOE and DOT** to monitor the implementation of electric vehicle charging and hydrogen fueling infrastructure designed to serve HD vehicles.
- EPA will release **periodic status reports**, beginning as early as 2026, which may support the current program or indicate a need for guidance documents or future regulatory action.

Stakeholders such as:

State and local governments

Communities with EJ concerns

Non-governmental organizations

Workers & labor unions

Trucking fleets and trade associations

Heavy-duty vehicle owner-operators

HD vehicle manufacturers

Utilities (investor-owned, publicly-owned, and cooperatives)

Infrastructure providers, installers



Projected GHG Emission Impacts of the Final Standards

- Net (downstream and upstream) cumulative GHG emission reductions of **1 billion metric tons** through 2055
 - Downstream CO₂e reductions from vehicles and refineries of **1.4 billion metric tons** through 2055
 - Upstream CO₂e increases from power plants of **0.4 billion metric tons** through 2055

Pollutant	Downstream Vehicle Emissions (MMT CO ₂ e)	Electricity Generation Units (MMT CO ₂ e)	Refinery (MMT CO ₂ e)	Net Impact (MMT CO ₂ e)
Carbon Dioxide (CO ₂)	-1,347	391	-13	-969
Methane (CH ₄)	-0.127	0.018	-0.001	-0.109
Nitrous Oxide (N ₂ O)	-0.199	0.002	0.000	-0.197
CO ₂ Equivalent (CO ₂ e)	-1,404	393	-13	-1,025

*We present emissions reductions as negative numbers and emission increases as positive numbers.



Projected Emission Impacts of the Final GHG Standards

- **Net reductions in NO_x, VOC, and SO₂** emissions in 2055.
- Although there is a small net increase in direct PM_{2.5} emissions in 2055, ambient PM_{2.5} is formed from emissions of direct PM_{2.5} as well as emissions of other precursors such as NO_x and SO₂. **We project overall PM_{2.5}-related benefits** based on the contribution of emissions from each of these pollutants

Pollutant	Downstream (U.S Short Tons)	EGU (U.S. Short Tons)	Refinery (U.S. Short Tons)	Net Impact (U.S. Short Tons)
Nitrogen Oxides (NO _x)	-54,268	1,520	-304	-53,051
Primary Exhaust PM _{2.5}	-331	513	-70	113
Volatile Organic Compounds (VOC)	-7,242	196	-226	-7,272
Sulfur Dioxide (SO ₂)	-270	69	-94	-295

*We present emissions reductions as negative numbers and emission increases as positive numbers.



Environmental Justice Impacts

- People of color, low-income populations and/or indigenous peoples may be especially vulnerable to the impacts of climate change and this final rule will reduce GHG emissions and thus contribute to efforts to **reduce the probability of severe impacts related to climate change**.
- The final standards will also **reduce air pollution near roads**
 - Near-roadway communities are often low income or communities of color, and children who attend school near major roads are disproportionately represented by children of color and children from low-income households
 - Reducing these emissions would also provide cleaner air for communities across the country, prevent health issues like asthma, and ultimately save money, lives, and trips to the hospital



Monetized Annual Benefits to Society

- The Phase 3 Program will reduce adverse impacts associated with climate change and exposure to non-GHG pollutants and thus would yield significant benefits, both monetized and unmonetized
- EPA estimates that monetized **annual net benefits to society would be approximately \$13 billion** through the year 2055, **more than 12 times the cost** in vehicle technology and associated electric vehicle supply equipment (EVSE) combined
- The annual cost of vehicle technology and EVSE (not including tax credits) would be approximately \$1.1 billion
- The HD industry would save approximately \$3.5 billion in annual operating costs (e.g., savings that come from less liquid fuel used, lower maintenance and repair costs for ZEV technologies as compared to ICE technologies, etc.)
- **Significant annual social benefits include:**
 - \$10 billion in climate benefits
 - \$0.3 billion in reduced emissions of non-GHG pollutants that contribute to ambient concentrations of PM_{2.5}.
 - \$0.45 billion in energy security benefits from 3 billion barrels of reduced oil imports

Values presented here are equivalent annualized values for 2027 through 2055 at 2% discount rate in 2022 dollars



Estimated Cost to **Manufacturers** for Model Year 2032 Vehicles

- The **average per-vehicle estimated cost to manufacturers for 2032** ZEVs and internal combustion engine vehicles combined are shown by regulatory group in the table below
- These estimates account for the battery tax credit under the Inflation Reduction Act (IRS 45X), but not the vehicle tax credit (IRS 45W) as this credit is available to purchasers (next slide)

Regulatory Group	Fleet-Average Per-Vehicle Manufacturer Cost
LHD Vocational	-\$2,900
MHD Vocational	-\$1,000
HHD Vocational	-\$700
Short-Haul (Day Cab) Tractors	\$3,200
Long-Haul (Sleeper Cab) Tractors	\$10,800

For comparison, the projected fleet average per-vehicle costs projected of the HD GHG Phase 2 CO₂ standards were:

- between \$1,900 and \$7,100 per vehicle for MY 2027 vocational vehicles
- between \$12,800 and \$17,100 per vehicle for MY 2027 tractors



Estimated Cost and Payback for **Purchasers of MY 2032 Vehicles**

- The **per-vehicle estimated upfront cost to purchasers** for a **2032 ZEV relative to a comparable internal combustion engine vehicle** are shown in the table below, including vehicle and Electric Vehicle Supply Equipment (EVSE) costs
- This is supported by incentives such as tax credits under the Inflation Reduction Act, including the vehicle tax credit (IRS 45W), the battery tax credit (IRS 45X), and the EVSE tax credit (IRS 30C)
- We project the upfront cost increases would be recouped by owners over the vehicle lifetime through operational savings, with payback periods ranging from 2 to 5 years

Regulatory Group	Incremental Per-ZEV Cost on Average (before IRA Purchase Tax Credit and Taxes)	EVSE Costs Per-ZEV on Average	Total Incremental Upfront Per-ZEV Costs on Average Including Taxes	Annual Incremental Operating Costs Per-ZEV on Average	Payback Period (year) on Average
LHD Vocational	-\$9,800	\$11,700	\$1,500	-\$3,700	2
MHD Vocational	-\$5,000	\$15,300	\$9,700	-\$5,100	3
HHD Vocational	-\$4,000	\$46,200	\$34,500	-\$10,500	4
Short-Haul (Day Cab) Tractors	\$10,800	\$5,900	\$4,400	-\$5,500	2
Long-Haul (Sleeper Cab) Tractors	\$53,300	\$0	\$22,400	-\$8,300	5



Other Elements in the FRM

- **Exempted small businesses vehicle manufacturers**
 - We exempted small businesses from the final Phase 3 GHG standards
 - Minimal impact on emissions, few small vehicle companies, and still required to meet existing MY 2027 standards
- **Heavy-Duty technical amendments**
 - We finalized limited amendments to correct, clarify, or create consistency in the test procedures and other compliance provisions relating to highway heavy-duty engines and vehicles
- **Removed vacated Phase 2 trailer standards**



Additional Information

- See our website for more information: <https://www.epa.gov/regulations-emissions-vehicles-and-engines/regulations-greenhouse-gas-emissions-commercial-trucks>