## ENVIRONMENTAL PROTECTION AGENCY

## 40 CFR Parts 85, 86, 600, 1036, 1037, and 1066

**[EPA–HQ–OAR–2022–0829; FRL 8953–03–OAR]**

**RIN 2060–AV49**

# Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles

**AGENCY:** Environmental Protection Agency (EPA).

**ACTION:** Proposed rule.

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**SUMMARY:** Under its Clean Air Act authority, the Environmental Protection Agency (EPA) is proposing new, more stringent emissions standards for criteria pollutants and greenhouse gases (GHG) for light-duty vehicles and Class 2b and 3 (''medium-duty'') vehicles that would phase-in over model years 2027 through 2032. In addition, EPA is proposing GHG program revisions in several areas, including off-cycle and air conditioning credits, the treatment of upstream emissions associated with zero-emission vehicles and plug-in hybrid electric vehicles in compliance calculations, medium-duty vehicle incentive multipliers, and vehicle certification and compliance. EPA is also proposing new standards to control refueling emissions from incomplete medium-duty vehicles, and battery durability and warranty requirements for light-duty and medium-duty plug-in vehicles. EPA is also proposing minor amendments to update program requirements related to aftermarket fuel conversions, importing vehicles and engines, evaporative emission test procedures, and test fuel specifications for measuring fuel economy.

**DATES:**

*Comments:* Written comments must be received on or before July 5, 2023.

Comments on the information collection provisions submitted to the Office of Management and Budget (OMB) under the Paperwork Reduction Act (PRA) are best assured of consideration by OMB if OMB receives a copy of your comments on or before June 5, 2023.

*Public Hearing:* EPA will announce information regarding the public hearing for this proposal in a supplemental **Federal Register** document.

**ADDRESSES:** You may send comments, identified by Docket ID No. EPA–HQ–OAR–2022–0829, by any of the following methods:

- *Federal eRulemaking Portal: https://www.regulations.gov/* (our preferred method). Follow the online instructions for submitting comments.
- *Email: a-and-r-Docket@epa.gov.* Include Docket ID No. EPA–HQ–OAR–2022–0829 in the subject line of the message.
- *Mail:* U.S. Environmental Protection Agency, EPA Docket Center, OAR, Docket EPA–HQ–OAR–2022–0829, Mail Code 28221T, 1200 Pennsylvania Avenue NW, Washington, DC 20460.
- *Hand Delivery or Courier (by scheduled appointment only):* EPA Docket Center, WJC West Building, Room 3334, 1301 Constitution Avenue NW, Washington, DC 20004. The Docket Center's hours of operations are 8:30 a.m.–4:30 p.m., Monday–Friday (except Federal Holidays).

*Instructions:* All submissions received must include the Docket ID No. for this rulemaking. Comments received may be posted without change to *https://www.regulations.gov/*, including any personal information provided. For detailed instructions on sending comments and additional information on the rulemaking process, see the ''Public Participation'' heading of the **SUPPLEMENTARY INFORMATION** section of this document.

**FOR FURTHER INFORMATION CONTACT:** Michael Safoutin, Office of Transportation and Air Quality, Assessment and Standards Division (ASD), Environmental Protection Agency, 2000 Traverwood Drive, Ann Arbor, MI 48105; telephone number: (734) 214–4348; email address: *Safoutin.Mike@epa.gov.*

**SUPPLEMENTARY INFORMATION:**

## A. Public Participation

### *Written Comments*

EPA will keep the comment period open until July 5, 2023. All information will be available for inspection at the EPA Air Docket No. EPA–HQ–OAR–2022–0829. Submit your comments, identified by Docket ID No. EPA–HQ–OAR–2022–0829, at *https://www.regulations.gov* (our preferred method), or the other methods identified in the **ADDRESSES** section. Once submitted, comments cannot be edited or removed from the docket. EPA may publish any comment received to its public docket. Do not submit to EPA's docket at *https://www.regulations.gov* any information you consider to be Confidential Business Information (CBI) or other information whose disclosure is restricted by statute. Multimedia submissions (audio, video, etc.) must be accompanied by a written comment. The written comment is considered the official comment and should include discussion of all points you wish to make. EPA will generally not consider comments or comment contents located outside of the primary submission (*i.e.,* on the web, cloud, or other file sharing system). For additional submission methods, the full EPA public comment policy, information about CBI or multimedia submissions, and general guidance on making effective comments, please visit *https://www.epa.gov/dockets/commenting-epa-dockets.*

### *Public Hearing*

Please refer to the separate **Federal Register** notice issued by EPA for public hearing details. The hearing notice is available at *https://www.epa.gov/regulations-emissions-vehicles-and-engines/proposed-rule-multi-pollutant-emissions-standards-model.* Please also refer to this website for any updates regarding the hearings. EPA does not intend to publish additional documents in the **Federal Register** announcing updates.

## B. Does this action apply to me?

Entities potentially affected by this proposed rule include light-duty vehicle manufacturers, independent commercial importers, alternative fuel converters, and manufacturers and converters of medium-duty vehicles (*i.e.,* vehicles between 8,501 and 14,000 pounds gross vehicle weight rating (GVWR)). Potentially affected categories and entities include:

| Category | NAICS codes $^{A}$ | Examples of potentially affected entities |
|---|---|---|
| Industry | 336111<br>336112 | Motor Vehicle Manufacturers. |

| Category | NAICS codes[A] | Examples of potentially affected entities |
|---|---|---|
| Industry | 811111<br>811112<br>811198<br>423110 | Commercial Importers of Vehicles and Vehicle Components. |
| Industry | 335312<br>811198 | Alternative Fuel Vehicle Converters. |
| Industry | 333618<br>336120<br>336211<br>336312 | On-highway medium-duty engine & vehicle (8,501–14,000 pounds GVWR) manufacturers. |

[A] North American Industry Classification System (NAICS).

This list is not intended to be exhaustive, but rather provides a guide regarding entities potentially affected by this action. To determine whether particular activities may be regulated by this action, you should carefully examine the regulations. You may direct questions regarding the applicability of this action to the person listed in **FOR FURTHER INFORMATION CONTACT**.

### C. Did EPA conduct a peer review before issuing this proposed action?

This proposed regulatory action was supported by influential scientific information. EPA therefore conducted peer review in accordance with OMB's Final Information Quality Bulletin for Peer Review. Specifically, we conducted peer review on five analyses: (1) Optimization Model for reducing Emissions of Greenhouse gases from Automobiles (OMEGA 2.0), (2) Advanced Light-duty Powertrain and Hybrid Analysis (ALPHA3), (3) Motor Vehicle Emission Simulator (MOVES), (4) The Effects of New-Vehicle Price Changes on New- and Used-Vehicle Markets and Scrappage; (5) Literature Review on U.S. Consumer Acceptance of New Personally Owned Light-Duty Plug-in Electric Vehicles. All peer review was in the form of letter reviews conducted by a contractor. The peer review reports for each analysis are in the docket for this action and at EPA's Science Inventory (*https://cfpub.epa.gov/si/*).

### Table of Contents

## I. Executive Summary

### *A. Purpose of This Proposed Rule and Legal Authority*

#### 1. Proposal for Light- and Medium-Duty Multipollutant Standards for Model Years 2027 and Later

The Environmental Protection Agency (EPA) is proposing multipollutant emissions standards for light-duty passenger cars and light trucks and Class 2b and 3 vehicles (''medium-duty vehicles'' or MDVs) under its authority in section 202(a) of the Clean Air Act (CAA), 42 U.S.C. 7521(a). The proposed program would establish new, more stringent vehicle emissions standards for criteria pollutant and greenhouse gas (GHG) emissions from motor vehicles for model years (MYs) 2027 through 2032.

Section 202(a) requires EPA to establish standards for emissions of air pollutants from new motor vehicles which, in the Administrator's judgment, cause or contribute to air pollution which may reasonably be anticipated to endanger public health or welfare. Standards under section 202(a) 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.'' Thus, in establishing or revising section 202(a) standards designed to reduce air pollution that endangers public health and welfare, EPA also must consider issues of technological feasibility, the cost of compliance, and lead time. EPA also may consider other factors, and in previous vehicle standards rulemakings, as well as in this proposal, has considered the impacts of potential standards on emissions of air pollutants and associated public health and welfare effects, impacts on the automotive industry, impacts on the vehicle purchasers/consumers, oil conservation, energy security and other energy impacts, safety, and other relevant considerations.

EPA has conducted outreach with a wide range of interested stakeholders to gather input which we have considered in developing this proposal, and we will continue to engage with the public and all interested stakeholders as part of our regulatory development process.

#### 2. Why does EPA believe the proposed standards are appropriate under the CAA?

##### i. Need for Continued Emissions Reductions Under 202(a) of the Clean Air Act

In 2014, EPA finalized criteria pollutant standards for light-duty vehicles (''Tier 3'') that were designed to be implemented alongside the GHG standards for light-duty vehicles that EPA had adopted in 2012 for model years 2017–2025.[1] In 2020, EPA revised the GHG standards that had previously been adopted for model years 2021–2026,[2] and in 2021, EPA proposed and finalized a rulemaking (the ''2021 rulemaking'')[3] that again revised GHG standards for light-duty passenger cars and light trucks for MYs 2023 through 2026, setting significantly more stringent standards for those MYs than had been set by the 2020 rulemaking, and somewhat more stringent than the standards adopted in 2012.

Despite the significant emissions reductions achieved by these and other rulemakings, air pollution from motor vehicles continues to impact public health, welfare, and the environment. On August 5, 2021, Executive Order 14037, ''Strengthening American Leadership in Clean Cars and Trucks,'' directed the Administrator to consider beginning work on a rulemaking to establish new multi-pollutant emissions standards, including both criteria pollutant and GHG emissions, for light- and medium-duty vehicles beginning with MY 2027 and extending through and including at least MY 2030. The Administrator determined that there was a need to begin work on such a rulemaking and accordingly is issuing this proposal.

Motor vehicle emissions contribute to ozone, particulate matter (PM), and air toxics, which are linked with premature death and other serious health impacts, including respiratory illness, cardiovascular problems, and cancer. This air pollution affects people nationwide, as well as those who live or work near transportation corridors. In addition, there is consensus that the effects of climate change represent a rapidly growing threat to human health and the environment, and are caused by GHG emissions from human activity, including motor vehicle transportation. Recent trends and developments in emissions control technology, including vehicle electrification and other advanced vehicle technologies, indicate that more stringent emissions standards are feasible at reasonable cost and would achieve significant improvements in public health and welfare. Addressing these public health and welfare needs will require substantial additional reductions in criteria pollutants and GHG emissions from the transportation sector.

Addressing the public health impacts of criteria pollutants (including particulate matter (PM), ozone, nitrogen oxides ($NO_X$), and carbon monoxide (CO)) will require continued reductions in these pollutants from the transportation sector. In 2023, mobile sources will account for approximately 54 percent of anthropogenic $NO_X$ emissions, 5 percent of anthropogenic direct $PM_{2.5}$ emissions, and 19 percent of anthropogenic volatile organic compound (VOC) emissions.[4] [5] [6] Light- and medium-duty-vehicles will account for approximately 20 percent, 19 percent, and 41 percent of 2023 mobile source $NO_X$, $PM_{2.5}$, and VOC emissions, respectively.[4] [5] [6] The benefits of reductions in criteria pollutant emissions accrue broadly across many populations and communities. There are currently 15 $PM_{2.5}$ nonattainment areas with a population of more than 32 million people[7] and 57 ozone nonattainment areas with a population of more than 130 million people. The importance of continued reductions in these emissions is detailed at length in Section II.

The transportation sector is the largest U.S. source of GHG emissions, representing 27.2 percent of total GHG emissions.[8] Within the transportation sector, light-duty vehicles are the largest contributor, at 57.1 percent, and thus comprise 15.5 percent of total U.S. GHG emissions,[9] even before considering the contribution of medium-duty Class 2b

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[1] 79 FR 23414, April 28, 2014, ''Control of Air Pollution From Motor Vehicles: Tier 3 Motor Vehicle Emission and Fuel Standards.

[2] 85 FR 24174, April 30, 2020, ''The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks.''

[3] 86 FR 74434, December 30, 2021, ''Revised 2023 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions Standards.''

[4] U.S. Environmental Protection Agency (2021). 2016v1 Platform (*https://www.epa.gov/air-emissions-modeling/2016v1-platform*).

[5] U.S. Environmental Protection Agency (2021). 2017 National Emissions Inventory (NEI) Data. *https://www.epa.gov/air-emissions-inventories/2017-national-emissions-inventory-nei-data.*

[6] U.S. Environmental Protection Agency (2021). MOVES 3.0.1. *https://www.epa.gov/moves.*

[7] 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*).

[8] Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2020 (EPA–430–R–22–003, published April 2022).

[9] *Ibid.*

and 3 vehicles which are also included under this rule. GHG emissions have significant impacts on public health and welfare as evidenced by the well-documented scientific record and as set forth in EPA's Endangerment and Cause or Contribute Findings under section 202(a) of the CAA.[10] Additionally, major scientific assessments continue to be released that further advance our understanding of the climate system and the impacts that GHGs have on public health and welfare both for current and future generations, as discussed in Section II.A, making it clear that continued GHG emission reductions in the motor vehicle sector are needed to protect public health and welfare.

In addition to and separate from this proposal, the Administration has recognized the need for action to address climate change. Executive Order 14008 (''Tackling the Climate Crisis at Home and Abroad,'' January 27, 2021) recognizes the need for a government-wide approach to addressing the climate crisis, directing Federal departments and agencies to facilitate the organization and deployment of such an effort. On April 22, 2021, the Administration announced a new target for the United States to achieve a 50 to 52 percent reduction from 2005 levels in economy-wide net greenhouse gas pollution in 2030, consistent with the goal of limiting global warming to no more than 1.5 degrees Celsius by 2050 and representing the U.S. Nationally Determined Contribution (NDC) under the Paris Agreement. These actions, while they do not inform the standards proposed here, serve to underscore the importance of the EPA's Clean Air Act authority to address pollution from motor vehicles.

Also separately from this proposal, the Administration has recognized the recent industry advancements in zero-emission vehicle technologies and their potential to bring about dramatic reductions in emissions. Executive Order 14037 (''Strengthening American Leadership in Clean Cars and Trucks,'' August 5, 2021) identified a goal for 50 percent of U.S. new vehicle sales to be zero-emission vehicles by 2030. Congress passed the Bipartisan Infrastructure Law (BIL)[11] in 2021, and the Inflation Reduction Act (IRA)[12] in 2022, which together provide further support for a government-wide approach to reducing emissions by providing significant funding and support for air pollution and GHG reductions across the economy, including specifically, for the component technology and infrastructure for the manufacture, sales, and use of electric vehicles.

These industry advancements in the production and sales of zero- and near-zero emission vehicles are already occurring both domestically and globally, due to significant investments from automakers, greatly increased acceptance by consumers, and added support from Congress, state governments, the European Union and other countries. EPA recognizes that these industry advancements, along with the additional support provided by the BIL and the IRA, represent an important opportunity for achieving the public health goals of the Clean Air Act. As the term ''zero-emission vehicle'' suggests, these cars and trucks have zero GHG and criteria pollutant emissions from their tailpipes, which can represent significant reductions over current emissions (particularly for GHG). In part because this technology reduces both GHG and criteria pollutant emissions, EPA finds it appropriate to set new standards for model years after 2026 for both criteria pollutants and GHG at this time, rather than continuing its prior approach of coordinating the standards but setting them in separate regulatory actions. Although EPA is proposing to set GHG and criteria pollutant standards in a single rulemaking, these standards are being proposed to meet distinct needs for control of distinct pollutants based on EPA's assessment of the available control technologies for those pollutants, recognizing that some of the available control technologies may overlap.

Likewise, it is important to recognize that, despite this anticipated growth in zero-emission vehicles, many internal combustion engine (ICE) vehicles will continue to be sold during the time frame of the rule and will remain on the road for many years afterward. In addition, some vehicle manufacturers have made public statements[13] that some portion of their light-duty sales will remain ICE-based for the foreseeable future, predominantly in large SUVs and pickup trucks. EPA anticipates that a compliant fleet under the proposed standards will include a diverse range of technologies, including higher penetrations of advanced gasoline technologies as well as zero-emission vehicles. It is therefore important to consider the environmental and other implications of the ICE portion of the fleet.

The Administrator finds that the standards proposed herein are consistent with EPA's responsibilities under the CAA and appropriate under CAA section 202(a). EPA has carefully considered the statutory factors, including technological feasibility and cost of the proposed standards and the available lead time for manufacturers to comply with them. Based on our analysis, it is our assessment that the proposed standards are appropriate and justified under section 202(a) of the CAA. Our analysis for this proposal supports the preliminary conclusion that the proposed standards are technologically feasible and that the costs of compliance for manufacturers would be reasonable. The proposed standards would result in significant reductions in emissions of criteria pollutants, GHGs, and air toxics, resulting in significant benefits for public health and welfare. We also estimate that the proposal would result in reduced vehicle operating costs for consumers and that the benefits of the proposed program would significantly exceed the costs.

### ii. Recent and Ongoing Advancements in Technology Enable Further Emissions Reductions

In designing the scope, structure, and stringency of the proposed standards, the Administrator considered previous rulemakings, as well as the increasing availability of vehicle technologies that can be utilized by manufacturers to further reduce emissions. This proposal continues EPA's longstanding approach of establishing an appropriate and achievable trajectory of emissions reductions by means of performance-based standards, for both criteria pollutant and GHG emissions, that can be achieved by employing feasible and available emissions-reducing vehicle technologies for the model years for which the standard will apply.

CAA section 202(a) directs EPA to regulate emissions of air pollutants from new motor vehicles and engines, which in the Administrator's judgment cause or contribute to air pollution that may reasonably be anticipated to endanger public health or welfare. While standards promulgated pursuant to CAA section 202(a) are based on application of technology, the statute does not specify a particular technology or technologies that must be used to set such standards; rather, Congress has authorized and directed EPA to adapt its standards to emerging technologies.

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[10] 74 FR 66496, December 15, 2009; 81 FR 54422, August 15, 2016.

[11] Public Law 117–58, November 15, 2021.

[12] Public Law 117–169, August 16, 2022.

[13] Gastelu, G., ''General Motors President says 'the ICE age is not over' amid shift to EVs,'' Fox Business, November 17, 2022. Accessed on November 29, 2022 at *https://www.foxbusiness.com/lifestyle/general-motors-president-ice-age-evs.*

Thus, as with prior rules, EPA is assessing the feasibility of new standards in light of current and anticipated progress by automakers in developing and deploying new technologies. The levels of stringency in this proposal continue the trend of increased emissions reductions which have been adopted by prior EPA rules. The Tier 3 standards achieved reductions of up to 80 percent in tailpipe criteria pollutant emissions by treating the engine and fuel as an integrated system and requiring cleaner fuel as well as improved catalytic emissions control systems. Compliance with the EPA GHG standards over the past decade has been achieved predominantly through the application of advanced technologies to internal-combustion engine (ICE) vehicles. In that same time frame, as the EPA GHG standards have increased in stringency, automakers have relied to a greater degree on a range of electrification technologies, including hybrid electric vehicles (HEVs) and, in recent years, plug-in electric vehicles (PEVs) which include plug-in hybrid electric vehicles (PHEVs) and battery-electric vehicles (BEVs). As these technologies have been advancing rapidly in just the past several years, and battery costs have continued to decline, automakers have begun to include BEVs and PHEVs as an integral and growing part of their current and future product lines, leading to an increasing diversity of these clean vehicles planned for high-volume production. As a result, zero- and near-zero emission technologies are more feasible and cost-effective now than at the time of prior rulemakings.

These industry developments in vehicle electrification are driven by a number of factors, including the need to compete in a diverse market, as zero-emission transportation policies continue to be implemented across the world. An increasing number of U.S. states have taken actions to shift the light-duty fleet toward zero-emissions technology. In 2022, California finalized the Advanced Clean Cars II rule[14] that will require, by 2035, all new light-duty vehicles sold in the state to be zero-emission vehicles,[15] with New York,[16] [17] Massachusetts,[18] [19] and Washington state[20] following suit, likely to be followed by Oregon and Vermont as well.[21] Several other states may adopt similar provisions as members of the International Zero-Emission Vehicle Alliance.[22] In addition to the U.S., auto manufacturers also compete in a global market that is becoming increasingly electrified. Globally, at least 20 countries, as well as numerous local jurisdictions, have announced targets for shifting all new passenger car sales to zero-emission vehicles in the coming years, including Norway (2025); Austria, the Netherlands, Denmark, Iceland, India, Ireland, Israel, Scotland, Singapore, Sweden, and Slovenia (2030); Canada, Chile, Germany, Thailand, and the United Kingdom (2035); and France, Spain, and Sri Lanka (2040).[23] [24] [25] [26] Many of these announcements extend to light commercial vehicles as well, and several also target a shift to 100 percent all-electric medium- and heavy-duty vehicle sales (Norway targeting 2030, Austria 2035, and Canada and the United Kingdom 2040).

Together, the countries that through mid-2022 had set a target of 100 percent light-duty zero-emission vehicle sales by 2035 represented at least 25 percent of today's global light-duty vehicle market.[27] In addition, in February 2023 the European Union gave preliminary approval to a measure to phase out sales of ICE passenger vehicles in its 27 member countries by 2035.[28] [29] In 2021, BEVs and PHEVs together already comprised about 18 percent of the new vehicle market in Western Europe,[30] led by Norway which reached 64.5 percent BEV and 86.2 percent combined BEV and PHEV sales in 2021, increasing to 79.3 percent BEV and 87.8 percent combined BEV and PHEV sales in 2022.[31] [32] [33]

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[14] California Air Resources Board, ''California moves to accelerate to 100% new zero-emission vehicle sales by 2035,'' Press Release, August 25, 2022. Accessed on Nov. 3, 2022 at *https://ww2.arb.ca.gov/news/california-moves-accelerate-100-new-zero-emission-vehicle-sales-2035*.

[15] State of California Office of the Governor, ''Governor Newsom Announces California Will Phase Out Gasoline-Powered Cars & Drastically Reduce Demand for Fossil Fuel in California's Fight Against Climate Change,'' Press Release, September 23, 2020.

[16] New York State Senate, Senate Bill S2758, 2021–2022 Legislative Session. January 25, 2021.

[17] Governor of New York Press Office, ''In Advance of Climate Week 2021, Governor Hochul Announces New Actions to Make New York's Transportation Sector Greener, Reduce Climate-Altering Emissions,'' September 8, 2021. Accessed on September 16, 2021 *at https://www.governor.ny.gov/news/advance-climate-week-2021-governor-hochul-announces-new-actions-make-new-yorks-transportation*.

[18] *Boston.com*, ''Following California's lead, state will likely ban all sales of new gas-powered cars by 2035,'' August 27, 2022. Accessed November 3, 2022 at *https://www.boston.com/news/local-news/2022/08/27/following-californias-lead-state-will-likely-ban-all-sales-of-new-gas-powered-cars-by-2035/*.

[19] Commonwealth of Massachusetts, ''Request for Comment on Clean Energy and Climate Plan for 2030,'' December 30, 2020.

[20] Washington Department of Ecology, ''Washington sets path to phase out gas vehicles by 2035,'' Press Release, Sept. 7, 2022. Accessed on Nov. 3, 2022 at *https://ecology.wa.gov/About-us/Who-we-are/News/2022/Sept-7-Clean-Vehicles-Public-Comment*.

[21] Associated Press, ''17 states weigh adopting California's electric car mandate,'' September 3, 2022. Accessed on November 4, 2022 at *https://apnews.com/article/technology-california-clean-air-act-vehicle-emissions-standards-eebb48c13e24835f2c5b9cb56796182a*.

[22] ZEV Alliance, ''International ZEV Alliance Announcement,'' Dec. 3, 2015. Accessed on July 16, 2021 at *http://www.zevalliance.org/international-zev-alliance-announcement/*.

[23] Environment and Climate Change Canada, ''Achieving a Zero-Emission Future for Light-Duty Vehicles: Stakeholder Engagement Discussion Document December 17,'' EC21255, December 17, 2021. Accessed on February 13, 2023 at *https://www.canada.ca/content/dam/eccc/documents/pdf/cepa/achieving-zero-emission-future-light-duty-vehicles.pdf*.

[24] International Council on Clean Transportation, ''Update on the global transition to electric vehicles through 2019,'' July 2020.

[25] International Council on Clean Transportation, ''Growing momentum: Global overview of government targets for phasing out new internal combustion engine vehicles,'' posted 11 November 2020, accessed April 28, 2021 at *https://theicct.org/blog/staff/global-ice-phaseout-nov2020*.

[26] Reuters, ''Canada to ban sale of new fuel-powered cars and light trucks from 2035,'' June 29, 2021. Accessed July 1, 2021 from *https://www.reuters.com/world/americas/canada-ban-sale-new-fuel-powered-cars-light-trucks-2035-2021-06-29/*.

[27] International Energy Agency, ''Global EV Outlook 2022,'' p. 57, May 2022. Accessed on November 18, 2022 at *https://iea.blob.core.windows.net/assets/e0d2081d-487d-4818-8c59-69b638969f9e/GlobalElectricVehicleOutlook2022.pdf*.

[28] Reuters, ''EU approves effective ban on new fossil fuel cars from 2035,'' October 28, 2022. Accessed on Nov. 2, 2022 at *https://www.reuters.com/markets/europe/eu-approves-effective-ban-new-fossil-fuel-cars-2035-2022-10-27/*.

[29] Reuters, ''EU lawmakers approve effective 2035 ban on new fossil fuel cars,'' February 14, 2023. Accessed on February 26, 2023 at *https://www.reuters.com/business/autos-transportation/eu-lawmakers-approve-effective-2035-ban-new-fossil-fuel-cars-2023-02-14/*.

[30] Ewing, J., ''China's Popular Electric Vehicles Have Put Europe's Automakers on Notice,'' New York Times, accessed on November 1, 2021 at *https://www.nytimes.com/2021/10/31/business/electric-cars-china-europe.html*.

[31] Klesty, V., ''With help from Tesla, nearly 80% of Norway's new car sales are electric,'' Reuters, accessed on November 1, 2021 at *https://www.reuters.com/business/autos-transportation/tesla-pushes-norways-ev-sales-new-record-2021-10-01/*.

[32] Norwegian Information Council for Road Traffic (OFV), ''New car boom and electric car record in September,'' October 1, 2021, accessed on November 1, 2021 at *https://ofv.no/aktuelt/2021/nybil-boom-og-elbilrekord-i-september*.

[33] Holland, M., '' Norway's EV Sales Explode Ahead Of Policy Changes,'' CleanTechnica, January 4, 2023. Accessed on February 22, 2023 at *https://cleantechnica.com/2023/01/04/norways-ev-sales-explode-ahead-of-policy-changes/*.

Recent trends in market penetration of zero and near-zero emission vehicles suggest that demand for these vehicles in the U.S. is rapidly increasing. Even under current standards, the production of new PEVs (including both BEVs and PHEVs) is growing rapidly and roughly doubling every year, projected to be 8.4 percent of U.S. light-duty vehicle production in MY 2022, up from 4.4 percent in MY 2021 and 2.2 percent in MY 2020.[34] In 2022, BEVs alone accounted for about 807,000 U.S. new car sales, or about 5.8 percent of the new light-duty passenger vehicle market, up from 3.2 percent BEVs the year before.[35] In California, new light-duty zero-emission vehicle (ZEV) sales in 2022 reached 18.8 percent of all new cars, up from 12.4 percent in 2021 and more than twice the share from 2020.[36]

Before the Inflation Reduction Act (IRA) became law, analysts were already projecting that significantly increased penetration of plug-in electric vehicles would occur in the United States and in global markets. For example, in 2021, IHS Markit predicted a nearly 40 percent U.S. PEV share by 2030.[37] More recent projections by Bloomberg New Energy Finance suggest that under current policy and market conditions, and prior to the IRA, the U.S. was on pace to reach 40 to 50 percent PEVs by 2030.[38] When adjusted for the effects of the Inflation Reduction Act, this estimate increases to 52 percent.[39] Another study by the International Council on Clean Transportation (ICCT) and Energy Innovation that includes the effect of the IRA estimates that the share of BEVs will increase to 56 to 67 percent by 2032.[40] These projections typically are based on assessment of a range of existing and developing factors, including state policies (such as the California Advanced Clean Cars II program and its adoption by Section 177 states); although the assumptions and other inputs to these forecasts vary, they point to greatly increased penetration of electrification across the U.S. light-duty fleet in the coming years, without specifically considering the effect of increased emission standards under this proposed rule.

These trends echo an ongoing global shift toward electrification. Global light-duty passenger PEV sales (including BEVs and PHEVs) reached 6.6 million in 2021, bringing the total number of PEVs on the road to more than 16.5 million globally.[41] For fully-electric BEVs, global sales rose to 7.8 million in 2022, an increase of about 68 percent from the previous year and representing about 10 percent of the new global light-duty passenger vehicle market.[42] [43] Leading sales forecasts predict that BEV sales will continue to accelerate globally in the years to come. For example, in June 2022, Bloomberg New Energy Finance predicted that global sales will rise to 21 million in 2025 (implying an annual growth rate of about 39 percent from 2022), with total global vehicle stock reaching 77 million BEVs by 2025 and 229 million BEVs by 2030.[44]

The year-over-year growth in U.S. PEV sales suggests that an increasing share of new vehicle buyers are concluding that a PEV is the best vehicle to meet their needs. Many of the zero-emission vehicles already on the market today cost less to operate than ICE vehicles, offer improved performance and handling, have a driving range similar to that of ICE vehicles, and can be charged at a growing network of public chargers as well as at home.[45] [46] [47] [48] [49] [50] PEV owners often describe these advantages as key factors motivating their purchase.[51] A 2022 survey by Consumer Reports shows that more than one third of Americans would either seriously consider or definitely buy or lease a BEV today, if they were in the market for a vehicle.[52] Given that most consumers are currently much less familiar with BEVs than with ICE vehicles, this share is likely to rapidly grow as familiarity increases in response to increasing numbers of BEVs on the road and growing visibility of charging infrastructure. Most PEV owners who purchase a subsequent vehicle choose another PEV, and often express resistance to returning to an ICE vehicle after experiencing PEV ownership.[53] [54]

Recent literature indicates that consumer affinity for PEVs is strong. A recent study utilizing data from all new light-duty vehicles sold in the U.S. between 2014 and 2020, focused on comparisons of BEVs with their closest ICE counterparts, found that BEVs are

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[34] Environmental Protection Agency, ‘‘The 2022 EPA Automotive Trends Report: Greenhouse Gas Emissions, Fuel Economy, and Technology since 1975,’’ EPA–420–R–22–029, December 2022.

[35] Colias, M., ‘‘U.S. EV Sales Jolted Higher in 2022 as Newcomers Target Tesla,’’ Wall Street Journal, January 6, 2023.

[36] California Energy Commission, ‘‘New ZEV Sales in California’’ online dashboard, viewed on February 13, 2023 at *https://www.energy.ca.gov/data-reports/energy-almanac/zero-emission-vehicle-and-infrastructure-statistics/new-zev-sales*.

[37] IHS Markit, ‘‘US EPA Proposed Greenhouse Gas Emissions Standards for Model Years 2023–2026; What to Expect,’’ August 9, 2021. Accessed on March 9, 2023 at *https://www.spglobal.com/mobility/en/research-analysis/us-epa-proposed-greenhouse-gas-emissions-standards-my2023-26.html*. The table indicates 32.3% BEVs and combined 39.7% BEV, PHEV, and range-extended electric vehicle (REX) in 2030.

[38] Bloomberg New Energy Finance (BNEF), ‘‘Electric Vehicle Outlook 2022,’’ Long term outlook economic transition scenario.

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[42] Boston, W., ‘‘EVs Made Up 10% of All New Cars Sold Last Year,’’ Wall Street Journal, January 16, 2023.

[43] Colias, M., ‘‘U.S. EV Sales Jolted Higher in 2022 as Newcomers Target Tesla,’’ Wall Street Journal, January 6, 2023.

[44] Bloomberg NEF, ‘‘Net-Zero Road Transport By 2050 Still Possible, As Electric Vehicles Set To Quintuple By 2025,’’ June 1, 2022. Accessed on February 21, 2023 at *https://about.bnef.com/blog/net-zero-road-transport-by-2050-still-possible-as-electric-vehicles-set-to-quintuple-by-2025/*.

[45] Department of Energy Vehicle Technologies Office, Transportation Office, Transportation Analysis Fact of the Week #1186, ‘‘The National Average Cost of Fuel for an Eletric Vehicle is about 60% Less than for a Gasoline Vehicle,’’ May 17, 2021.

[46] Department of Energy Vehicle Technologies Office, Transportation Office, Transportation Analysis Fact of the Week #1190, ‘‘Battery-Electric Vehicles Have Lower Scheduled Maintenance Costs than Other Light-Duty Vehicles,’’ June 14, 2021.

[47] International Council on Clean Transportation, ‘‘Assessment of Light-Duty Electric Vehicle Costs and Consumer Benefits in the United States in the 2022–2035 Time Frame,’’ October 2022.

[48] Consumer Reports, ‘‘Electric Cars 101: The Answers to All Your EV Questions,’’ November 5, 2020. Accessed June 8, 2021 at *https://www.consumerreports.org/hybrids-evs/electric-cars-101-the-answers-to-all-your-ev-questions/.*

[49] Department of Energy Vehicle Technologies Office, Transportation Analysis Fact of the Week #1253, ‘‘Fourteen Model Year 2022 Light-Duty Electric Vehicle Models Have a Driving Range of 300 Miles or Greater,’’ August 29, 2022.

[50] Department of Energy Alternative Fuels Data Center, Electric Vehicle Charging Station Locations. Accessed on May 19, 2021 at *https://afdc.energy.gov/fuels/electricity_locations.html#/find/nearest?fuel=ELEC.*

[51] Hardman, S., and Tal, G., ‘‘Understanding discontinuance among California’s electric vehicle owners,’’ Nature Energy, v.538 n.6, May 2021 (pp. 538–545).

[52] Consumer Reports, ‘‘More Americans Would Buy an Electric Vehicle, and Some Consumers Would Use Low-Carbon Fuels, Survey Shows,’’ July 7, 2022. Accessed on March 8, 2023 at *https://www.consumerreports.org/hybrids-evs/interest-in-electric-vehicles-and-low-carbon-fuels-survey-a8457332578/.*

[53] Muller, J., ‘‘Most electric car buyers don’t switch back to gas,’’ *Axios.com.* Accessed on February 24, 2023 at *https://www.axios.com/2022/10/05/ev-adoption-loyalty-electric-cars.*

[54] Hardman, S., and Tal, G., ‘‘Understanding discontinuance among California’s electric vehicle owners,’’ Nature Energy, v.538 n.6, May 2021 (pp. 538-545).

preferred to the ICE counterpart in some segments.[55] In addition, when comparing all BEV sales with sales of the closest ICE counterparts, BEVs attain a market share of over 30 percent, which is significantly greater than the BEV market share among all vehicles.[56] This suggests that the share of PEVs in the marketplace is, at least partially, constrained due to the lack of offerings needed to convert existing demand into market share.[56] However, the number and diversity of electrified vehicle models is rapidly increasing.[56] For example, the number of PEV models available for sale in the U.S. has more than doubled from about 24 in MY 2015 to about 60 in MY 2021, with offerings in a growing range of vehicle segments.[57] Recent announcements indicate that this number will increase to more than 80 models by MY 2023,[58] and more than 180 models by 2025.[59]

According to the U.S. Bureau of Labor Statistics, growth in PEV sales is driven in part by growing consumer demand and growing automaker commitments to electrification and will be further supported by policy measures including the Bipartisan Infrastructure Law and the Inflation Reduction Act.[60] As the presence of PEVs in the fleet increases, consumers are encountering PEVs more often in their daily experience. Many analysts believe that as PEVs continue to increase their market share, PEV ownership will continue to broaden its appeal as consumers gain more exposure and experience with the technology and with the benefits of PEV ownership,[61] with some analysts suggesting that a ''tipping point'' for PEV adoption may then result.[62] [63] [64]

While the retail price of PEVs is typically higher than for comparable ICE vehicles at this time, the price difference is widely expected to narrow or disappear, particularly for BEVs, as the cost of batteries and other components fall in the coming years.[65] Among the many studies that address cost parity of BEVs vs. ICE vehicles, an emerging consensus suggests that purchase price parity is likely to occur by the mid-2020s for some vehicle segments and models, and for a broader segment of the market on a total cost of ownership (TCO) basis.[66] [67] By some accounts, a compact car with a relatively small battery (for example, a 40 kWh battery and approximately 150 miles of range) may already be possible to produce and sell for the same price as a compact ICE vehicle.[68] For larger vehicles and/or those with a longer range (either of which call for a larger battery), many analysts expect examples of price parity to increasingly appear over the mid- to late-2020s. Assessments of price parity often do not include the effect of various state and Federal purchase incentives. For example, the Clean Vehicle Credit provides up to $7,500, under the Inflation Reduction Act, effectively making some BEVs more affordable to buy and operate today than comparable ICE vehicles. Many expect TCO parity to precede price parity by several years, as it accounts for the reduced cost of operation and maintenance for BEVs.[69] [70] For example, Kelley Blue Book already estimates that the vehicle with lowest TCO in both the full-size pickup and luxury car classes of vehicle is a BEV.[71] [72] TCO parity is of particular interest to commercial and fleet operators, for whom lower TCO is a compelling business consideration.

A proliferation of announcements by automakers in the past two years signals a rapidly growing shift in product development focus among automakers away from internal-combustion technologies and toward electrification. For example, in January 2021, General Motors announced plans to become carbon neutral by 2040, including an effort to shift its light-duty vehicles entirely to zero-emissions by 2035.[73] In March 2021, Volvo announced plans to make only electric cars by 2030,[74] and Volkswagen announced that it expects half of its U.S. sales will be all-electric by 2030.[75] In April 2021, Honda announced a full electrification plan to take effect by 2040, with 40 percent of North American sales expected to be fully electric or fuel cell vehicles by 2030, 80 percent by 2035 and 100 percent by 2040.[76] In May 2021, Ford announced that they expect 40 percent of their global sales will be all-electric by 2030.[77] In June 2021, Fiat announced

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[55] Gillingham, K., van Benthem, A., Weber, S., Saafi, D., He, X. ''Has Consumer Acceptance of Electric Vehicles Been Increasing: Evidence from Microdata on Every New Vehicle Sale in the United States.'' American Economic Association: Papers & Proceedings, 2023, forthcoming. *https://resources.environment.yale.edu/gillingham/GBWSH_ConsumerAcceptanceEVs.pdf.*

[56] Muratori et al., ''The rise of electric vehicles—2020 status and future expectations,'' Progress in Energy v3n2 (2021), March 25, 2021. Accessed July 15, 2021 at *https://iopscience.iop.org/article/10.1088/2516-1083/abe0ad.*

[57] *Fueleconomy.gov,* 2015 Fuel Economy Guide and 2021 Fuel Economy Guide.

[58] Environmental Defense Fund and M.J. Bradley & Associates, ''Electric Vehicle Market Status—Update, Manufacturer Commitments to Future Electric Mobility in the U.S. and Worldwide,'' April 2021.

[59] Environmental Defense Fund and ERM, ''Electric Vehicle Market Update: Manufacturer Commitments and Public Policy Initiatives Supporting Electric Mobility in the U.S. and Worldwide,'' September 2022.

[60] U.S. Bureau of Labor Statistics, ''Charging into the future: the transition to electric vehicles,'' Beyond the Numbers v12 n4, February 2023. Available at: *https://www.bls.gov/opub/btn/volume-12/charging-into-the-future-the-transition-to-electric-vehicles.htm.*

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[62] Car and Driver, ''Electric Cars' Turning Point May Be Happening as U.S. Sales Numbers Start Climb,'' August 8, 2022. Accessed on February 24, 2023 at *https://www.caranddriver.com/news/a39998609/electric-car-sales-usa/.*

[63] Randall, T., ''US Crosses the Electric-Car Tipping Point for Mass Adoption,'' *Bloomberg.com*, July 9, 2022. Accessed on February 24, 2023 at *https://www.bloomberg.com/news/articles/2022-07-09/us-electric-car-sales-reach-key-milestone.*

[64] Romano, P., ''EV adoption has reached a tipping point. Here's how today's electric fleets will shape the future of mobility,'' Fortune, October 11, 2022. Accessed on February 24, 2023 at *https://fortune.com/2022/10/11/ev-adoption-tesla-semi-tipping-point-electric-fleets-future-mobility-pasquale-romano/*.

[65] International Council on Clean Transportation, ''Assessment of Light-Duty Electric Vehicle Costs and Consumer Benefits in the United States in the 2022–2035 Time Frame,'' October 2022.

[66] International Council on Clean Transportation, ''Assessment of Light-Duty Electric Vehicle Costs and Consumer Benefits in the United States in the 2022–2035 Time Frame,'' October 2022.

[67] Environmental Defense Fund and ERM, ''Electric Vehicle Market Update: Manufacturer Commitments and Public Policy Initiatives Supporting Electric Mobility in the U.S. and Worldwide,'' September 2022.

[68] Walton, R., ''Electric vehicle models expected to triple in 4 years as declining battery costs boost adoption,'' *UtilityDive.com,* December 14, 2020.

[69] International Council on Clean Transportation, ''Assessment of Light-Duty Electric Vehicle Costs and Consumer Benefits in the United States in the 2022–2035 Time Frame,'' October 2022.

[70] Environmental Defense Fund and ERM, ''Electric Vehicle Market Update: Manufacturer Commitments and Public Policy Initiatives Supporting Electric Mobility in the U.S. and Worldwide,'' September 2022.

[71] Kelley Blue Book, ''What is 5-Year Cost to Own?'', Full-size Pickup Truck selected (Ford F–150 Lighting is lowest TCO). Accessed on February 28, 2023 at *https://www.kbb.com/new-cars/total-cost-of-ownership/*.

[72] Kelley Blue Book, ''What is 5-Year Cost to Own?'', Luxury Car selected (Polestar 2 and Tesla Model 3 are lowest TCO). Accessed on February 28, 2023 at *https://www.kbb.com/new-cars/total-cost-of-ownership/*.

[73] General Motors, ''General Motors, the Largest U.S. Automaker, Plans to be Carbon Neutral by 2040,'' Press Release, January 28, 2021.

[74] Volvo Car Group, ''Volvo Cars to be fully electric by 2030,'' Press Release, March 2, 2021.

[75] Volkswagen Newsroom, ''Strategy update at Volkswagen: The transformation to electromobility was only the beginning,'' March 5, 2021. Accessed June 15, 2021 at *https://www.volkswagen-newsroom.com/en/stories/strategy-update-at-volkswagen-the-transformation-to-electromobility-was-only-the-beginning-6875*.

[76] Honda News Room, ''Summary of Honda Global CEO Inaugural Press Conference,'' April 23, 2021. Accessed June 15, 2021 at *https://global.honda/newsroom/news/2021/c210423eng.html.*

[77] Ford Motor Company, ''Superior Value From EVs, Commercial Business, Connected Services is

a move to all electric vehicles by 2030, and in July 2021 its parent corporation Stellantis announced an intensified focus on electrification across all of its brands.[78] [79] Also in July 2021, Mercedes-Benz announced that all of its new architectures would be electric-only from 2025, with plans to become ready to go all-electric by 2030 where possible.[80] In December 2021, Toyota announced plans to introduce 30 BEV models by 2030.[81] Figure 1, taken from work by the Environmental Defense Fund and ERM, illustrates how these and other announcements mean that virtually every major manufacturer of light-duty vehicles is already planning to introduce widespread electrification across their global fleets in the coming years.[82]

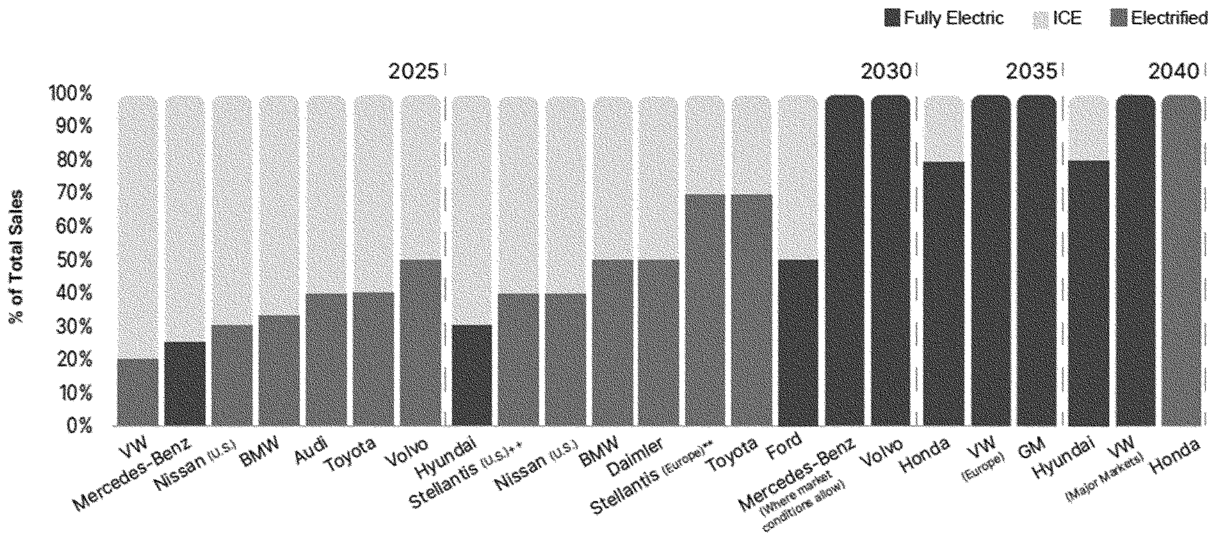

**Figure 1. Future electrified and fully electric global sales goals by manufacturer (EDF 2022).**

Accompanying this global-market focus on electrification, as shown in Figure 2, the number of PHEV and BEV models available in the U.S. has steadily grown, and a large number of public model announcements by manufacturers indicate further steep growth will occur in the years to come.

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Strategic Focus of Today's 'Delivering Ford+' Capital Markets Day,'' Press Release, May 26, 2021.

[78] Stellantis, ''World Environment Day 2021—Comparing Visions: Olivier Francois and Stefano Boeri, in Conversation to Rewrite the Future of Cities,'' Press Release, June 4, 2021.

[79] Stellantis, ''Stellantis Intensifies Electrification While Targeting Sustainable Double-Digit Adjusted Operating Income Margins in the Mid-Term,'' Press Release, July 8, 2021.

[80] Mercedes-Benz, ''Mercedes-Benz prepares to go all-electric,'' Press Release, July 22, 2021.

[81] Toyota Motor Corporation, ''Video: Media Briefing on Battery EV Strategies,'' Press Release, December 14, 2021. Accessed on December 14, 2021 at *https://global.toyota/en/newsroom/corporate/36428993.html.*

[82] Environmental Defense Fund and ERM, ''Electric Vehicle Market Update: Manufacturer Commitments and Public Policy Initiatives Supporting Electric Mobility in the U.S. and Worldwide,'' September 2022.

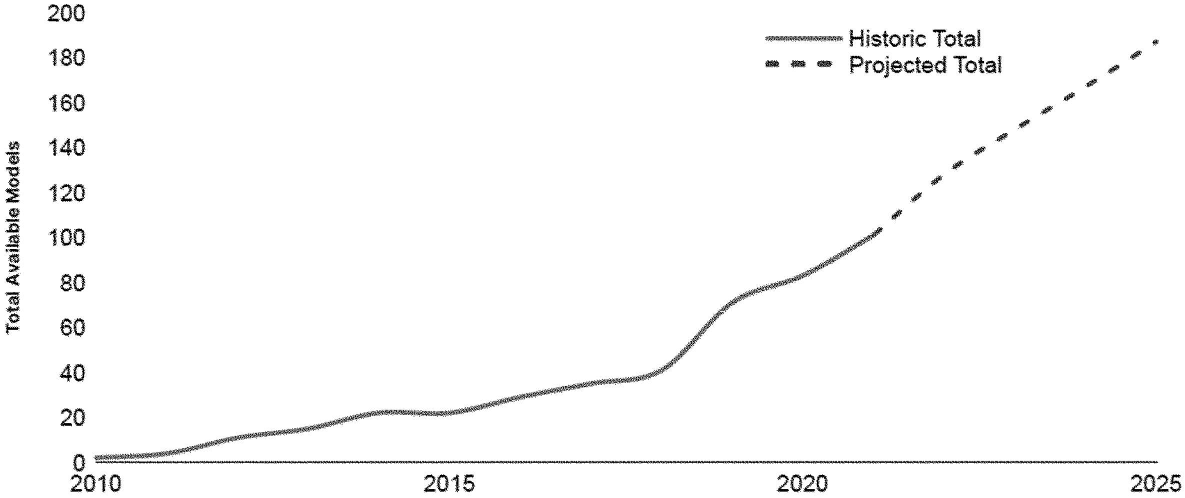

**Figure 2. Projection of total light-duty PHEV and BEV U.S. models available by year (EDF 2022).**

Globally and domestically, these ongoing announcements indicate a strong industry momentum toward electrification that is common to every major manufacturer. Given the breadth of these announcements, it is instructive to consider the penetrations of PEVs that they imply when taken collectively.

Table 1 compiles public announcements of U.S. and global electrification targets to date by major manufacturers. Assuming that the MY 2022 U.S. sales shares for each manufacturer were to persist in 2030, these targets would collectively imply a U.S. PEV sales share approaching 50 percent in 2030 (48.6 percent), consisting primarily of BEVs.

TABLE 1—EXAMPLE OF U.S. ELECTRIFIED NEW SALES PERCENTAGES IMPLIED BY OEM ANNOUNCEMENTS FOR 2030 OR BEFORE

| 2022 U.S. sales rank | OEM | Share of total 2022 U.S. sales [1] (%) | Stated EV share in 2030 [2] (%) | Powertrain [3] | Implied OEM contribution to 2030 total PEV market share (%) |
|---|---|---|---|---|---|
| 1 | General Motors | 16.4 | 50 | PEV | 8.2 |
| 2 | Toyota | 15.4 | [4] 33 | BEV | 5.1 |
| 3 | Ford | 13.1 | 50 | BEV | 6.5 |
| 4 | Stellantis | 11.2 | 50 | BEV | 5.6 |
| 5 | Honda | 7.2 | 40 | BEV | 2.9 |
| 6 | Hyundai | 5.7 | 50 | BEV | 2.8 |
| 7 | Nissan | 5.3 | 40 | BEV | 2.1 |
| 8 | Kia | 5.0 | 45 | BEV | 2.3 |
| 9 | Subaru | 4.1 | 40 | BEV | 1.6 |
| 10 | Volkswagen, Audi | 3.6 | 50 | BEV | 1.8 |
| 11 | Tesla | 3.4 | 100 | BEV | 3.4 |
| 12 | Mercedes-Benz | 2.6 | 100 | BEV | 2.6 |
| 13 | BMW | 2.6 | 50 | BEV | 1.3 |
| 14 | Mazda | 2.1 | 25 | BEV | 0.5 |
| 15 | Volvo | 0.8 | 100 | BEV | 0.8 |
| 16 | Mitsubishi | 0.6 | 50 | PEV [5] | 0.3 |
| 17 | Porsche | 0.5 | 80 | BEV | 0.4 |
| 18 | Land Rover | 0.4 | 60 | BEV | 0.3 |
| 19 | Jaguar | 0.07 | 100 | BEV | 0.7 |
| 20 | Lucid | 0.02 | 100 | BEV | 0.02 |
| Total | | 100.0 | | | 48.6 |

**Notes:**

[1] 2022 U.S. sales shares based on data from Ward's Automotive Intelligence.

[2] Where a U.S. target was not specified, the global target was assumed for the U.S.

[3] PEV = combination of BEV and PHEV. PEV and BEV may include fuel cell electric vehicles (FCEV).

[4] Based on announced goal of 3.5 million BEVs globally in 2030, divided by 10.5 million vehicles sold in 2022.

[5] Announcement includes unspecified amount of HEVs.

A version of this table with supporting citations for each automaker announcement, and the raw data with additional tabulations, are available in the Docket.[83]

While manufacturer announcements such as these are not binding, and often are conditioned as forward-looking and subject to uncertainty, they indicate that manufacturers are confident in the suitability of PEV technology as an effective and attractive option that can serve the functional needs of a large portion of light-duty vehicle buyers.

As seen in Figure 3, an analysis by the International Energy Agency similarly concludes that the 2030 U.S. zero-emission vehicle sales share collectively implied by such announcements (''range of OEM declarations'') would amount to nearly 50 percent if not more, far exceeding the 20 percent that IEA considers sufficient to meet existing U.S. policies and regulations (''Stated Policies'' scenario).[84]

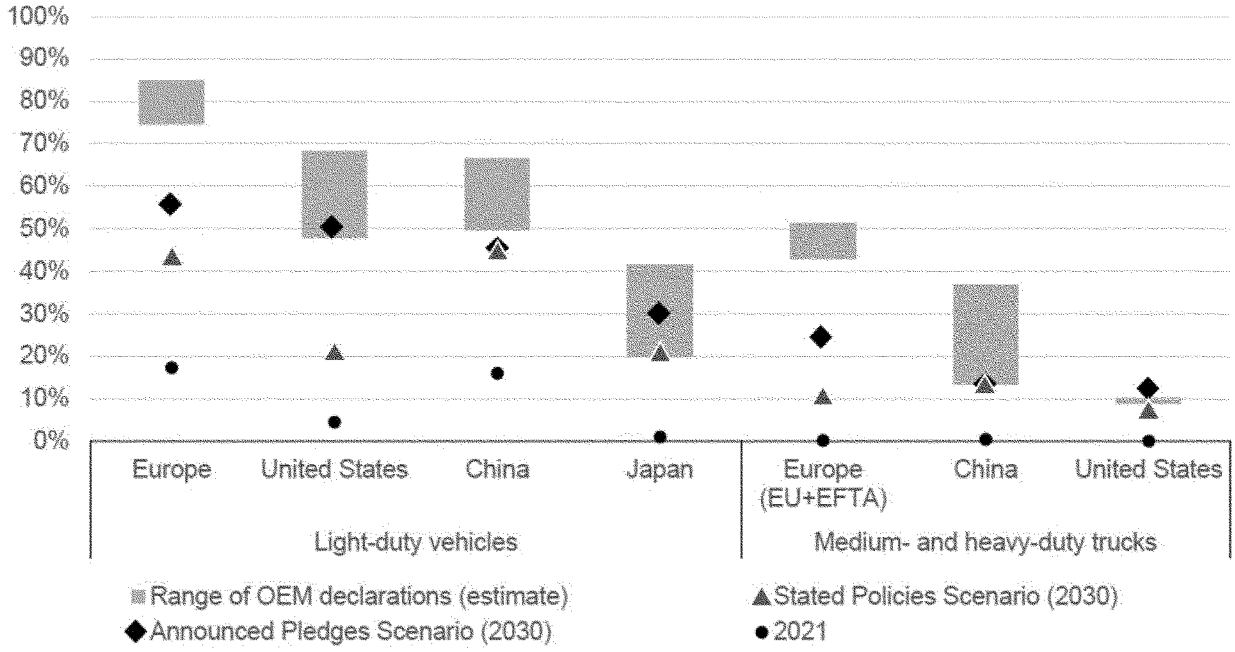

**Figure 3. Estimated zero-emission vehicle sales shares resulting from OEM announcements compared to stated and potential policies (IEA 2022).**

Fleet electrification plans are not limited to light-duty vehicles. Numerous commitments to purchase all-electric medium-duty delivery vans have been announced by large fleet owners including FedEx,[85] Amazon,[86] and Walmart,[87] in partnerships with various OEMs. For example, Amazon has deployed thousands of electric delivery vans in over 100 cities, with the goal of 100,000 vans by 2030. Many other fleet electrification commitments that include large numbers of medium-duty and heavier vehicles have been announced by large corporations in many sectors of the economy, including not only retailers like Amazon and Walmart but also consumer product manufacturers with large delivery fleets (*e.g.* IKEA, Unilever), large delivery firms (*e.g.* DHL, FedEx, USPS), and numerous firms in many other sectors including power and utilities, biotech, public transportation, and municipal fleets across the country.[88] As another example, Daimler Trucks North America announced in 2021 that it expected 60 percent of its sales in 2030 and 100 percent of its sales by 2039 would be zero-emission.[89]

These announcements and others like them continue a pattern over the past several years in which most major manufacturers have taken steps to aggressively invest in zero-emission technologies and reduce their reliance on the internal-combustion engine in various markets around the globe.[90] [91] According to one analysis, 37 of the world's automakers are planning to invest a total of almost $1.2 trillion by 2030 toward electrification,[92] a large

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[83] See Memo to Docket ID No. EPA–HQ–OAR–2022–0829 titled ''Electrification Announcements and Implied PEV Penetration by 2030.''

[84] International Energy Agency, ''Global EV Outlook 2022,'' p. 107, May 2022. Accessed on November 18, 2022 at *https://iea.blob.core.windows.net/assets/e0d2081d-487d-4818-8c59-69b638969f9e/GlobalElectricVehicleOutlook2022.pdf.*

[85] BrightDrop, ''BrightDrop Accelerates EV Production with First 150 Electric Delivery Vans Integrated into FedEx Fleet,'' Press Release, June 21, 2022.

[86] Amazon Corporation, ''Amazon's Custom Electric Delivery Vehicles from Rivian Start Rolling Out Across the U.S.,'' Press Release, July 21, 2022.

[87] Walmart, ''Walmart To Purchase 4,500 Canoo Electric Delivery Vehicles To Be Used for Last Mile Deliveries in Support of Its Growing eCommerce Business,'' Press Release, July 12, 2022.

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[89] Carey, N., ''Daimler Truck 'all in' on green energy as it targets costs,'' May 20, 2021.

[90] Environmental Defense Fund and M.J. Bradley & Associates, ''Electric Vehicle Market Status—Update, Manufacturer Commitments to Future Electric Mobility in the U.S. and Worldwide,'' April 2021.

[91] International Council on Clean Transportation, ''The end of the road? An overview of combustion-engine car phase-out announcements across Europe,'' May 10, 2020.

[92] Reuters, ''A Reuters analysis of 37 global automakers found that they plan to invest nearly $1.2 trillion in electric vehicles and batteries through 2030,'' October 21, 2022. Accessed on November 4, 2022 at *https://graphics.reuters.com/AUTOS-INVESTMENT/ELECTRIC/akpeqgzqypr/.*

portion of which will be used for construction of manufacturing facilities for vehicles, battery cells and packs, and materials, supporting up to 5.8 terawatt-hours of battery production and 54 million BEVs per year globally.[93] Similarly, an analysis by the Center for Automotive Research shows that a significant shift in North American investment is occurring toward electrification technologies, with $36 billion of about $38 billion in total automaker manufacturing facility investments announced in 2021 being slated for electrification-related manufacturing in North America, with a similar proportion and amount on track for 2022.[94] For example, in September 2021, Toyota announced large new investments in battery production and development to support an increasing focus on electrification,[95] and in December 2021, announced plans to increase this investment.[96] In December 2021, Hyundai closed its engine development division at its research and development center in Namyang, South Korea in order to refocus on BEV development.[97] In summer 2022, Hyundai invested $5.5 billion to fund new battery and electric vehicle manufacturing facilities in Georgia, and recently announced a $1.9 billion joint venture with SK to fund additional battery manufacturing in the U.S.[98] [99]

On August 5, 2021, many of these automakers, as well as the Alliance for Automotive Innovation, expressed continued commitment to their announcements of a shift to electrification, and expressed their support for the goal of achieving 40 to 50 percent sales of zero-emission vehicles by 2030.[100] In September 2022, jointly with the Environmental Defense Fund, General Motors announced a set of recommendations that ‘‘seek to accelerate a zero-emissions, all-electric future for passenger vehicles in model year 2027 and beyond,’’ including a recommendation that EPA establish standards to achieve at least a 60 percent reduction in GHG emissions (compared to MY 2021) and 50 percent zero-emitting vehicles by MY 2030, and that standards be consistent with eliminating tailpipe pollution from new passenger vehicles by 2035. GM and EDF further recommended that the EPA standards extend at least through MY 2032, and that EPA should consider adoption through 2035.[101]

Investments in PEV charging infrastructure have grown rapidly in recent years and are expected to continue to climb. According to BloombergNEF, annual global investment was $62 billion in 2022, nearly twice that of the prior year, and while about 10 years was needed for cumulative investment to total $100 billion, a total of $200 billion could be reached in just three more years.[102] U.S. infrastructure spending has also grown quickly. Combined investments in hardware and installation for U.S. home and public charging ports was over $1.2 billion in 2021, nearly a three-fold increase from 2017.[103]

The U.S. government is making large investments in infrastructure through the Bipartisan Infrastructure Law [104] and the Inflation Reduction Act.[105] However, we expect that private investments will also play a critical role in meeting future infrastructure needs. Private charging companies have already attracted billions globally in venture capital and mergers and acquisitions.[106] In the United States, there was $200 million or more in mergers and acquisition activity in 2022 [107] indicating strong interest in the future of the charging industry. And Bain projects that by 2030, the U.S. market for electric vehicle charging will be ‘‘large and profitable’’ with both revenue and profits estimated to grow by a factor of twenty relative to 2021.[108] Automakers, electric companies, charging network providers, and retailers are among those who have made significant commitments to expand charging infrastructure in the coming years.[109] See Section IV.C.4 of this document and DRIA Chapter 5 for a discussion of public and private infrastructure investments.

Taken together, these developments indicate that proven, zero-emissions technologies such as BEVs, PHEVs, and FCEVs are already poised to become a rapidly growing segment of the U.S. fleet, as manufacturers continue to invest in these technologies and integrate them into their product plans, and infrastructure continues to be developed. Accordingly, EPA considers these technologies to be an available and feasible way to greatly reduce emissions, and expects that these technologies will likely play a significant role in meeting the proposed standards for both criteria pollutants and GHGs.

At the same time, EPA anticipates that a compliant fleet under the proposed standards would include a diverse range of technologies. The advanced gasoline technologies that have played a

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[93] Reuters, ‘‘Exclusive: Automakers to double spending on EVs, batteries to $1.2 trillion by 2030,’’ October 25, 2022. Accessed on November 4, 2022 at *https://www.reuters.com/technology/exclusive-automakers-double-spending-evs-batteries-12-trillion-by-2030-2022-10-21/.*

[94] Center for Automotive Research, ‘‘Automakers Invest Billions in North American EV and Battery Manufacturing Facilities,’’ July 21, 2022. Retrieved on November 10, 2022 at *https://www.cargroup.org/automakers-invest-billions-in-north-american-ev-and-battery-manufacturing-facilities/.*

[95] Toyota Motor Corporation, ‘‘Video: Media briefing & Investors briefing on batteries and carbon neutrality’’ (transcript), September 7, 2021. Accessed on September 16, 2021 at *https://global.toyota/en/newsroom/corporate/35971839.html#presentation.*

[96] Toyota Motor Corporation, ‘‘Video: Media Briefing on Battery EV Strategies,’’ Press Release, December 14, 2021. Accessed on December 14, 2021 at *https://global.toyota/en/newsroom/corporate/36428993.html.*

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[104] *https://www.congress.gov/117/plaws/publ58/PLAW-117publ58.pdf.*

[105] *https://www.congress.gov/117/plaws/publ169/PLAW-117publ169.pdf.*

[106] Hampleton, ‘‘Autotech & Mobility M&A market report 1H2023’’. Accessed March 4, 2023, at *https://www.hampletonpartners.com/fileadmin/user_upload/Report_PDFs/Hampleton-Partners-Autotech-Mobility-Report-1H2023-FINAL.pdf.*

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fundamental role in meeting previous standards will continue to play an important role going forward as they remain key to reducing the criteria and GHG emissions of ICE, mild hybrid (MHEV), and strong HEV powertrains as well as PHEVs. The proposed standards will also provide regulatory certainty to support the many private automaker announcements and investments in zero-emission vehicles that have been outlined in the preceding paragraphs. In developing the proposed standards, EPA has also considered many of the key issues associated with growth in penetration of zero-emission vehicles, including charging infrastructure, consumer acceptance, critical minerals and mineral security, and others, as well as the need to consider emissions from the many ICE vehicles that will enter the fleet during this time. We discuss each of these issues in more detail in respective sections of the Preamble and Draft Regulatory Impact Analysis (DRIA).

### iii. The Bipartisan Infrastructure Law and Inflation Reduction Act

A particular consideration with regard to the increased penetration of zero-emission vehicle technology is Congress' recent passage of the Bipartisan Infrastructure Law (BIL)[110] and the Inflation Reduction Act (IRA).[111] These measures represent significant Congressional support for investment in expanding the manufacture, sale, and use of zero-emission vehicles by addressing elements critical to the advancement of clean transportation and clean electricity generation in ways that will facilitate and accelerate the development, production and adoption of zero-emission technology during the time frame of the rule.

The BIL became law in November 2021 and includes a wide range of programs and significant funding for infrastructure investments, many of which are oriented toward reducing GHG emissions across the U.S. transportation network, upgrading power generation infrastructure, and making the transportation infrastructure resilient to climate impacts such as extreme weather. Notably, in support of light-duty zero-emissions transportation the BIL included $7.5 billion in funding for installation of public charging and other alternative fueling infrastructure. This will have a major impact on feasibility of PEVs across the U.S. by improving access to charging and other infrastructure, and it will further support the Administration's goal of deploying 500,000 PEV chargers by 2030. It also includes $5 billion for electrification of school buses through the Clean School Bus Program, providing for further reductions in emissions from the heavy-duty sector.[112] [113] To help ensure that clean vehicles are powered by clean energy, it also includes $65 billion to upgrade the power infrastructure to facilitate increased use of renewables and clean energy.

The IRA became law in August 2022, bringing significant new momentum to clean vehicles (PEVs and FCEVs) through measures that reduce the cost to purchase and manufacture them, incentivize the growth of manufacturing capacity and onshore sourcing of critical minerals needed for their manufacture, incentivize buildout of public charging infrastructure for PEVs, and promote modernization of the electrical grid that will power them. It includes significant purchase incentives of up to $7,500 for new clean vehicles (Clean Vehicle Credit, IRS 30D) and up to $4,000 for used vehicles (IRS 25E), which will have a strong impact on affordability of these vehicles for a wide range of customers. These incentives extend not only to light-duty vehicles but also to commercial purchase of light- and medium-duty vehicles, with a credit of up to $40,000 for the latter (Commercial Clean Vehicle Credit, IRS 45W). Manufacturer production tax incentives of $35 per kilowatt-hour (kWh) for U.S. production of battery cells, $10 per kWh for U.S. production of modules, and 10 percent of production cost for U.S.-made critical minerals and battery active materials (Production Tax Credit, IRS 45X), will significantly reduce the manufacturing cost of these components, further reducing PEV and FCEV cost for consumers. In addition, the IRA includes significant tax credits for certain charging infrastructure equipment, and sizeable incentives for investment in and production of clean electricity.

With respect to sourcing of critical minerals and building a secure supply chain for clean vehicles, the IRA also includes provisions that will greatly reduce reliance on foreign imports by strongly supporting the continued development of a domestic or North American supply chain for these critical products. Manufacturers who want their customers to take advantage of the Clean Vehicle Credit must meet a gradually increasing requirement for sourcing of critical minerals and battery components from U.S. or free-trade countries, and cannot utilize content acquired from foreign entities of concern. Manufacturer eligibility for the Production Tax Credit for cells and modules is conditioned on their manufacture in the U.S., as is eligibility for the 10 percent credit on the cost of producing critical minerals and battery active materials. Manufacturers are already taking advantage of these opportunities to improve their sales and reduce their production costs by securing eligible sources of critical mineral content and siting new production facilities in the U.S.[114] [115] [116] [117] [118] [119] [120] [121] [122] There is a coordinated effort by Executive Branch agencies, including the Department of Energy and the National Laboratories, to provide guidance and resources and to administer funding to support this collective effort to further develop a robust supply chain for clean vehicles and the infrastructure that will support them.[123] [124] [125] Section IV.C.6 of this

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[110] *https://www.congress.gov/117/plaws/publ58/PLAW-117publ58.pdf.*

[111] *https://www.congress.gov/117/plaws/publ169/PLAW-117publ169.pdf.*

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Continued

Preamble and Chapters 3.1.3.2 and 3.1.3.3 of the DRIA discuss these provisions and measures in more detail.

Congressional passage of the BIL and IRA represent pivotal milestones in the creation of a broad-based infrastructure instrumental to the expansion of clean transportation, including light- and medium-duty zero-emission vehicles, and we have taken these developments into account in our assessment of the feasibility of the proposed standards.

### *B. Summary of Proposed Light- and Medium-Duty Vehicle Emissions Programs*

EPA is proposing emissions standards for both light-duty and medium-duty vehicles. The light-duty vehicle category includes passenger cars and light trucks consistent with previous EPA criteria pollutant and GHG rules. In this rule, heavy-duty Class 2b and 3 vehicles are referred to as ''medium-duty vehicles'' (MDVs) to distinguish them from Class 4 and higher vehicles that remain under the heavy-duty program. EPA has not previously used the MDV nomenclature, referring to these larger vehicles in prior rules as light-heavy-duty vehicles,[126] heavy-duty Class 2b and 3 vehicles,[127] or heavy-duty pickups and vans.[128] In the context of this rule, the MDV category includes primarily large pickups and vans with a gross vehicle weight rating (GVWR) of between 8,501 and 14,000 pounds and excludes vehicles used primarily as passenger vehicles (medium-duty passenger vehicles, or MDPVs).

The proposed program consists of several key elements: More stringent emissions standards for criteria pollutants, more stringent emissions standards for GHGs, changes to certain optional credit programs, durability provisions for light-duty electrified vehicle batteries and warranty provisions for both electrified vehicles and diesel engine-equipped vehicles, and various improvements to several elements of the existing light-duty program that will also apply to the proposed program.

The levels of stringency proposed in this rule for both light- and medium-duty vehicles continue the trend over the past fifty years for criteria pollutants, and over the past decade for GHGs, of EPA establishing numerically lower emissions standards based on continued advancements in emissions control technology that make it possible to achieve important emissions reductions at a reasonable cost. While EPA's feasibility assessments in past rulemakings were predominantly based on advancements in ICE technologies that provided incremental emissions reductions, in this proposal EPA's technology feasibility assessment includes the increasing availability of zero and near-zero tailpipe emissions technologies, including PEVs, as a cost-effective compliance technology. The technological feasibility of PEVs is further bolstered by the economic incentives provided in the IRA and the auto manufacturers' stated plans for producing significant volumes of zero and near-zero emission vehicles in the timeframe of this rule. Because of this increased feasibility of zero and near-zero tailpipe emissions technologies, EPA believes it is appropriate to propose over the six-year timeframe of these standards even lower emissions standards than has been possible in past rulemakings.

#### 1. GHG Emissions Standards

EPA is proposing more stringent GHG standards for both light-duty vehicles and medium-duty vehicles for MYs 2027 through 2032. EPA also seeks comment on whether the standards should continue to increase in stringency for future years, such as through MY 2035. For light-duty vehicles, EPA is proposing standards that would increase in stringency each year over a six-year period, from MYs 2027–2032. The proposed standards are projected to result in an industry-wide average target for the light-duty fleet of 82 grams/mile (g/mile) of $CO_2$ in MY 2032, representing a 56 percent reduction in projected fleet average GHG emissions target levels from the existing MY 2026 standards.

For medium-duty vehicles, EPA is proposing to revise the existing standard for MY 2027 given the increased feasibility of GHG emissions reducing technologies in this sector in this time frame. EPA's proposed standards for MDVs would increase in stringency year over year from MY 2027 through MY 2032. When phased in, the MDV standards are projected to result in an average target of 275 grams/mile of $CO_2$ by MY 2032, which would represent a reduction of 44 percent compared to the current MY 2026 standards.

The light-duty $CO_2$ standards continue to be footprint-based, with separate standards curves for cars and light trucks. EPA has updated its assessment of the footprint standards curves to reflect anticipated changes in the vehicle technologies that we project will be used to meet the standards. EPA also has assessed ways to ensure future fleet mix changes do not inadvertently provide an incentive for manufacturers to change the size or regulatory class of vehicles as a compliance strategy. EPA is proposing to revise the footprint standards curves to flatten the slope of each curve and to narrow the numerical stringency difference between the car and truck curves. The medium-duty vehicle standards continue to be based on a work-factor metric designed for commercially-oriented vehicles, which reflects a combination of payload, towing and 4-wheel drive equipment.

EPA has reassessed certain credit programs available under the existing GHG programs in light of experience with the program implementation to date, trends in technology development, recent related statutory provisions, and other factors. EPA is proposing to revise the air conditioning (AC) credits program in two ways. First, for AC system efficiency credits under the light-duty GHG program, EPA is proposing to limit the eligibility for these voluntary credits for tailpipe $CO_2$ emissions control to ICE vehicles starting in MY 2027 (*i.e.,* BEVs would not earn AC efficiency credits because even without such credits they would be counted as zero g/mi $CO_2$ emissions for compliance calculations). Second, EPA is proposing to remove refrigerant-based AC provisions for both light- and medium-duty vehicles because, under a separate rulemaking, EPA has proposed to disallow the use of high global warming potential refrigerants under the American Innovation and Manufacturing (AIM) Act of 2020.

EPA is also proposing to sunset the off-cycle credits program for both light and medium-duty vehicles as follows. First, EPA proposes to phase out menu-based credits by reducing the menu credit cap year-over-year until it is fully phased out in MY 2031. Specifically, EPA is proposing a declining menu cap of 10/8/6/3/0 g/mile over MYs 2027–2031 such that MY 2030 would be the last year manufacturers could generate optional off-cycle credits. Second, EPA proposes to eliminate the 5-cycle and public process pathways starting in MY 2027. Third, EPA proposes to limit eligibility for off-cycle credits only to vehicles with tailpipe emissions greater than zero (*i.e.,* vehicle equipped with IC engines) starting in MY 2027.

EPA is not reopening its averaging, banking, and trading provisions, which continue to be a central part of its fleet average standards compliance program and which help manufacturers to employ a wide range of compliance

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Chain for Advanced Batteries for Vehicles and Energy Storage,'' February 11, 2022. Available at: *https://www.energy.gov/articles/biden-administration-doe-invest-3-billion-strengthen-us-supply-chain-advanced-batteries.*

[126] 66 FR 5002, January 18, 2001.

[127] 79 FR 23414, April 28, 2014.

[128] 76 FR 57106, September 15, 2011.

paths. EPA is also not proposing to restore multiplier incentives for BEVs, PHEVs and fuel cell vehicles, which currently end after MY 2024 under existing regulations. EPA is proposing to revise multiplier incentives currently in place for MDVs through MY 2027, established in the heavy-duty Phase 2 rule, to end the multipliers a model year earlier, in MY 2026. EPA is also proposing that the requirement for upstream emissions accounting for BEVs and PHEVs as part of a manufacturer's compliance calculation, which under the current regulations would begin in MY 2027, would be removed under the proposed program; thus, BEVs would continue to be counted as zero grams/mile in a manufacturer's compliance calculation as has been the case since the beginning of the light-duty GHG program in MY 2012.

Finally, EPA also is proposing changes to the provisions for small volume manufacturers (*i.e.,* production of less than 5,000 vehicles per year) to transition them from the existing approach of unique case-by-case alternative standards to the primary program standards by MY 2032, recognizing that additional lead time is appropriate given their challenges in averaging across limited product lines.

### 2. Criteria Pollutant Standards

EPA is proposing more stringent emissions standards for criteria pollutants for both light-duty and medium-duty vehicles for MYs 2027–2032. For light-duty vehicles, EPA is proposing non-methane organic gases (NMOG) plus nitrogen oxides ($NO_X$) standards that would phase-down to a fleet average level of 12 mg/mi by MY 2032, representing a 60 percent reduction from the existing 30 mg/mi standards for MY 2025 established in the Tier 3 rule in 2014. For medium-duty vehicles, EPA is proposing NMOG+$NO_X$ standards that would require a fleet average level of 60 mg/mi by MY 2032, representing a 66 percent to 76 percent reduction from the Tier 3 standards of 178 mg/mi for Class 2b vehicles and 247 mg/mi for Class 3 vehicles. EPA is proposing cold temperature (−7 °C) NMOG+$NO_X$ standards for light- and medium-duty vehicles to ensure robust emissions control over a broad range of operating conditions.

For both light-duty and all medium-duty vehicles, EPA is proposing a particulate matter (PM) standard of 0.5 mg/mi and a requirement that the standard be met across three test cycles, including a cold temperature (−7 °C) test. This proposed standard would revise the existing PM standards established in the 2014 Tier 3 rule. Through the application of readily available emissions control technology and requiring compliance across the broad range of driving conditions represented by the three test cycles, EPA projects the standards will reduce tailpipe PM emissions from ICE vehicles by over 95 percent. In addition to reducing PM emissions, the proposed standards would reduce emissions of mobile source air toxics.

EPA is also proposing requirements to certify compliance with criteria pollutants standards for medium-duty vehicles with high gross combined weight rating (GCWR) under the heavy-duty engine program, changes to medium-duty vehicle refueling emissions requirements for incomplete vehicles, and several NMOG+$NO_X$ provisions aligned with the CARB Advanced Clean Cars II program for light-duty vehicles. EPA is proposing changes to the carbon monoxide and formaldehyde standards for light- and medium-duty vehicles, including at −7 °C. EPA is also proposing to eliminate commanded enrichment for ICE-powered vehicles for power and component protection. Averaging, banking, and trading provisions may be employed within the new program, and with certain limitations, credits may be transferred from the Tier 3 program to provide manufacturers with flexibilities in developing compliance strategies.

In addition to these proposals, EPA is seeking comment on potential future gasoline fuel property standards aimed at further reducing PM emissions, for consideration in a possible subsequent rulemaking, which could provide an important complement to the vehicle standards being proposed in the current action. The proposed emissions standards for new vehicles in model years 2027 and later would achieve significant air quality benefits. However, there is an opportunity to further reduce PM emissions from the existing vehicle fleet, the millions of vehicles that will be produced during the phase-in period of the proposed vehicle standards, as well as millions of nonroad gasoline engines, through changes in market fuel composition. Although EPA has not undertaken sufficient analysis to propose changes to fuel requirements under CAA section 211(c) in this rulemaking and considers such changes beyond the scope of this rulemaking, EPA has begun to consider the possibility of such changes and, in Section IX, EPA describes and requests comment on various aspects of a possible future rulemaking aimed at further PM reductions from these sources via gasoline fuel property standards.

### 3. Electrified Vehicle Battery Durability and Warranty Provisions

As described in more detail in Section III.F.2, the importance of battery durability in the context of BEVs and PHEVs as an emission control technology is well documented and has been cited by several authorities in recent years. Recognizing that electrified vehicles are playing an increasing role in automakers' compliance strategies, that their durability and reliability are important to achieving the emissions reductions projected by this proposed program, and that emissions credit calculations are based on mileage over a vehicle's full useful life, EPA is proposing new battery durability requirements for light-duty and medium-duty BEVs and PHEVs. In addition, the agency is proposing revised regulations which would include BEV and PHEV batteries and associated electric powertrain components under existing emission warranty provisions. Relatedly, EPA is also proposing the addition of two new grouping definitions for BEVs and PHEVs (monitor family and battery durability family), new reporting requirements, and a new calculation for the PHEV charge depletion test to support the battery durability requirements. The background and content of the proposed battery durability and warranty provisions are outlined in Section III.F.2 of this Preamble and are detailed in the regulatory text.

### 4. Light-Duty Vehicle Certification and Testing Program Improvements

EPA is proposing various improvements to the current light-duty program in order to clarify, simplify, streamline and update the certification and testing provisions for manufacturers. These proposed improvements include: Clarification of the certification compliance and enforcement requirements for $CO_2$ exhaust emission standards found in 40 CFR 86.1865–12 to more accurately reflect the intention of the 2010 light-duty vehicle GHG rule; a revision to the In Use Confirmatory Program (IUCP) threshold criteria; changes to the Part 2 application; updating the On Board Diagnostics (OBD) program to the latest version of the CARB OBD regulation and the removal of any conflicting or redundant text from EPA's OBD requirements; streamlining the test procedures for Fuel Economy Data Vehicles (FEDVs); streamlining the manufacturer conducted confirmatory testing requirements; updating the emissions warranty for diesel powered vehicles (including Class 2b and 3 vehicles) by designating major emissions components subject to the 8 year/80,000 mile warranty period; making the definition of light-duty truck consistent between programs; and miscellaneous other amendments. EPA is also proposing to add a new monitoring and warranty requirement for gasoline particulate filters (GPFs). These improvements and changes are described in more detail in Sections III.F and III.G.

### *C. Summary of Emission Reductions, Costs, and Benefits*

This section summarizes our analysis of the proposal's estimated emission impacts, costs, and monetized benefits, which is described in more detail in Sections V through VIII of this preamble. EPA notes that, consistent with CAA section 202, in evaluating potential standards we carefully weigh the statutory factors, including the emissions impacts of the standards, and the feasibility of the standards (including cost of compliance in light of available lead time). We monetize benefits of the proposed standards and evaluate other costs in part to enable a comparison of costs and benefits pursuant to E.O. 12866, but we recognize there are benefits that we are currently unable to fully quantify. EPA's practice has been to set standards to achieve improved air quality consistent with CAA section 202, and not to rely on cost-benefit calculations, with their uncertainties and limitations, as identifying the appropriate standards. Nonetheless, our conclusion that the estimated benefits considerably exceed the estimated costs of the proposed program reinforces our view that the proposed standards are appropriate under section 202(a).

The proposed standards would result in net reductions of emissions of GHGs and criteria air pollutants in 2055, considering the impacts from light- and medium-duty vehicles, power plants (*i.e.,* electric generating units (EGUs)), and refineries. Table 2 shows the GHG emission impacts in 2055 while Table 3 shows the cumulative impacts for the years 2027 through 2055. We show cumulative impacts for GHGs as elevated concentrations of GHGs in the atmosphere are resulting in warming and changes in the Earth's climate. Table 4 shows the criteria pollutant emissions impacts in 2055. As shown in Table 5, we also predict reductions in air toxic emissions from light-and medium-duty vehicles. We project that GHG and criteria pollutant emissions from EGUs would increase as a result of the increased demand for electricity associated with the proposal, although those projected impacts decrease over time because of projected increases in renewables in the future power generation mix. We also project that GHG and criteria pollutant emissions from refineries would decrease as a result of the lower demand for liquid fuel associated with the proposed GHG standards. Sections VI and VII of this preamble and Chapter 9 of the DRIA provide more information on the projected emission reductions for the proposed standards and alternatives.

TABLE 2—PROJECTED GHG EMISSION IMPACTS IN 2055 FROM THE PROPOSED RULE, LIGHT-DUTY AND MEDIUM-DUTY

[Million metric tons]

| Pollutant | Vehicle | EGU | Refinery * | Net impact | Net impact (%) |
|---|---|---|---|---|---|
| $CO_2$ | −440 | 16 | 0 | −420 | −47 |
| $CH_4$ | −0.0088 | 0.00038 | 0 | −0.0084 | −45 |
| $N_2O$ | −0.0077 | 0.00003 | 0 | −0.0077 | −41 |

* GHG emission rates were not available for calculating GHG inventories from refineries.

TABLE 3—PROJECTED CUMULATIVE GHG EMISSION IMPACTS THROUGH 2055 FROM THE PROPOSED RULE, LIGHT-DUTY AND MEDIUM-DUTY

[Million metric tons]

| Pollutant | Vehicle | EGU | Refinery * | Net impact | Net impact (%) |
|---|---|---|---|---|---|
| $CO_2$ | −8,000 | 710 | 0 | −7,300 | −26 |
| $CH_4$ | −0.16 | 0.035 | 0 | −0.12 | −17 |
| $N_2O$ | −0.14 | 0.0045 | 0 | −0.13 | −25 |

TABLE 4—PROJECTED CRITERIA AIR POLLUTANT IMPACTS IN 2055 FROM THE PROPOSED RULE, LIGHT-DUTY AND MEDIUM-DUTY

[U.S. tons]

| Pollutant | Vehicle | EGU | Refinery | Net impact | Net impact (%) |
|---|---|---|---|---|---|
| $PM_{2.5}$ | −9,800 | 1,500 | −6,900 | −15,000 | −35 |
| $NO_X$ | −44,000 | 2,600 | −25,000 | −66,000 | −41 |
| VOC | −200,000 | 1,000 | −21,000 | −220,000 | −50 |
| $SO_X$ | −2,800 | 1,600 | −11,000 | −12,000 | −42 |
| CO * | −1,800,000 | 0 | 0 | −1,800,000 | −49 |

* EPA did not have data available to calculate CO impacts from EGUs or refineries.

TABLE 5—PROJECTED AIR TOXIC IMPACTS FROM VEHICLES IN 2055 FROM THE PROPOSED RULE, LIGHT-DUTY AND MEDIUM-DUTY

[U.S. tons]

| Pollutant | Vehicle | Vehicle (%) |
|---|---|---|
| Acetaldehyde | −840 | −49 |
| Acrolein | −55 | −48 |
| Benzene | −2,900 | −51 |
| Ethylbenzene | −3,400 | −50 |
| Formaldehyde | −510 | −49 |
| Naphthalene | −100 | −51 |
| 1,3-Butadiene | −340 | −51 |
| 15 Polyaromatic Hydrocarbons | −5 | −78 |

The GHG emission reductions would contribute toward the goal of holding the increase in the global average temperature to well below 2 °C above pre-industrial levels, and subsequently reduce the probability of severe climate change related impacts including heat waves, drought, sea level rise, extreme climate and weather events, coastal flooding, and wildfires. People of color, low-income populations and/or indigenous peoples may be especially vulnerable to the impacts of climate change (see Section VIII.I.2).

The decreases in vehicle emissions would reduce traffic-related pollution in close proximity to roadways. As discussed in Section II.C.8, concentrations of many air pollutants are elevated near high-traffic roadways, and populations who live, work, or go to school near high-traffic roadways experience higher rates of numerous adverse health effects, compared to populations far away from major roads. An EPA study estimated that 72 million people live near truck freight routes, which includes many large highways and other routes where light- and medium-duty vehicles operate.[129] Our consideration of environmental justice literature indicates that people of color and people with low income are disproportionately exposed to elevated concentrations of many pollutants in close proximity to major roadways (see Section VIII.I.3.i).

We expect that increases in criteria and toxic pollutant emissions from EGUs and reductions in petroleum-sector emissions could lead to changes in exposure to these pollutants for people living in the communities near these facilities. Analyses of communities in close proximity to these sources (such as EGUs and refineries) have found that a higher percentage of communities of color and low-income communities live near these sources when compared to national averages (see Section VIII.1.3.ii).

The changes in emissions of criteria and toxic pollutants from vehicles, EGUs, and refineries would also impact ambient levels of ozone, $PM_{2.5}$, $NO_2$, $SO_2$, CO, and air toxics over a larger geographic scale. As discussed in Section VII.B, we expect that in 2055 the proposal would result in widespread decreases in ozone, $PM_{2.5}$, $NO_2$, CO, and some air toxics, even when accounting for the impacts of increased electricity generation. We expect that in some areas, increased electricity generation would increase ambient $SO_2$, $PM_{2.5}$, ozone, or some air toxics. However, as the power sector becomes cleaner over time, these impacts would decrease. Although the specific locations of increased air pollution are uncertain, we expect them to be in more limited geographic areas, compared to the widespread decreases that we predict to result from the reductions in vehicle emissions.

EPA estimates that the total benefits of this proposal far exceed the total costs. The present value of monetized benefits range from $350 billion to $590 billion, with pre-tax fuel savings providing another $450 billion to $890 billion. The present value of vehicle technology costs range from $180 billion to $280 billion, while the present value of repair and maintenance savings are estimated at $280 billion to $580 billion. The results presented here project the monetized environmental and economic impacts associated with the proposed program during each calendar year through 2055. Table 6 summarizes EPA's estimates of total costs, savings, and benefits. Note EPA projects lower maintenance and repair costs for several advanced technologies (*e.g.,* battery electric vehicles) and those societal maintenance and repair savings grow significantly over time, and by 2040 and later are larger than our projected new vehicle technology costs.

The benefits include climate-related economic benefits from reducing emissions of GHGs that contribute to climate change, reductions in energy security externalities caused by U.S. petroleum consumption and imports, the value of certain particulate matter-related health benefits, the value of additional driving attributed to the rebound effect, and the value of reduced refueling time needed to refuel vehicles. Between $63 and $280 billion of the present value of total monetized benefits through 2055 (assuming a 7 percent and 3 percent discount rate, respectively, as well as different long-term PM-related mortality risk studies) are attributable to reduced emissions of criteria pollutants that contribute to ambient concentrations of smaller particulate matter ($PM_{2.5}$). $PM_{2.5}$ is associated with premature death and serious health effects such as hospital admissions due to respiratory and cardiovascular illnesses, nonfatal heart attacks, aggravated asthma, and decreased lung function. The proposed program would also have other significant social benefits including $330 billion in climate benefits (with the average SC–GHGs at a 3 percent discount rate which is the rate used in past GHG rules when we speak of a single value for simplicity in presentation).[130]

The analysis also includes estimates of economic impacts stemming from additional vehicle use from increased

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[129] U.S. EPA (2021). Estimation of Population Size and Demographic Characteristics among People Living Near Truck Routes in the Conterminous United States. Memorandum to the Docket.

[130] Climate benefits are monetized using estimates of the social cost of greenhouse gases (SC–GHG), which in principle includes the value of all climate change impacts (both negative and positive), however in practice, data and modeling limitations naturally restrain the ability of SC–GHG estimates to include all the important physical, ecological, and economic impacts of climate change, such that the estimates are a partial accounting of climate change impacts and will therefore, tend to be underestimates of the marginal benefits of abatement. See Chapter 10 of the DRIA for a full discussion of the SC–GHG estimates and the important considerations and limitations associated with its use.

rebound driving, such as the economic damages caused by crashes, congestion, and noise. See Chapter 10 of the DRIA for more information regarding these estimates.

Note that some non-emission costs are shown as negative values in Table 6. Those entries represent savings but are included as costs because, traditionally, categories such as repair and maintenance have been viewed as costs of vehicle operation. Where negative values are shown, we are estimating that those costs are lower in the proposal than in the no-action case. Congestion and noise costs are attributable to increased congestion and roadway noise resulting our assumption that drivers choose to drive more under the proposal versus the No Action case. Those increased miles are known as rebound miles and are discussed in Section VIII.

Similarly, some of the traditional benefits of rulemakings that result in lower fuel consumption by the transportation fleet, *i.e.,* the non-emission benefits, are shown as negative values. Our past GHG rules have estimated that time spent refueling vehicles would be reduced due to the lower fuel consumption of new vehicles; hence, a benefit. However, in this analysis, we are estimating that refueling time would increase somewhat due to our assumptions for mid-trip recharging events for electric vehicles. Therefore, the increased refueling time represents a disbenefit (a negative benefit) as shown. As noted in Section VIII and in DRIA Chapter 4, we consider our refueling time estimate to be dated considering the rapid changes taking place in electric vehicle charging infrastructure driven largely by the Bipartisan Infrastructure Law and the Inflation Reduction Act, and we request comment and data on how our estimates could be improved.

TABLE 6—MONETIZED DISCOUNTED COSTS, BENEFITS, AND NET BENEFITS OF THE PROPOSED PROGRAM FOR CALENDAR YEARS 2027 THROUGH 2055, LIGHT-DUTY AND MEDIUM-DUTY

[Billions of 2020 dollars] [a] [b] [c]

| | CY 2055 | PV, 3% | PV, 7% | EAV, 3% | EAV, 7% |
|---|---|---|---|---|---|
| **Non-Emission Costs** | | | | | |
| Vehicle Technology Costs | 10 | 280 | 180 | 15 | 15 |
| Repair Costs | −24 | −170 | −79 | −8.9 | −6.5 |
| Maintenance Costs | −51 | −410 | −200 | −21 | −16 |
| Congestion Costs | 0.16 | 2.3 | 1.3 | 0.12 | 0.11 |
| Noise Costs | 0.0025 | 0.037 | 0.021 | 0.0019 | 0.0017 |
| Sum of Non-Emission Costs | −65 | −290 | −96 | −15 | −7.8 |
| **Fueling Impacts** | | | | | |
| Pre-tax Fuel Savings | 93 | 890 | 450 | 46 | 37 |
| EVSE Port Costs | 7.1 | 120 | 68 | 6.2 | 5.6 |
| Sum of Fuel Savings less EVSE Port Costs | 86 | 770 | 380 | 40 | 31 |
| **Non-Emission Benefits** | | | | | |
| Drive Value Benefits | 0.31 | 4.8 | 2.7 | 0.25 | 0.22 |
| Refueling Time Benefits | −8.2 | −85 | −45 | −4.4 | −3.6 |
| Energy Security Benefits | 4.4 | 41 | 21 | 2.2 | 1.7 |
| Sum of Non-Emission Benefits | −3.6 | −39 | −21 | −2 | −1.7 |
| **Climate Benefits** | | | | | |
| 5% Average | 15 | 82 | 82 | 5.4 | 5.4 |
| 3% Average | 38 | 330 | 330 | 17 | 17 |
| 2.5% Average | 52 | 500 | 500 | 25 | 25 |
| 3% 95th Percentile | 110 | 1,000 | 1,000 | 52 | 52 |
| **Criteria Air Pollutant Benefits** | | | | | |
| $PM_{2.5}$ Health Benefits—Wu et al., 2020 | 16–18 | 140 | 63 | 7.5 | 5.1 |
| $PM_{2.5}$ Health Benefits—Pope III et al., 2019 | 31–34 | 280 | 130 | 15 | 10 |
| **Net Benefits** | | | | | |
| With Climate 5% Average | 180–200 | 1,400 | 610 | 74 | 48 |
| With Climate 3% Average | 200–220 | 1,600 | 850 | 85 | 60 |
| With Climate 2.5% Average | 210–230 | 1,800 | 1,000 | 93 | 67 |
| With Climate 3% 95th Percentile | 280–290 | 2,300 | 1,500 | 120 | 95 |

[a] The same discount rate used to discount the value of damages from future emissions (SC–GHG at 5, 3, 2.5 percent) is used to calculate present and equivalent annualized values of SC–GHGs for internal consistency, while all other costs and benefits are discounted at either 3 percent or 7 percent.

[b] $PM_{2.5}$-related health benefits are presented based on two different long-term exposure studies of mortality risk: a Medicare study (Wu et al., 2020) and a National Health Interview Survey study (Pope III et al., 2019). The criteria pollutant benefits associated with the standards presented here do not include the full complement of health and environmental benefits that, if quantified and monetized, would increase the total monetized benefits.

[c] For net benefits, the range in 2055 uses the low end of the Wu range and the high end of the Pope III et al. range. The present and equivalent annualized value of net benefits for a 3 percent discount rate reflect benefits based on the Pope III et al. study while the present and equivalent annualized values of net benefits for a 7 percent discount rate reflect benefits based on the Wu et al. study.

EPA estimates the average upfront per-vehicle cost to meet the proposed standards to be approximately $1,200 in MY 2032, as shown in Table 7.[131] We discuss per-vehicle cost in more detail in Section IV.C and DRIA Chapter 13. While the average purchase price of vehicles is estimated to be higher, this is attributable to the larger share of BEVs relative to ICE vehicles. However, after considering purchase incentives and their lower operating costs relative to ICE vehicles, BEVs are estimated to save vehicle owners money over time. For example, a BEV owner of a model year 2032 sedan, wagon, crossover or SUV would save more than $9,000 on average on fuel, maintenance, and repair costs over an eight-year period (the average period of first ownership) compared to a gasoline vehicle. A BEV pickup truck owner would save even more—about $13,000. We discuss ownership savings and expenses in more detail in DRIA Chapter 4.

TABLE 7—AVERAGE INCREMENTAL VEHICLE COST BY REG CLASS, RELATIVE TO THE NO ACTION SCENARIO

[2020 Dollars]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| Cars | $249 | $102 | $32 | $100 | $527 | $844 |
| Trucks | 891 | 767 | 653 | 821 | 1,100 | 1,385 |
| Total | 633 | 497 | 401 | 526 | 866 | 1,164 |

In addition, the proposal would result in significant savings for consumers from fuel savings and reduced vehicle repair and maintenance. These lower operating costs would offset the upfront vehicle costs. Total retail fuel savings for consumers through 2055 are estimated at $560 billion to $1.1 trillion (7 percent and 3 percent discount rates, see Section VIII.B.2). Also, reduced maintenance and repair costs through 2055 are estimated at $280 billion to $580 billion (7 percent and 3 percent discount rates, see Section VIII of this preamble and Chapter 10 of the DRIA).

### *D. What are the alternatives that EPA is considering?*

#### 1. Description of the Alternatives

EPA is seeking comment on three alternatives to its proposed standards. Alternative 1 is more stringent than the proposal across the MY 2027–2032 time period, and Alternative 2 is less stringent. The proposal as well as Alternatives 1 and 2 all have a similar proportional ramp rate of year over year stringency, which includes a higher rate of stringency increase in the earlier years (MYs 2027–2029) than in the later years. Alternative 3 achieves the same stringency as the proposed standards in MY 2032 but provides for a more consistent rate of stringency increase for MY 2027–2031.

The Alternative 1 projected fleet-wide $CO_2$ targets are 10 g/mi lower on average than the proposed targets; Alternative 2 projected fleet-wide $CO_2$ targets averaged 10 g/mi higher than the proposed targets.[132] While the 20 g/mi range of stringency options may appear fairly narrow, for the MY 2032 standards the alternatives capture a range of 12 percent higher and lower than the proposed standards in the final year. Our goal in selecting the alternatives was to identify a range of stringencies that we believe are appropriate to consider for the final standards because they represent a range of standards that are anticipated to be feasible and are highly protective of human health and the environment.

While the proposed standards, Alternative 1 and Alternative 2 all have a larger increase in stringency between MY 2026 and MY 2027, Alternative 3 was constructed with the goal of evaluating roughly equal reductions in absolute g/mi targets over the duration of the program while achieving the same overall targets by MY 2032. This has the effect of less stringent year-over-year increases in the early years of the program.

EPA is soliciting comment on all of the model year standards of Alternatives 1, 2, and 3, and standards generally represented by the range across those alternatives. EPA anticipates that the appropriate choice of final standards within this range will reflect the Administrator's judgments about the uncertainties in EPA's analyses as well as consideration of public comment and updated information where available. However, EPA proposes to find that standards substantially more stringent than Alternative 1 would not be appropriate because of uncertainties concerning the cost and feasibility of such standards. EPA proposes to find that standards substantially less stringent than Alternative 2 or 3 would not be appropriate because they would forgo feasible emissions reductions that would improve the protection of public health and welfare.

Table 8, Table 9 and Table 10 compare the projected fleet average targets for cars, trucks, and the combined fleet, respectively, across the proposed standards and the three alternatives for model years 2027–2032.[133] Table 11 compares the relative percentage year-over-year reductions of the proposed standards and the three alternatives.

TABLE 8—COMPARISON OF PROPOSED CAR STANDARDS TO ALTERNATIVES

| Model year | Proposed stds $CO_2$ (g/mile) | Alternative 1 $CO_2$ (g/mile) | Alternative 2 $CO_2$ (g/mile) | Alternative 3 $CO_2$ (g/mile) |
|---|---|---|---|---|
| 2026 adjusted | 152 | 152 | 152 | 152 |
| 2027 | 134 | 124 | 144 | 139 |
| 2028 | 116 | 106 | 126 | 126 |
| 2029 | 99 | 89 | 108 | 112 |

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[131] Unless otherwise specified, all monetized values are expressed in 2020 dollars.

[132] For reference, the targets at a footprint of 50 square feet were exactly 10 g/mi lower and greater for the alternatives.

[133] In these tables, and throughout this proposal, the MY 2026 targets have been adjusted to reflect differences in off-cycle and AC credits between the 2021 Rule and this proposal. This is explained in greater detail in III.B.2.iv.

TABLE 8—COMPARISON OF PROPOSED CAR STANDARDS TO ALTERNATIVES—Continued

| Model year | Proposed stds $CO_2$ (g/mile) | Alternative 1 $CO_2$ (g/mile) | Alternative 2 $CO_2$ (g/mile) | Alternative 3 $CO_2$ (g/mile) |
|---|---|---|---|---|
| 2030 | 91 | 81 | 100 | 99 |
| 2031 | 82 | 72 | 92 | 86 |
| 2032 and later | 73 | 63 | 83 | 73 |
| % reduction vs. 2026 | 52% | 59% | 46% | 52% |

TABLE 9—COMPARISON OF PROPOSED TRUCK STANDARDS TO ALTERNATIVES

| Model year | Proposed stds $CO_2$ (g/mile) | Alternative 1 $CO_2$ (g/mile) | Alternative 2 $CO_2$ (g/mile) | Alternative 3 $CO_2$ (g/mile) |
|---|---|---|---|---|
| 2026 adjusted | 207 | 207 | 207 | 207 |
| 2027 | 163 | 153 | 173 | 183 |
| 2028 | 142 | 131 | 152 | 163 |
| 2029 | 120 | 110 | 130 | 144 |
| 2030 | 110 | 100 | 121 | 126 |
| 2031 | 100 | 90 | 111 | 107 |
| 2032 and later | 89 | 78 | 99 | 89 |
| % reduction vs. 2026 | 57% | 62% | 52% | 57% |

TABLE 10—COMPARISON OF PROPOSED COMBINED FLEET STANDARDS TO ALTERNATIVES

| Model year | Proposed stds $CO_2$ (g/mile) | Alternative 1 $CO_2$ (g/mile) | Alternative 2 $CO_2$ (g/mile) | Alternative 3 $CO_2$ (g/mile) |
|---|---|---|---|---|
| 2026 adjusted | 186 | 186 | 186 | 186 |
| 2027 | 152 | 141 | 162 | 165 |
| 2028 | 131 | 121 | 141 | 148 |
| 2029 | 111 | 101 | 122 | 132 |
| 2030 | 102 | 92 | 112 | 115 |
| 2031 | 93 | 83 | 103 | 99 |
| 2032 and later | 82 | 72 | 92 | 82 |
| % reduction vs. 2026 | 56% | 61% | 50% | 56% |

TABLE 11—COMBINED FLEET YEAR-OVER-YEAR DECREASES FOR PROPOSED STANDARDS AND ALTERNATIVES

| Model year | Proposed Stds $CO_2$ (g/mile) (%) | Alternative 1 $CO_2$ (g/mile) (%) | Alternative 2 $CO_2$ (g/mile) (%) | Alternative 3 $CO_2$ (g/mile) (%) |
|---|---|---|---|---|
| 2027 | −18 | −24 | −13 | −11 |
| 2028 | −13 | −14 | −13 | −10 |
| 2029 | −15 | −16 | −14 | −11 |
| 2030 | −8 | −9 | −8 | −12 |
| 2031 | −9 | −10 | −8 | −15 |
| 2032 | −11 | −13 | −10 | −17 |
| Average YoY | −13 | −15 | −11 | −13 |

The proposed standards will result in industry-wide average GHG emissions target for the light-duty fleet of 82 g/mi in MY 2032, representing a 56 percent reduction in average emission target levels from the existing MY 2026 standards established in 2021. Alternative 1 is projected to result in an industry-wide average target of 72 grams/mile (g/mile) of $CO_2$ in MY 2032, representing a 61 percent reduction in projected fleet average GHG emissions target levels from the existing MY 2026 standards. Alternative 2 is projected to result in an industry-wide average target of 92 g/mile of $CO_2$ in MY 2032, which corresponds to a 50 percent reduction in projected fleet average GHG emissions target levels from the existing MY 2026 standards. Like the proposed standards, Alternative 3 is projected to result in an industry-wide average target of 82 g/mile of $CO_2$ in MY 2032, which corresponds to a 56 percent reduction in projected fleet average GHG emissions target levels from the existing MY 2026 standards.

Table 12 gives a comparison of average incremental per-vehicle costs for the proposed standards and the alternatives. As shown, the 2032 MY industry average vehicle cost increase (compared to the No Action case) ranges from approximately $1,000 to $1,800 per vehicle for the alternatives, compared to $1,200 per vehicle for the proposed standards. These projections represent compliance costs to the industry and are not the same as the costs experienced by the consumer when purchasing a new vehicle. For example, the costs presented here do not include any state and Federal purchase incentives that are available to consumers. Also, the manufacturer decisions for the pricing of individual vehicles may not align exactly with the cost impacts for that particular vehicle. After considering purchase incentives and their lower operating costs relative to ICE vehicles, BEVs are estimated to save vehicle owners money over time. For example, under the proposed standards, a BEV owner of a model year 2032 sedan, wagon, crossover or SUV would save more than $9,000 on average on fuel, maintenance, and repair costs over an eight-year period (the average period of first ownership) compared to a gasoline vehicle. A BEV pickup truck owner would save even more—about $13,000. Consumer savings would be similar to those of the proposal under Alternative 3, somewhat higher under Alternative 1, and somewhat lower under Alternative 2. We discuss ownership savings and expenses under the proposed standards in more detail in DRIA Chapter 4.

TABLE 12—COMPARISON OF PROJECTED INCREMENTAL PER-VEHICLE COSTS RELATIVE TO THE NO ACTION SCENARIO

[2020 Dollars]

| Model year | Proposed stds $/vehicle | Alternative 1 $/vehicle | Alternative 2 $/vehicle | Alternative 3 $/vehicle |
|---|---|---|---|---|
| 2027 | $633 | $668 | $462 | $189 |
| 2028 | 497 | 804 | 355 | 125 |
| 2029 | 401 | 1,120 | 353 | 45 |
| 2030 | 526 | 1,262 | 337 | 250 |
| 2031 | 866 | 1,565 | 718 | 800 |
| 2032 | 1,164 | 1,775 | 1,041 | 1,256 |

### 2. Projected Emission Reductions From the Alternatives

TABLE 13—PROJECTED GHG EMISSION IMPACTS IN 2055 FROM THE PROPOSED RULE, LIGHT-DUTY AND MEDIUM-DUTY

[Million metric tons]

| Pollutant | Vehicle | EGU | Refinery * | Net impact | Net impact (%) |
|---|---|---|---|---|---|
| **Alternative 1** | | | | | |
| $CO_2$ | −480 | 18 | 0 | −460 | −52 |
| $CH_4$ | −0.0096 | 0.00043 | 0 | −0.0092 | −49 |
| $N_2O$ | −0.0084 | 0.000034 | 0 | −0.0083 | −44 |
| **Alternative 2** | | | | | |
| $CO_2$ | −400 | 14 | 0 | −380 | −43 |
| $CH_4$ | −0.0081 | 0.00035 | 0 | −0.0078 | −42 |
| $N_2O$ | −0.0072 | 0.000027 | 0 | −0.0072 | −38 |
| **Alternative 3** | | | | | |
| $CO_2$ | −440 | 16 | 0 | −420 | −47 |
| $CH_4$ | −0.0088 | 0.00039 | 0 | −0.0084 | −45 |
| $N_2O$ | −0.0078 | 0.00003 | 0 | −0.0077 | −41 |

* GHG emission rates were not available for calculating GHG inventories from refineries.

TABLE 14—PROJECTED CUMULATIVE GHG EMISSION IMPACTS THROUGH 2055 FROM THE PROPOSED RULE, LIGHT-DUTY AND MEDIUM-DUTY

[Million metric tons]

| Pollutant | Vehicle | EGU | Refinery | Net impact | Net impact (%) |
|---|---|---|---|---|---|
| **Alternative 1** | | | | | |
| $CO_2$ | −8,900 | 780 | 0 | −8,100 | −29 |
| $CH_4$ | −0.17 | 0.039 | 0 | −0.13 | −18 |
| $N_2O$ | −0.15 | 0.005 | 0 | −0.14 | −27 |
| **Alternative 2** | | | | | |
| $CO_2$ | −7,200 | 630 | 0 | −6,600 | −23 |
| $CH_4$ | −0.14 | 0.032 | 0 | −0.11 | −15 |
| $N_2O$ | −0.13 | 0.004 | 0 | −0.12 | −23 |

### TABLE 14—PROJECTED CUMULATIVE GHG EMISSION IMPACTS THROUGH 2055 FROM THE PROPOSED RULE, LIGHT-DUTY AND MEDIUM-DUTY—Continued

[Million metric tons]

| Pollutant | Vehicle | EGU | Refinery | Net impact | Net impact (%) |
|---|---|---|---|---|---|
| **Alternative 3** | | | | | |
| $CO_2$ | −7,800 | 670 | 0 | −7,100 | −25 |
| $CH_4$ | −0.15 | 0.033 | 0 | −0.12 | −16 |
| $N_2O$ | −0.13 | 0.0042 | 0 | −0.13 | −24 |

* GHG emission rates were not available for calculating GHG inventories from refineries.

### TABLE 15—PROJECTED CRITERIA AIR POLLUTANT IMPACTS IN 2055 FROM THE PROPOSED RULE, LIGHT-DUTY AND MEDIUM-DUTY

[U.S. tons]

| Pollutant | Vehicle | EGU | Refinery | Net impact | Net impact (%) |
|---|---|---|---|---|---|
| **Alternative 1** | | | | | |
| $PM_{2.5}$ | −9,800 | 1,700 | −7,600 | −16,000 | −37 |
| $NO_X$ | −47,000 | 2,800 | −27,000 | −71,000 | −44 |
| VOC | −230,000 | 1,100 | −23,000 | −250,000 | −55 |
| $SO_X$ | −3,000 | 1,900 | −12,000 | −13,000 | −46 |
| CO * | −2,000,000 | 0 | 0 | −2,000,000 | −55 |
| **Alternative 2** | | | | | |
| $PM_{2.5}$ | −9,800 | 1,400 | −6,200 | −15,000 | −34 |
| $NO_X$ | −41,000 | 2,400 | −22,000 | −61,000 | −38 |
| VOC | −190,000 | 950 | −19,000 | −200,000 | −45 |
| $SO_X$ | −2,500 | 1,500 | −9,500 | −11,000 | −38 |
| CO * | −1,600,000 | 0 | 0 | −1,600,000 | −45 |
| **Alternative 3** | | | | | |
| $PM_{2.5}$ | −9,800 | 1,500 | −6,900 | −15,000 | −35 |
| $NO_X$ | −44,000 | 2,600 | −25,000 | −66,000 | −41 |
| VOC | −200,000 | 1,000 | −21,000 | −220,000 | −50 |
| $SO_X$ | −2,800 | 1,700 | −11,000 | −12,000 | −42 |
| CO * | −1,800,000 | 0 | 0 | −1,800,000 | −50 |

* EPA did not have data available to calculate CO impacts from EGUs or refineries.

### TABLE 16—PROJECTED AIR TOXIC IMPACTS FROM VEHICLES IN 2055 FROM THE PROPOSED RULE, LIGHT-DUTY AND MEDIUM-DUTY

[U.S. tons]

| Pollutant | Vehicle | Vehicle (%) |
|---|---|---|
| **Alternative 1** | | |
| Acetaldehyde | −920 | −53 |
| Acrolein | −60 | −52 |
| Benzene | −3,200 | −56 |
| Ethylbenzene | −3,700 | −55 |
| Formaldehyde | −550 | −53 |
| Naphthalene | −110 | −56 |
| 1,3-Butadiene | −370 | −56 |
| 15 Polyaromatic Hydrocarbons | −5 | −80 |
| **Alternative 2** | | |
| Acetaldehyde | −780 | −45 |
| Acrolein | −51 | −44 |
| Benzene | −2,600 | −47 |
| Ethylbenzene | −3,100 | −46 |
| Formaldehyde | −470 | −45 |
| Naphthalene | −95 | −47 |
| 1,3-Butadiene | −310 | −47 |

### TABLE 16—PROJECTED AIR TOXIC IMPACTS FROM VEHICLES IN 2055 FROM THE PROPOSED RULE, LIGHT-DUTY AND MEDIUM-DUTY—Continued

[U.S. tons]

| Pollutant | Vehicle | Vehicle (%) |
|---|---|---|
| 15 Polyaromatic Hydrocarbons | −5 | −77 |
| **Alternative 3** | | |
| Acetaldehyde | −850 | −49 |
| Acrolein | −55 | −48 |
| Benzene | −2,900 | −51 |
| Ethylbenzene | −3,400 | −50 |
| Formaldehyde | −510 | −49 |
| Naphthalene | −100 | −51 |
| 1,3-Butadiene | −340 | −51 |
| 15 Polyaromatic Hydrocarbons | −5 | −78 |

### 3. Summary of Costs and Benefits of the Alternatives

Table 17, Table 18., and Table 19 show the summary of costs, savings and benefits under alternatives 1, 2 and 3, respectively.

### TABLE 17—MONETIZED DISCOUNTED COSTS, BENEFITS, AND NET BENEFITS OF ALTERNATIVE 1 FOR CALENDAR YEARS 2027 THROUGH 2055, LIGHT-DUTY AND MEDIUM-DUTY

[Billions of 2020 dollars] [a] [b] [c]

| | CY 2055 | PV, 3% | PV, 7% | EAV, 3% | EAV, 7% |
|---|---|---|---|---|---|
| **Non-Emission Costs** | | | | | |
| Vehicle Technology Costs | 11 | 330 | 220 | 17 | 18 |
| Repair Costs | −26 | −180 | −82 | −9.3 | −6.7 |
| Maintenance Costs | −57 | −450 | −220 | −24 | −18 |
| Congestion Costs | 0.11 | 3.5 | 2.2 | 0.18 | 0.18 |
| Noise Costs | 0.0017 | 0.055 | 0.034 | 0.0028 | 0.0027 |
| Sum of Non-Emission Costs | −71 | −300 | −82 | −15 | −6.7 |
| **Fueling Impacts** | | | | | |
| Pre-tax Fuel Savings | 100 | 990 | 510 | 51 | 41 |
| EVSE Port Costs | 7.1 | 120 | 68 | 6.2 | 5.6 |
| Sum of Fuel Savings less EVSE Port Costs | 95 | 870 | 440 | 45 | 36 |
| **Non-Emission Benefits** | | | | | |
| Drive Value Benefits | 0.22 | 6.5 | 3.9 | 0.34 | 0.32 |
| Refueling Time Benefits | −8.8 | −90 | −47 | −4.7 | −3.8 |
| Energy Security Benefits | 4.8 | 46 | 23 | 2.4 | 1.9 |
| Sum of Non-Emission Benefits | −3.8 | −38 | −20 | −2 | −1.6 |
| **Climate Benefits** | | | | | |
| 5% Average | 16 | 91 | 91 | 6 | 6 |
| 3% Average | 41 | 360 | 360 | 19 | 19 |
| 2.5% Average | 57 | 560 | 560 | 27 | 27 |
| 3% 95th Percentile | 120 | 1,100 | 1,100 | 58 | 58 |
| **Criteria Air Pollutant Benefits** | | | | | |
| $PM_{2.5}$ Health Benefits—Wu et al., 2020 | 16–18 | 150 | 66 | 7.7 | 5.3 |
| $PM_{2.5}$ Health Benefits—Pope III et al., 2019 | 32–35 | 290 | 130 | 15 | 11 |
| **Net Benefits** | | | | | |
| With Climate 5% Average | 200–210 | 1,500 | 660 | 80 | 52 |
| With Climate 3% Average | 220–240 | 1,800 | 930 | 93 | 65 |
| With Climate 2.5% Average | 240–260 | 2,000 | 1,100 | 100 | 73 |

### TABLE 17—MONETIZED DISCOUNTED COSTS, BENEFITS, AND NET BENEFITS OF ALTERNATIVE 1 FOR CALENDAR YEARS 2027 THROUGH 2055, LIGHT-DUTY AND MEDIUM-DUTY—Continued

[Billions of 2020 dollars] [a] [b] [c]

| | CY 2055 | PV, 3% | PV, 7% | EAV, 3% | EAV, 7% |
|---|---|---|---|---|---|
| With Climate 3% 95th Percentile | 300–320 | 2,500 | 1,700 | 130 | 100 |

[a] The same discount rate used to discount the value of damages from future emissions (SC–GHG at 5, 3, 2.5 percent) is used to calculate present and equivalent annualized values of SC–GHGs for internal consistency, while all other costs and benefits are discounted at either 3 percent or 7 percent.

[b] $PM_{2.5}$-related health benefits are presented based on two different long-term exposure studies of mortality risk: a Medicare study (Wu et al., 2020) and a National Health Interview Survey study (Pope III et al., 2019). The criteria pollutant benefits associated with the standards presented here do not include the full complement of health and environmental benefits that, if quantified and monetized, would increase the total monetized benefits.

[c] For net benefits, the range in 2055 uses the low end of the Wu range and the high end of the Pope III et al. range. The present and equivalent annualized values for 3 percent use the Pope III et al. values while the 7 percent values use the Wu values.

### TABLE 18—MONETIZED DISCOUNTED COSTS, BENEFITS, AND NET BENEFITS OF ALTERNATIVE 2 FOR CALENDAR YEARS 2027 THROUGH 2055, LIGHT-DUTY AND MEDIUM-DUTY

[Billions of 2020 dollars] [a] [b] [c]

| | CY 2055 | PV, 3% | PV, 7% | EAV, 3% | EAV, 7% |
|---|---|---|---|---|---|
| **Non-Emission Costs** | | | | | |
| Vehicle Technology Costs | 8.8 | 230 | 140 | 12 | 12 |
| Repair Costs | −22 | −160 | −74 | −8.3 | −6 |
| Maintenance Costs | −47 | −370 | −180 | −19 | −14 |
| Congestion Costs | 0.064 | 0.74 | 0.48 | 0.039 | 0.039 |
| Noise Costs | 0.001 | 0.012 | 0.0078 | 0.00064 | 0.00064 |
| Sum of Non-Emission Costs | −60 | −300 | −110 | −16 | −8.7 |
| **Fueling Impacts** | | | | | |
| Pre-tax Fuel Savings | 84 | 790 | 400 | 41 | 33 |
| EVSE Port Costs | 7.1 | 120 | 68 | 6.2 | 5.6 |
| Sum of Fuel Savings less EVSE Port Costs | 77 | 680 | 330 | 35 | 27 |
| **Non-Emission Benefits** | | | | | |
| Drive Value Benefits | 0.17 | 2.4 | 1.5 | 0.12 | 0.12 |
| Refueling Time Benefits | −7.6 | −79 | −41 | −4.1 | −3.3 |
| Energy Security Benefits | 3.9 | 37 | 19 | 1.9 | 1.5 |
| Sum of Non-Emission Benefits | −3.5 | −39 | −21 | −2 | −1.7 |
| **Climate Benefits** | | | | | |
| 5% Average | 13 | 74 | 74 | 4.9 | 4.9 |
| 3% Average | 34 | 290 | 290 | 15 | 15 |
| 2.5% Average | 47 | 450 | 450 | 22 | 22 |
| 3% 95th Percentile | 100 | 900 | 900 | 47 | 47 |
| **Criteria Air Pollutant Benefits** | | | | | |
| $PM_{2.5}$ Health Benefits—Wu et al., 2020 | 15–17 | 140 | 61 | 7.2 | 4.9 |
| $PM_{2.5}$ Health Benefits—Pope III et al., 2019 | 30–33 | 270 | 120 | 14 | 10 |
| **Net Benefits** | | | | | |
| With Climate 5% Average | 160–180 | 1,300 | 550 | 68 | 44 |
| With Climate 3% Average | 180–200 | 1,500 | 780 | 78 | 54 |
| With Climate 2.5% Average | 200–210 | 1,700 | 930 | 85 | 61 |
| With Climate 3% 95th Percentile | 250–270 | 2,100 | 1,400 | 110 | 86 |

[a] The same discount rate used to discount the value of damages from future emissions (SC–GHG at 5, 3, 2.5 percent) is used to calculate present and equivalent annualized values of SC–GHGs for internal consistency, while all other costs and benefits are discounted at either 3 percent or 7 percent.

[b] $PM_{2.5}$-related health benefits are presented based on two different long-term exposure studies of mortality risk: a Medicare study (Wu et al., 2020) and a National Health Interview Survey study (Pope III et al., 2019). The criteria pollutant benefits associated with the standards presented here do not include the full complement of health and environmental benefits that, if quantified and monetized, would increase the total monetized benefits.

[c] For net benefits, the range in 2055 uses the low end of the Wu range and the high end of the Pope III et al. range. The present and equivalent annualized values for 3 percent use the Pope III et al. values while the 7 percent values use the Wu values.

TABLE 19—MONETIZED DISCOUNTED COSTS, BENEFITS, AND NET BENEFITS OF ALTERNATIVE 3 FOR CALENDAR YEARS 2027 THROUGH 2055, LIGHT-DUTY AND MEDIUM-DUTY

[Billions of 2020 dollars] [a] [b] [c]

| | CY 2055 | PV, 3% | PV, 7% | EAV, 3% | EAV, 7% |
|---|---|---|---|---|---|
| **Non-Emission Costs** | | | | | |
| Vehicle Technology Costs | 11 | 270 | 170 | 14 | 14 |
| Repair Costs | −24 | −170 | −77 | −8.6 | −6.3 |
| Maintenance Costs | −51 | −390 | −190 | −20 | −15 |
| Congestion Costs | 0.11 | 1.5 | 0.82 | 0.078 | 0.066 |
| Noise Costs | 0.0016 | 0.024 | 0.013 | 0.0012 | 0.0011 |
| Sum of Non-Emission Costs | −64 | −290 | −95 | −15 | −7.8 |
| **Fueling Impacts** | | | | | |
| Pre-tax Fuel Savings | 93 | 850 | 430 | 45 | 35 |
| EVSE Port Costs | 7.1 | 120 | 68 | 6.2 | 5.6 |
| Sum of Fuel Savings less EVSE Port Costs | 86 | 740 | 360 | 38 | 29 |
| **Non-Emission Benefits** | | | | | |
| Drive Value Benefits | 0.21 | 3.2 | 1.8 | 0.17 | 0.15 |
| Refueling Time Benefits | −8.2 | −83 | −43 | −4.3 | −3.5 |
| Energy Security Benefits | 4.4 | 40 | 20 | 2.1 | 1.6 |
| Sum of Non-Emission Benefits | −3.6 | −39 | −21 | −2.1 | −1.7 |
| **Climate Benefits** | | | | | |
| 5% Average | 15 | 80 | 80 | 5.3 | 5.3 |
| 3% Average | 38 | 320 | 320 | 17 | 17 |
| 2.5% Average | 52 | 490 | 490 | 24 | 24 |
| 3% 95th Percentile | 110 | 970 | 970 | 51 | 51 |
| **Criteria Air Pollutant Benefits** | | | | | |
| $PM_{2.5}$ Health Benefits—Wu et al., 2020 | 16–18 | 140 | 62 | 7.3 | 5.0 |
| $PM_{2.5}$ Health Benefits—Pope III et al., 2019 | 31–34 | 280 | 120 | 14 | 10 |
| **Net Benefits** | | | | | |
| With Climate 5% Average | 180–190 | 1,300 | 580 | 71 | 46 |
| With Climate 3% Average | 200–220 | 1,600 | 820 | 82 | 57 |
| With Climate 2.5% Average | 210–230 | 1,800 | 990 | 90 | 64 |
| With Climate 3% 95th Percentile | 270–290 | 2,200 | 1,500 | 120 | 91 |

[a] The same discount rate used to discount the value of damages from future emissions (SC–GHG at 5, 3, 2.5 percent) is used to calculate present and equivalent annualized values of SC–GHGs for internal consistency, while all other costs and benefits are discounted at either 3 percent or 7 percent.

[b] $PM_{2.5}$-related health benefits are presented based on two different long-term exposure studies of mortality risk: a Medicare study (Wu et al., 2020) and a National Health Interview Survey study (Pope III et al., 2019). The criteria pollutant benefits associated with the standards presented here do not include the full complement of health and environmental benefits that, if quantified and monetized, would increase the total monetized benefits.

[c] For net benefits, the range in 2055 uses the low end of the Wu range and the high end of the Pope III et al. range. The present and equivalent annualized values for 3 percent use the Pope III et al. values while the 7 percent values use the Wu values.

## II. Public Health and Welfare Need for Emission Reductions

### *A. Climate Change From GHG Emissions*

Elevated concentrations of GHGs have been warming the planet, leading to changes in the Earth's climate including changes in the frequency and intensity of heat waves, precipitation, and extreme weather events, rising seas, and retreating snow and ice. The changes taking place in the atmosphere as a result of the well-documented buildup of GHGs due to human activities are changing the climate at a pace and in a way that threatens human health, society, and the natural environment. While EPA is not making any new scientific or factual findings with regard to the well-documented impact of GHG emissions on public health and welfare in support of this rule, EPA is providing some scientific background on climate change to offer additional context for this rulemaking and to increase the public's understanding of the environmental impacts of GHGs.

Extensive additional information on climate change is available in the scientific assessments and the EPA documents that are briefly described in this section, as well as in the technical and scientific information supporting them. One of those documents is EPA's 2009 Endangerment and Cause or Contribute Findings for Greenhouse Gases Under section 202(a) of the CAA (74 FR 66496, December 15, 2009). In the 2009 Endangerment Finding, the Administrator found under section 202(a) of the CAA that elevated atmospheric concentrations of six key well-mixed GHGs—$CO_2$, methane (CH4), nitrous oxide (N2O), HFCs, perfluorocarbons (PFCs), and sulfur hexafluoride (SF6)—"may reasonably be anticipated to endanger the public health and welfare of current and future generations" (74 FR 66523). The 2009 Endangerment Finding, together with the extensive scientific and technical evidence in the supporting record, documented that climate change caused by human emissions of GHGs threatens the public health of the U.S. population. It explained that by raising average temperatures, climate change increases the likelihood of heat waves, which are associated with increased deaths and illnesses (74 FR 66497). While climate change also increases the likelihood of reductions in cold-related mortality, evidence indicates that the increases in heat mortality will be larger than the decreases in cold mortality in the U.S. (74 FR 66525). The 2009 Endangerment Finding further explained that compared with a future without climate change, climate change is expected to increase tropospheric ozone pollution over broad areas of the U.S., including in the largest metropolitan areas with the worst tropospheric ozone problems, and thereby increase the risk of adverse effects on public health (74 FR 66525). Climate change is also expected to cause more intense hurricanes and more frequent and intense storms of other types and heavy precipitation, with impacts on other areas of public health, such as the potential for increased deaths, injuries, infectious and waterborne diseases, and stress-related disorders (74 FR 66525). Children, the elderly, and the poor are among the most vulnerable to these climate-related health effects (74 FR 66498).

The 2009 Endangerment Finding also documented, together with the extensive scientific and technical evidence in the supporting record, that climate change touches nearly every aspect of public welfare [134] in the U.S., including: Changes in water supply and quality due to changes in drought and extreme rainfall events; increased risk of storm surge and flooding in coastal areas and land loss due to inundation; increases in peak electricity demand and risks to electricity infrastructure; and the potential for significant agricultural disruptions and crop failures (though offset to some extent by carbon fertilization). These impacts are also global and may exacerbate problems outside the U.S. that raise humanitarian, trade, and national security issues for the U.S. (74 FR 66530).

In 2016, the Administrator issued a similar finding for GHG emissions from aircraft under section 231(a)(2)(A) of the CAA.[135] In the 2016 Endangerment Finding, the Administrator found that the body of scientific evidence amassed in the record for the 2009 Endangerment Finding compellingly supported a similar endangerment finding under CAA section 231(a)(2)(A), and also found that the science assessments released between the 2009 and the 2016 Findings ''strengthen and further support the judgment that GHGs in the atmosphere may reasonably be anticipated to endanger the public health and welfare of current and future generations'' (81 FR 54424).

Since the 2016 Endangerment Finding, the climate has continued to change, with new observational records being set for several climate indicators such as global average surface temperatures, GHG concentrations, and sea level rise. Additionally, major scientific assessments continue to be released that further advance our understanding of the climate system and the impacts that GHGs have on public health and welfare both for current and future generations. These updated observations and projections document the rapid rate of current and future climate change both globally and in the U.S.[136] [137] [138] [139]

### *B. Background on Criteria and Air Toxics Pollutants Impacted by This Proposal*

#### 1. Particulate Matter

Particulate matter (PM) is a complex mixture of solid particles and liquid droplets distributed among numerous atmospheric gases which interact with solid and liquid phases. Particles in the atmosphere range in size from less than 0.01 to more than 10 micrometers (μm) in diameter.[140] Atmospheric particles can be grouped into several classes according to their aerodynamic diameter and physical sizes. Generally, the three broad classes of particles include ultrafine particles (UFPs, generally considered as particles with a diameter less than or equal to 0.1 μm [typically based on physical size, thermal diffusivity or electrical mobility]), ''fine'' particles ($PM_{2.5}$; particles with a nominal mean aerodynamic diameter less than or equal to 2.5 μm), and ''thoracic'' particles ($PM_{10}$; particles with a nominal mean aerodynamic diameter less than or equal to 10 μm). Particles that fall within the size range between $PM_{2.5}$ and $PM_{10}$, are referred to as ''thoracic coarse particles'' ($PM_{10\text{-}2.5}$, particles with a nominal mean aerodynamic diameter greater than 2.5 μm and less than or equal to 10 μm). EPA currently has NAAQS for $PM_{2.5}$ and $PM_{10}$.[141]

Most particles are found in the lower troposphere, where they can have residence times ranging from a few hours to weeks. Particles are removed from the atmosphere by wet deposition, such as when they are carried by rain or snow, or by dry deposition, when particles settle out of suspension due to gravity. Atmospheric lifetimes are generally longest for $PM_{2.5}$, which often remains in the atmosphere for days to weeks before being removed by wet or dry deposition.[142] In contrast, atmospheric lifetimes for UFP and $PM_{10\text{-}2.5}$ are shorter. Within hours, UFP

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[134] The CAA states in section 302(h) that ''[a]ll language referring to effects on welfare includes, but is 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 air pollutants.'' 42 U.S.C. 7602(h).

[135] ''Finding that Greenhouse Gas Emissions From Aircraft Cause or Contribute to Air Pollution That May Reasonably Be Anticipated To Endanger Public Health and Welfare.'' 81 FR 54422, August 15, 2016. (''2016 Endangerment Finding'').

[136] USGCRP, 2018: Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 1515 pp. doi: 10.7930/NCA4.2018. *https://nca2018.globalchange.gov*.

[137] Roy, J., P. Tschakert, H. Waisman, S. Abdul Halim, P. Antwi-Agyei, P. Dasgupta, B. Hayward, M. Kanninen, D. Liverman, C. Okereke, P.F. Pinho, K. Riahi, and A.G. Suarez Rodriguez, 2018: Sustainable Development, Poverty Eradication and Reducing Inequalities. In: Global Warming of 1.5 °C. An IPCC Special Report on the impacts of global warming of 1.5 °C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. In Press. *https://www.ipcc.ch/sr15/chapter/chapter-5*.

[138] National Academies of Sciences, Engineering, and Medicine. 2019. Climate Change and Ecosystems. Washington, DC: The National Academies Press. *https://doi.org/10.17226/25504*.

[139] NOAA National Centers for Environmental Information, State of the Climate: Global Climate Report for Annual 2020, published online January 2021, retrieved on February 10, 2021, from *https://www.ncdc.noaa.gov/sotc/global/202013*.

[140] U.S. EPA. Policy Assessment (PA) for the Review of the National Ambient Air Quality Standards for Particulate Matter (Final Report, 2020). U.S. Environmental Protection Agency, Washington, DC, EPA/452/R–20/002, 2020.

[141] Regulatory definitions of PM size fractions, and information on reference and equivalent methods for measuring PM in ambient air, are provided in 40 CFR parts 50, 53, and 58. With regard to NAAQS which provide protection against health and welfare effects, the 24-hour $PM_{10}$ standard provides protection against effects associated with short-term exposure to thoracic coarse particles (*i.e.*, $PM_{10\text{-}2.5}$).

[142] U.S. EPA. Integrated Science Assessment (ISA) for Particulate Matter (Final Report, 2019). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–19/188, 2019. Table 2–1.

can undergo coagulation and condensation that lead to formation of larger particles in the accumulation mode, or can be removed from the atmosphere by evaporation, deposition, or reactions with other atmospheric components. PM$_{10\text{-}2.5}$ are also generally removed from the atmosphere within hours, through wet or dry deposition.[143]

Particulate matter consists of both primary and secondary particles. Primary particles are emitted directly from sources, such as combustion-related activities (*e.g.,* industrial activities, motor vehicle operation, biomass burning), while secondary particles are formed through atmospheric chemical reactions of gaseous precursors (*e.g.,* sulfur oxides (SO$_X$), nitrogen oxides (NO$_X$) and volatile organic compounds (VOCs)). From 2000 to 2021, national annual average ambient PM$_{2.5}$ concentrations have declined by over 35 percent,[144] largely reflecting reductions in emissions of precursor gases.

There are two primary NAAQS for PM$_{2.5}$: An annual standard (12.0 micrograms per cubic meter (μg/m$^3$)) and a 24-hour standard (35 μg/m$^3$), and there are two secondary NAAQS for PM$_{2.5}$: An annual standard (15.0 μg/m$^3$) and a 24-hour standard (35 μg/m$^3$). The initial PM$_{2.5}$ standards were set in 1997 and revisions to the standards were finalized in 2006 and in December 2012 and then retained in 2020. On January 6, 2023, EPA announced its proposed decision to revise the PM NAAQS.[145]

There are many areas of the country that are currently in nonattainment for the annual and 24-hour primary PM$_{2.5}$ NAAQS. As of August 31, 2022, more than 19 million people lived in the 4 areas that are designated as nonattainment for the 1997 PM$_{2.5}$ NAAQS. Also, as of August 31, 2022, more than 31 million people lived in the 14 areas that are designated as nonattainment for the 2006 PM$_{2.5}$ NAAQS and more than 20 million people lived in the 5 areas designated as nonattainment for the 2012 PM$_{2.5}$ NAAQS. In total, there are currently 15 PM$_{2.5}$ nonattainment areas with a population of more than 32 million people.[146] The proposed standards would take effect beginning in MY 2027 and would assist areas with attaining the NAAQS and may relieve areas with already stringent local regulations from some of the burden associated with adopting additional local controls. The rule would also assist counties with ambient concentrations near the level of the NAAQS who are working to ensure long-term attainment or maintenance of the PM$_{2.5}$ NAAQS.

### 2. Ozone

Ground-level ozone pollution forms in areas with high concentrations of ambient NO$_X$ and VOCs when solar radiation is strong. Major U.S. sources of NO$_X$ are highway and nonroad motor vehicles, engines, power plants and other industrial sources, with natural sources, such as soil, vegetation, and lightning, serving as smaller sources. Vegetation is the dominant source of VOCs in the U.S. Volatile consumer and commercial products, such as propellants and solvents, highway and nonroad vehicles, engines, fires, and industrial sources also contribute to the atmospheric burden of VOCs at ground-level.

The processes underlying ozone formation, transport, and accumulation are complex. Ground-level ozone is produced and destroyed by an interwoven network of free radical reactions involving the hydroxyl radical (OH), NO, NO$_2$, and complex reaction intermediates derived from VOCs. Many of these reactions are sensitive to temperature and available sunlight. High ozone events most often occur when ambient temperatures and sunlight intensities remain high for several days under stagnant conditions. Ozone and its precursors can also be transported hundreds of miles downwind, which can lead to elevated ozone levels in areas with otherwise low VOC or NO$_X$ emissions. As an air mass moves and is exposed to changing ambient concentrations of NO$_X$ and VOCs, the ozone photochemical regime (relative sensitivity of ozone formation to NO$_X$ and VOC emissions) can change.

When ambient VOC concentrations are high, comparatively small amounts of NO$_X$ catalyze rapid ozone formation. Without available NO$_X$, ground-level ozone production is severely limited, and VOC reductions would have little impact on ozone concentrations. Photochemistry under these conditions is said to be ''NO$_X$-limited.'' When NO$_X$ levels are sufficiently high, faster NO$_2$ oxidation consumes more radicals, dampening ozone production. Under these ''VOC-limited'' conditions (also referred to as ''NO$_X$-saturated'' conditions), VOC reductions are effective in reducing ozone, and NO$_X$ can react directly with ozone, resulting in suppressed ozone concentrations near NO$_X$ emission sources. Under these NO$_X$-saturated conditions, NO$_X$ reductions can actually increase local ozone under certain circumstances, but overall ozone production (considering downwind formation) decreases and even in VOC-limited areas, NO$_X$ reductions are not expected to increase ozone levels if the NO$_X$ reductions are sufficiently large—large enough to become NO$_X$-limited.

The primary NAAQS for ozone, established in 2015 and retained in 2020, is an 8-hour standard with a level of 0.07 ppm.[147] EPA announced that it will reconsider the decision to retain the ozone NAAQS.[148] EPA is also implementing the previous 8-hour ozone primary standard, set in 2008, at a level of 0.075 ppm. As of August 31, 2022, there were 34 ozone nonattainment areas for the 2008 ozone NAAQS, composed of 141 full or partial counties, with a population of more than 90 million, and 49 ozone nonattainment areas for the 2015 ozone NAAQS, composed of 212 full or partial counties, with a population of more than 125 million. In total, there are currently, as of August 31, 2022, 57 ozone nonattainment areas with a population of more than 130 million people.[149]

States with ozone nonattainment areas are required to take action to bring those areas into attainment. The attainment date assigned to an ozone nonattainment area is based on the area's classification. The attainment dates for areas designated nonattainment for the 2008 8-hour ozone NAAQS are in the 2015 to 2032 timeframe, depending on the severity of the problem in each area. Attainment dates for areas designated nonattainment for the 2015 ozone NAAQS are in the 2021 to 2038 timeframe, again depending on the severity of the problem in each area.[150]

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[143] U.S. EPA. Integrated Science Assessment (ISA) for Particulate Matter (Final Report, 2019). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–19/188, 2019. Table 2–1.

[144] See *https://www.epa.gov/air-trends/particulate-matter-pm25-trends* for more information.

[145] *https://www.epa.gov/pm-pollution/national-ambient-air-quality-standards-naaqs-pm.*

[146] The population total is calculated by summing, without double counting, the 1997, 2006 and 2012 PM2.5 nonattainment populations contained in the Criteria Pollutant Nonattainment Summary report (*https://www.epa.gov/green-book/green-book-data-download*).

[147] *https://www.epa.gov/ground-level-ozone-pollution/ozone-national-ambient-air-quality-standards-naaqs.*

[148] *https://www.epa.gov/ground-level-ozone-pollution/epa-reconsider-previous-administrations-decision-retain-2015-ozone.*

[149] The population total 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*).

[150] *https://www.epa.gov/ground-level-ozone-pollution/ozone-naaqs-timelines.*

The proposed standards would take effect starting in MY 2027 and would assist areas with attaining the NAAQS and may relieve areas with already stringent local regulations from some of the burden associated with adopting additional local controls. The rule would also provide assistance to counties with ambient concentrations near the level of the NAAQS who are working to ensure long-term attainment or maintenance of the NAAQS.

3. Nitrogen Oxides

Oxides of nitrogen ($NO_X$) refers to nitric oxide (NO) and nitrogen dioxide ($NO_2$). Most $NO_2$ is formed in the air through the oxidation of nitric oxide (NO) emitted when fuel is burned at a high temperature. $NO_X$ is a criteria pollutant, regulated for its adverse effects on public health and the environment, and highway vehicles are an important contributor to $NO_X$ emissions. $NO_X$, along with VOCs, are the two major precursors of ozone and $NO_X$ is also a major contributor to secondary $PM_{2.5}$ formation. There are two primary NAAQS for $NO_2$: An annual standard (53 ppb) and a 1-hour standard (100 ppb).[151] In 2010, EPA established requirements for monitoring $NO_2$ near roadways expected to have the highest concentrations 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 $NO_2$.

4. Sulfur Oxides

Sulfur dioxide ($SO_2$), a member of the sulfur oxide ($SO_X$) family of gases, is formed from burning fuels containing sulfur (*e.g.,* coal or oil), extracting gasoline from oil, or extracting metals from ore. $SO_2$ and its gas phase oxidation products can dissolve in water droplets and further oxidize to form sulfuric acid which reacts with ammonia to form sulfates, which are important components of ambient PM.

EPA most recently completed a review of the primary $SO_2$ NAAQS in February 2019 and decided to retain the existing 2010 $SO_2$ NAAQS.[152] The current primary NAAQS for $SO_2$ is a 1-hour standard of 75 ppb. As of September 30, 2022, more than two million people lived in the 30 areas that are designated as nonattainment for the 2010 $SO_2$ NAAQS.[153]

5. Carbon Monoxide

Carbon monoxide (CO) is a colorless, odorless gas emitted from combustion processes. Nationally, particularly in urban areas, the majority of CO emissions to ambient air come from mobile sources.[154] There are two primary NAAQS for CO: An 8-hour standard (9 ppm) and a 1-hour standard (35 ppm). There are currently no CO nonattainment areas; as of September 27, 2010, all CO nonattainment areas have been redesignated to attainment. The past designations were based on the existing community-wide monitoring network. EPA made an addition to the ambient air monitoring requirements for CO during the 2011 NAAQS review. Those new requirements called for CO monitors to be operated near roads in Core Based Statistical Areas (CBSAs) of 1 million or more persons, in addition to the existing community-based network (76 FR 54294, August 31, 2011).

6. Diesel Exhaust

Diesel exhaust is a complex mixture composed of particulate matter, carbon dioxide, oxygen, nitrogen, water vapor, carbon monoxide, nitrogen compounds, sulfur compounds and numerous low-molecular-weight hydrocarbons. A number of these gaseous hydrocarbon components are individually known to be toxic, including aldehydes, benzene and 1,3-butadiene. The diesel particulate matter present in diesel exhaust consists mostly of fine particles (<2.5 μm), of which a significant fraction is ultrafine particles (<0.1 μm). These particles have a large surface area which makes them an excellent medium for adsorbing organics and their small size makes them highly respirable. Many of the organic compounds present in the gases and on the particles, such as polycyclic organic matter, are individually known to have mutagenic and carcinogenic properties.

Diesel exhaust varies significantly in chemical composition and particle sizes between different engine types (heavy-duty, light-duty), engine operating conditions (idle, acceleration, deceleration), and fuel formulations (high/low sulfur fuel). Also, there are emissions differences between onroad and nonroad engines because the nonroad engines are generally of older technology. After being emitted in the engine exhaust, diesel exhaust undergoes dilution as well as chemical and physical changes in the atmosphere. The lifetimes of the components present in diesel exhaust range from seconds to days.

7. Air Toxics

The most recent available data indicate that millions of Americans live in areas where air toxics pose potential health concerns.[155] [156] 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 EPA's 2007 Mobile Source Air Toxics Rule.[157] According to EPA's Air Toxics Screening Assessment (AirToxScreen) for 2018, mobile sources were responsible for 40 percent of outdoor anthropogenic toxic emissions and were the largest contributor to national average cancer and noncancer risk from directly emitted pollutants.[158] [159] Mobile sources are also significant contributors to precursor emissions which react to form air toxics.[160] Formaldehyde is the largest contributor to cancer risk of all 71 pollutants quantitatively assessed in the 2018 AirToxScreen. Mobile sources were responsible for 26 percent of primary anthropogenic emissions of this pollutant in 2018 and are significant contributors to formaldehyde precursor emissions. Benzene is also a large contributor to cancer risk, and mobile sources account for about 60 percent of

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[151] The statistical form of the 1-hour NAAQS for $NO_2$ is the 3-year average of the yearly distribution of 1-hour daily maximum concentrations.

[152] *https://www.epa.gov/so2-pollution/primary-national-ambient-air-quality-standard-naaqs-sulfur-dioxide.*

[153] *https://www3.epa.gov/airquality/greenbook/tnsum.html.*

[154] U.S. EPA, (2010). Integrated Science Assessment for Carbon Monoxide (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–09/019F, 2010. *http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=218686.* See Section 2.1.

[155] Air toxics are pollutants known to cause or suspected of causing cancer or other serious health effects. Air toxics are also known as toxic air pollutants or hazardous air pollutants. *https://www.epa.gov/AirToxScreen/airtoxscreen-glossary-terms#air-toxics.*

[156] U.S. EPA (2022) Technical Support Document EPA Air Toxics Screening Assessment. 2017AirToxScreen TSD. *https://www.epa.gov/system/files/documents/2022-03/airtoxscreen_2017tsd.pdf.*

[157] U.S. Environmental Protection Agency (2007). Control of Hazardous Air Pollutants from Mobile Sources; Final Rule. 72 FR 8434, February 26, 2007.

[158] U.S. EPA. (2022) 2018 Air Toxics Screening Assessment. *https://www.epa.gov/AirToxScreen/2018-airtoxscreen-assessment-results.*

[159] AirToxScreen also includes estimates of risk attributable to background concentrations, which includes contributions from long-range transport, persistent air toxics, and natural sources; as well as secondary concentrations, where toxics are formed via secondary formation. Mobile sources substantially contribute to long-range transport and secondarily formed air toxics.

[160] Rich Cook, Sharon Phillips, Madeleine Strum, Alison Eyth & James Thurman (2020): Contribution of mobile sources to secondary formation of carbonyl compounds, Journal of the Air & Waste Management Association, DOI: 10.1080/10962247.2020.1813839.

average exposure to ambient concentrations.

### *C. Health Effects Associated With Exposure to Criteria and Air Toxics Pollutants*

Emissions sources impacted by this proposal, including vehicles and power plants, emit pollutants that contribute to ambient concentrations of ozone, PM, $NO_2$, $SO_2$, CO, and air toxics. This section of the preamble discusses the health effects associated with exposure to these pollutants.

Additionally, because children have increased vulnerability and susceptibility for adverse health effects related to air pollution exposures, EPA's findings regarding adverse effects for children related to exposure to pollutants that are impacted by this rule are noted in this section. The increased vulnerability and susceptibility of children to air pollution exposures may arise because infants and children generally breathe more relative to their size than adults do, and consequently may be exposed to relatively higher amounts of air pollution.[161] Children also tend to breathe through their mouths more than adults and their nasal passages are less effective at removing pollutants, which leads to greater lung deposition of some pollutants, such as PM.[162] [163] Furthermore, air pollutants may pose health risks specific to children because children's bodies are still developing.[164] For example, during periods of rapid growth such as fetal development, infancy and puberty, their developing systems and organs may be more easily harmed.[165] [166] EPA produces the report titled ''America's Children and the Environment,'' which presents national trends on air pollution and other contaminants and environmental health of children.[167]

Information on environmental effects associated with exposure to these pollutants is included in Section II.D, information on environmental justice is included in Section VIII.I and information on emission reductions and air quality impacts from this rule are included in Sections VI and VII of this preamble.

#### 1. Particulate Matter

Scientific evidence spanning animal toxicological, controlled human exposure, and epidemiologic studies shows that exposure to ambient PM is associated with a broad range of health effects. These health effects are discussed in detail in the Integrated Science Assessment for Particulate Matter, which was finalized in December 2019 (2019 PM ISA), with a more targeted evaluation of studies published since the literature cutoff date of the 2019 PM ISA in the Supplement to the Integrated Science Assessment for PM (Supplement).[168] [169] The PM ISA characterizes the causal nature of relationships between PM exposure and broad health categories (*e.g.,* cardiovascular effects, respiratory effects, etc.) using a weight-of-evidence approach.[170] Within this characterization, the PM ISA summarizes the health effects evidence for short-term (*i.e.,* hours up to one month) and long-term (*i.e.,* one month to years) exposures to $PM_{2.5}$, $PM_{10\text{-}2.5}$, and ultrafine particles, and concludes that exposures to ambient $PM_{2.5}$ are associated with a number of adverse health effects. The following discussion highlights the PM ISA's conclusions, and summarizes additional information from the Supplement where appropriate, pertaining to the health effects evidence for both short- and long-term PM exposures. Further discussion of PM-related health effects can also be found in the 2022 Policy Assessment for the review of the PM NAAQS.[171]

EPA has concluded that recent evidence in combination with evidence evaluated in the 2009 PM ISA supports a ''causal relationship'' between both long- and short-term exposures to $PM_{2.5}$ and premature mortality and cardiovascular effects and a ''likely to be causal relationship'' between long- and short-term $PM_{2.5}$ exposures and respiratory effects.[172] Additionally, recent experimental and epidemiologic studies provide evidence supporting a ''likely to be causal relationship'' between long-term $PM_{2.5}$ exposure and nervous system effects, and long-term $PM_{2.5}$ exposure and cancer. Because of remaining uncertainties and limitations in the evidence base, EPA determined a ''suggestive of, but not sufficient to infer, a causal relationship'' for long-term $PM_{2.5}$ exposure and reproductive and developmental effects (*i.e.,* male/female reproduction and fertility; pregnancy and birth outcomes), long- and short-term exposures and metabolic effects, and short-term exposure and nervous system effects.

As discussed extensively in the 2019 PM ISA and the Supplement, recent studies continue to support a ''causal relationship'' between short- and long-term $PM_{2.5}$ exposures and mortality.[173] [174] For short-term $PM_{2.5}$ exposure, multi-city studies, in combination with single- and multi-city studies evaluated in the 2009 PM ISA, provide evidence of consistent, positive associations across studies conducted in

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[161] EPA (2009) Metabolically-derived ventilation rates: A revised approach based upon oxygen consumption rates. Washington, DC: Office of Research and Development. EPA/600/R–06/129F. *http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=202543.*

[162] U.S. EPA Integrated Science Assessment for Particulate Matter (Final Report, 2019). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–19/188, 2019. Chapter 4 ''Overall Conclusions'' p. 4–1.

[163] Foos, B.; Marty, M.; Schwartz, J.; Bennet, W.; Moya, J.; Jarabek, A.M.; Salmon, A.G. (2008) Focusing on children's inhalation dosimetry and health effects for risk assessment: An introduction. J Toxicol Environ Health 71A: 149–165.

[164] Children's environmental health includes conception, infancy, early childhood and through adolescence until 21 years of age as described in the EPA Memorandum: Issuance of EPA's 2021 Policy on Children's Health. October 5, 2021. Available at *https://www.epa.gov/system/files/documents/2021-10/2021-policy-on-childrens-health.pdf.*

[165] EPA (2006) A Framework for Assessing Health Risks of Environmental Exposures to Children. EPA, Washington, DC, EPA/600/R–05/093F, 2006.

[166] U.S. Environmental Protection Agency. (2005). Supplemental guidance for assessing susceptibility from early-life exposure to carcinogens. Washington, DC: Risk Assessment Forum. EPA/630/R–03/003F. *https://www3.epa.gov/airtoxics/childrens_supplement_final.pdf.*

[167] U.S. EPA. America's Children and the Environment. Available at: *https://www.epa.gov/americaschildrenenvironment.*

[168] U.S. EPA. Integrated Science Assessment (ISA) for Particulate Matter (Final Report, 2019). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–19/188, 2019.

[169] U.S. EPA. Supplement to the 2019 Integrated Science Assessment for Particulate Matter (Final Report, 2022). U.S. Environmental Protection Agency, Washington, DC, EPA/635/R–22/028, 2022.

[170] The causal framework draws upon the assessment and integration of evidence from across scientific disciplines, spanning atmospheric chemistry, exposure, dosimetry and health effects studies (*i.e.,* epidemiologic, controlled human exposure, and animal toxicological studies), and assess the related uncertainties and limitations that ultimately influence our understanding of the evidence. This framework employs a five-level hierarchy that classifies the overall weight-of-evidence with respect to the causal nature of relationships between criteria pollutant exposures and health and welfare effects using the following categorizations: causal relationship; likely to be causal relationship; suggestive of, but not sufficient to infer, a causal relationship; inadequate to infer the presence or absence of a causal relationship; and not likely to be a causal relationship (U.S. EPA. (2019). Integrated Science Assessment for Particulate Matter (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–19/188, Section P. 3.2.3).

[171] U.S. EPA. Policy Assessment (PA) for the Reconsideration of the National Ambient Air Quality Standards for Particulate Matter (Final Report, 2022). U.S. Environmental Protection Agency, Washington, DC, EPA–452/R–22–004, 2022.

[172] U.S. EPA. (2009). Integrated Science Assessment for Particulate Matter (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–08/139F.

[173] U.S. EPA. Integrated Science Assessment (ISA) for Particulate Matter (Final Report, 2019). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–19/188, 2019.

[174] U.S. EPA. Supplement to the 2019 Integrated Science Assessment for Particulate Matter (Final Report, 2022). U.S. Environmental Protection Agency, Washington, DC, EPA/635/R–22/028, 2022.

different geographic locations, populations with different demographic characteristics, and studies using different exposure assignment techniques. Additionally, the consistent and coherent evidence across scientific disciplines for cardiovascular morbidity, particularly ischemic events and heart failure, and to a lesser degree for respiratory morbidity, including exacerbations of chronic obstructive pulmonary disease (COPD) and asthma, provide biological plausibility for cause-specific mortality and ultimately total mortality. Recent epidemiologic studies evaluated in the Supplement, including studies that employed alternative methods for confounder control, provide additional support to the evidence base that contributed to the 2019 PM ISA conclusion for short-term $PM_{2.5}$ exposure and mortality.

The 2019 PM ISA concluded a ''causal relationship'' between long-term $PM_{2.5}$ exposure and mortality. In addition to reanalyses and extensions of the American Cancer Society (ACS) and Harvard Six Cities (HSC) cohorts, multiple new cohort studies conducted in the U.S. and Canada consisting of people employed in a specific job (*e.g.,* teacher, nurse), and that apply different exposure assignment techniques, provide evidence of positive associations between long-term $PM_{2.5}$ exposure and mortality. Biological plausibility for mortality due to long-term $PM_{2.5}$ exposure is provided by the coherence of effects across scientific disciplines for cardiovascular morbidity, particularly for coronary heart disease, stroke, and atherosclerosis, and for respiratory morbidity, particularly for the development of COPD. Additionally, recent studies provide evidence indicating that as long-term $PM_{2.5}$ concentrations decrease there is an increase in life expectancy. Recent cohort studies evaluated in the Supplement, as well as epidemiologic studies that conducted accountability analyses or employed alternative methods for confounder controls, support and extend the evidence base that contributed to the 2019 PM ISA conclusion for long-term $PM_{2.5}$ exposure and mortality.

A large body of studies examining both short- and long-term $PM_{2.5}$ exposure and cardiovascular effects builds on the evidence base evaluated in the 2009 PM ISA. The strongest evidence for cardiovascular effects in response to short-term $PM_{2.5}$ exposures is for ischemic heart disease and heart failure. The evidence for short-term $PM_{2.5}$ exposure and cardiovascular effects is coherent across scientific disciplines and supports a continuum of effects ranging from subtle changes in indicators of cardiovascular health to serious clinical events, such as increased emergency department visits and hospital admissions due to cardiovascular disease and cardiovascular mortality. For long-term $PM_{2.5}$ exposure, there is strong and consistent epidemiologic evidence of a relationship with cardiovascular mortality. This evidence is supported by epidemiologic and animal toxicological studies demonstrating a range of cardiovascular effects including coronary heart disease, stroke, impaired heart function, and subclinical markers (*e.g.,* coronary artery calcification, atherosclerotic plaque progression), which collectively provide coherence and biological plausibility. Recent epidemiologic studies evaluated in the Supplement, as well as studies that conducted accountability analyses or employed alternative methods for confounder control, support and extend the evidence base that contributed to the 2019 PM ISA conclusion for both short- and long-term $PM_{2.5}$ exposure and cardiovascular effects.

Studies evaluated in the 2019 PM ISA continue to provide evidence of a ''likely to be causal relationship'' between both short- and long-term $PM_{2.5}$ exposure and respiratory effects. Epidemiologic studies provide consistent evidence of a relationship between short-term $PM_{2.5}$ exposure and asthma exacerbation in children and COPD exacerbation in adults as indicated by increases in emergency department visits and hospital admissions, which is supported by animal toxicological studies indicating worsening allergic airways disease and subclinical effects related to COPD. Epidemiologic studies also provide evidence of a relationship between short-term $PM_{2.5}$ exposure and respiratory mortality. However, there is inconsistent evidence of respiratory effects, specifically lung function declines and pulmonary inflammation, in controlled human exposure studies. With respect to long term $PM_{2.5}$ exposure, epidemiologic studies conducted in the U.S. and abroad provide evidence of a relationship with respiratory effects, including consistent changes in lung function and lung function growth rate, increased asthma incidence, asthma prevalence, and wheeze in children; acceleration of lung function decline in adults; and respiratory mortality. The epidemiologic evidence is supported by animal toxicological studies, which provide coherence and biological plausibility for a range of effects including impaired lung development, decrements in lung function growth, and asthma development.

Since the 2009 PM ISA, a growing body of scientific evidence examined the relationship between long-term $PM_{2.5}$ exposure and nervous system effects, resulting for the first time in a causality determination for this health effects category of a ''likely to be causal relationship.'' The strongest evidence for effects on the nervous system come from epidemiologic studies that consistently report cognitive decrements and reductions in brain volume in adults. The effects observed in epidemiologic studies in adults are supported by animal toxicological studies demonstrating effects on the brain of adult animals including inflammation, morphologic changes, and neurodegeneration of specific regions of the brain. There is more limited evidence for neurodevelopmental effects in children, with some studies reporting positive associations with autism spectrum disorder and others providing limited evidence of an association with cognitive function. While there is some evidence from animal toxicological studies indicating effects on the brain (*i.e.,* inflammatory and morphological changes) to support a biologically plausible pathway for neurodevelopmental effects, epidemiologic studies are limited due to their lack of control for potential confounding by copollutants, the small number of studies conducted, and uncertainty regarding critical exposure windows.

Building off the decades of research demonstrating mutagenicity, DNA damage, and other endpoints related to genotoxicity due to whole PM exposures, recent experimental and epidemiologic studies focusing specifically on $PM_{2.5}$ provide evidence of a relationship between long-term $PM_{2.5}$ exposure and cancer. Epidemiologic studies examining long-term $PM_{2.5}$ exposure and lung cancer incidence and mortality provide evidence of generally positive associations in cohort studies spanning different populations, locations, and exposure assignment techniques. Additionally, there is evidence of positive associations with lung cancer incidence and mortality in analyses limited to never smokers. The epidemiologic evidence is supported by both experimental and epidemiologic evidence of genotoxicity, epigenetic effects, carcinogenic potential, and that $PM_{2.5}$ exhibits several characteristics of carcinogens, which collectively provides biological plausibility for cancer development and resulted in the conclusion of a ''likely to be causal relationship.''

For the additional health effects categories evaluated for $PM_{2.5}$ in the 2019 PM ISA, experimental and epidemiologic studies provide limited and/or inconsistent evidence of a relationship with $PM_{2.5}$ exposure. As a result, the 2019 PM ISA concluded that the evidence is ''suggestive of, but not sufficient to infer a causal relationship'' for short-term $PM_{2.5}$ exposure and metabolic effects and nervous system effects, and long-term $PM_{2.5}$ exposures and metabolic effects as well as reproductive and developmental effects.

In addition to evaluating the health effects attributed to short- and long-term exposure to $PM_{2.5}$, the 2019 PM ISA also conducted an extensive evaluation as to whether specific components or sources of $PM_{2.5}$ are more strongly related with health effects than $PM_{2.5}$ mass. An evaluation of those studies resulted in the 2019 PM ISA concluding that ''many $PM_{2.5}$ components and sources are associated with many health effects, and the evidence does not indicate that any one source or component is consistently more strongly related to health effects than $PM_{2.5}$ mass.'' [175]

For both $PM_{10\text{-}2.5}$ and UFPs, for all health effects categories evaluated, the 2019 PM ISA concluded that the evidence was ''suggestive of, but not sufficient to infer, a causal relationship'' or ''inadequate to determine the presence or absence of a causal relationship.'' For $PM_{10\text{-}2.5}$, although a Federal Reference Method (FRM) was instituted in 2011 to measure $PM_{10\text{-}2.5}$ concentrations nationally, the causality determinations reflect that the same uncertainty identified in the 2009 PM ISA with respect to the method used to estimate $PM_{10\text{-}2.5}$ concentrations in epidemiologic studies persists. Specifically, across epidemiologic studies, different approaches are used to estimate $PM_{10\text{-}2.5}$ concentrations (*e.g.,* direct measurement of $PM_{10\text{-}2.5}$, difference between $PM_{10}$ and $PM_{2.5}$ concentrations), and it remains unclear how well correlated $PM_{10\text{-}2.5}$ concentrations are both spatially and temporally across the different methods used.

For UFPs, which have often been defined as particles <0.1 µm, the uncertainty in the evidence for the health effect categories evaluated across experimental and epidemiologic studies reflects the inconsistency in the exposure metric used (*i.e.,* particle number concentration, surface area concentration, mass concentration) as well as the size fractions examined. In epidemiologic studies the size fraction examined can vary depending on the monitor used and exposure metric, with some studies examining number count over the entire particle size range, while experimental studies that use a particle concentrator often examine particles up to 0.3 µm. Additionally, due to the lack of a monitoring network, there is limited information on the spatial and temporal variability of UFPs within the U.S., as well as population exposures to UFPs, which adds uncertainty to epidemiologic study results.

The 2019 PM ISA cites extensive evidence indicating that ''both the general population as well as specific populations and life stages are at risk for $PM_{2.5}$-related health effects.'' [176] For example, in support of its ''causal'' and ''likely to be causal'' determinations, the ISA cites substantial evidence for: (1) PM-related mortality and cardiovascular effects in older adults; (2) PM-related cardiovascular effects in people with pre-existing cardiovascular disease; (3) PM-related respiratory effects in people with pre-existing respiratory disease, particularly asthma exacerbations in children; and (4) PM-related impairments in lung function growth and asthma development in children. The ISA additionally notes that stratified analyses (*i.e.,* analyses that directly compare PM-related health effects across groups) provide strong evidence for racial and ethnic differences in $PM_{2.5}$ exposures and in the risk of $PM_{2.5}$-related health effects, specifically within Hispanic and non-Hispanic Black populations, with some evidence of increased risk for populations of low socioeconomic status. Recent studies evaluated in the Supplement support the conclusion of the 2019 PM ISA with respect to disparities in both $PM_{2.5}$ exposure and health risk by race and ethnicity and provide additional support for disparities for populations of lower socioeconomic status.[177] Additionally, evidence spanning epidemiologic studies that conducted stratified analyses, experimental studies focusing on animal models of disease or individuals with pre-existing disease, dosimetry studies, as well as studies focusing on differential exposure suggest that populations with pre-existing cardiovascular or respiratory disease, populations that are overweight or obese, populations that have particular genetic variants, and current/former smokers could be at increased risk for adverse $PM_{2.5}$-related health effects. The 2022 Policy Assessment for the review of the PM NAAQS also highlights that factors that may contribute to increased risk of $PM_{2.5}$-related health effects include lifestage (children and older adults), pre-existing diseases (cardiovascular disease and respiratory disease), race/ethnicity, and socioeconomic status.[178]

### 2. Ozone

This section provides a summary of the health effects associated with exposure to ambient concentrations of ozone.[179] The information in this section is based on the information and conclusions in the April 2020 Integrated Science Assessment for Ozone (Ozone ISA).[180] The Ozone ISA concludes that human exposures to ambient concentrations of ozone are associated with a number of adverse health effects and characterizes the weight of evidence for these health effects.[181] The following discussion highlights the Ozone ISA's conclusions pertaining to health effects associated with both short-term and long-term periods of exposure to ozone.

For short-term exposure to ozone, the Ozone ISA concludes that respiratory effects, including lung function decrements, pulmonary inflammation, exacerbation of asthma, respiratory-related hospital admissions, and mortality, are causally associated with ozone exposure. It also concludes that

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[175] U.S. EPA. Integrated Science Assessment (ISA) for Particulate Matter (Final Report, 2019). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–19/188, 2019.

[176] U.S. EPA. Integrated Science Assessment (ISA) for Particulate Matter (Final Report, 2019). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–19/188, 2019.

[177] U.S. EPA. Supplement to the 2019 Integrated Science Assessment for Particulate Matter (Final Report, 2022). U.S. Environmental Protection Agency, Washington, DC, EPA/635/R–22/028, 2022.

[178] U.S. EPA. Policy Assessment (PA) for the Reconsideration of the National Ambient Air Quality Standards for Particulate Matter (Final Report, 2022). U.S. Environmental Protection Agency, Washington, DC, EPA–452/R–22–004, 2022, p. 3–53.

[179] Human exposure to ozone varies over time due to changes in ambient ozone concentration and because people move between locations which have notably different ozone concentrations. Also, the amount of ozone delivered to the lung is influenced not only by the ambient concentrations but also by the breathing route and rate.

[180] U.S. EPA. Integrated Science Assessment (ISA) for Ozone and Related Photochemical Oxidants (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–20/012, 2020.

[181] The ISA evaluates evidence and draws conclusions on the causal relationship between relevant pollutant exposures and health effects, assigning one of five ''weight of evidence'' determinations: causal relationship, likely to be a causal relationship, suggestive of a causal relationship, inadequate to infer a causal relationship, and not likely to be a causal relationship. For more information on these levels of evidence, please refer to Table II in the Preamble of the ISA.

metabolic effects, including metabolic syndrome (*i.e.,* changes in insulin or glucose levels, cholesterol levels, obesity, and blood pressure) and complications due to diabetes are likely to be causally associated with short-term exposure to ozone and that evidence is suggestive of a causal relationship between cardiovascular effects, central nervous system effects and total mortality and short-term exposure to ozone.

For long-term exposure to ozone, the Ozone ISA concludes that respiratory effects, including new onset asthma, pulmonary inflammation and injury, are likely to be causally related with ozone exposure. The Ozone ISA characterizes the evidence as suggestive of a causal relationship for associations between long-term ozone exposure and cardiovascular effects, metabolic effects, reproductive and developmental effects, central nervous system effects and total mortality. The evidence is inadequate to infer a causal relationship between chronic ozone exposure and increased risk of cancer.

Finally, interindividual variation in human responses to ozone exposure can result in some groups being at increased risk for detrimental effects in response to exposure. In addition, some groups are at increased risk of exposure due to their activities, such as outdoor workers and children. The Ozone ISA identified several groups that are at increased risk for ozone-related health effects. These groups are people with asthma, children and older adults, individuals with reduced intake of certain nutrients (*i.e.,* Vitamins C and E), outdoor workers, and individuals having certain genetic variants related to oxidative metabolism or inflammation. Ozone exposure during childhood can have lasting effects through adulthood. Such effects include altered function of the respiratory and immune systems. Children absorb higher doses (normalized to lung surface area) of ambient ozone, compared to adults, due to their increased time spent outdoors, higher ventilation rates relative to body size, and a tendency to breathe a greater fraction of air through the mouth. Children also have a higher asthma prevalence compared to adults. Recent epidemiologic studies provide generally consistent evidence that long-term ozone exposure is associated with the development of asthma in children. Studies comparing age groups reported higher magnitude associations for short-term ozone exposure and respiratory hospital admissions and emergency room visits among children than among adults. Panel studies also provide support for experimental studies with consistent associations between short-term ozone exposure and lung function and pulmonary inflammation in healthy children. Additional children's vulnerability and susceptibility factors are listed in Section X.G of the Preamble.

### 3. Nitrogen Oxides

The most recent review of the health effects of oxides of nitrogen completed by EPA can be found in the 2016 Integrated Science Assessment for Oxides of Nitrogen—Health Criteria (Oxides of Nitrogen ISA).[182] The primary source of $NO_2$ is motor vehicle emissions, and ambient $NO_2$ concentrations tend to be highly correlated with other traffic-related pollutants. Thus, a key issue in characterizing the causality of $NO_2$-health effect relationships consists of evaluating the extent to which studies supported an effect of $NO_2$ that is independent of other traffic-related pollutants. EPA concluded that the findings for asthma exacerbation integrated from epidemiologic and controlled human exposure studies provided evidence that is sufficient to infer a causal relationship between respiratory effects and short-term $NO_2$ exposure. The strongest evidence supporting an independent effect of $NO_2$ exposure comes from controlled human exposure studies demonstrating increased airway responsiveness in individuals with asthma following ambient-relevant $NO_2$ exposures. The coherence of this evidence with epidemiologic findings for asthma hospital admissions and ED visits as well as lung function decrements and increased pulmonary inflammation in children with asthma describe a plausible pathway by which $NO_2$ exposure can cause an asthma exacerbation. The 2016 ISA for Oxides of Nitrogen also concluded that there is likely to be a causal relationship between long-term $NO_2$ exposure and respiratory effects. This conclusion is based on new epidemiologic evidence for associations of $NO_2$ with asthma development in children combined with biological plausibility from experimental studies.

In evaluating a broader range of health effects, the 2016 ISA for Oxides of Nitrogen concluded that evidence is ''suggestive of, but not sufficient to infer, a causal relationship'' between short-term $NO_2$ exposure and cardiovascular effects and mortality and between long-term $NO_2$ exposure and cardiovascular effects and diabetes, birth outcomes, and cancer. In addition, the scientific evidence is inadequate (insufficient consistency of epidemiologic and toxicological evidence) to infer a causal relationship for long-term $NO_2$ exposure with fertility, reproduction, and pregnancy, as well as with postnatal development. A key uncertainty in understanding the relationship between these non-respiratory health effects and short- or long-term exposure to $NO_2$ is copollutant confounding, particularly by other roadway pollutants. The available evidence for non-respiratory health effects does not adequately address whether $NO_2$ has an independent effect or whether it primarily represents effects related to other or a mixture of traffic-related pollutants.

The 2016 ISA for Oxides of Nitrogen concluded that people with asthma, children, and older adults are at increased risk for $NO_2$-related health effects. In these groups and lifestages, $NO_2$ is consistently related to larger effects on outcomes related to asthma exacerbation, for which there is confidence in the relationship with $NO_2$ exposure.

### 4. Sulfur Oxides

This section provides an overview of the health effects associated with $SO_2$. Additional information on the health effects of $SO_2$ can be found in the 2017 Integrated Science Assessment for Sulfur Oxides—Health Criteria ($SO_X$ ISA).[183] Following an extensive evaluation of health evidence from animal toxicological, controlled human exposure, and epidemiologic studies, EPA has concluded that there is a causal relationship between respiratory health effects and short-term exposure to $SO_2$. The immediate effect of $SO_2$ on the respiratory system in humans is bronchoconstriction. People with asthma are more sensitive to the effects of $SO_2$, likely resulting from preexisting inflammation associated with this disease. In addition to those with asthma (both children and adults), there is suggestive evidence that all children and older adults may be at increased risk of $SO_2$-related health effects. In free-breathing laboratory studies involving controlled human exposures to $SO_2$, respiratory effects have consistently been observed following 5–10 min exposures at $SO_2$ concentrations ≥400

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[182] U.S. EPA. Integrated Science Assessment for Oxides of Nitrogen—Health Criteria (2016 Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–15/068, 2016.

[183] U.S. EPA. Integrated Science Assessment (ISA) for Sulfur Oxides—Health Criteria (Final Report, Dec 2017). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–17/451, 2017.

ppb in people with asthma engaged in moderate to heavy levels of exercise, with respiratory effects occurring at concentrations as low as 200 ppb in some individuals with asthma. A clear concentration-response relationship has been demonstrated in these studies following exposures to $SO_2$ at concentrations between 200 and 1000 ppb, both in terms of increasing severity of respiratory symptoms and decrements in lung function, as well as the percentage of individuals with asthma adversely affected. Epidemiologic studies have reported positive associations between short-term ambient $SO_2$ concentrations and hospital admissions and emergency department visits for asthma and for all respiratory causes, particularly among children and older adults (≥65 years). The studies provide supportive evidence for the causal relationship.

For long-term $SO_2$ exposure and respiratory effects, EPA has concluded that the evidence is suggestive of a causal relationship. This conclusion is based on new epidemiologic evidence for positive associations between long-term $SO_2$ exposure and increases in asthma incidence among children, together with animal toxicological evidence that provides a pathophysiologic basis for the development of asthma. However, uncertainty remains regarding the influence of other pollutants on the observed associations with $SO_2$ because these epidemiologic studies have not examined the potential for copollutant confounding.

Consistent associations between short-term exposure to $SO_2$ and mortality have been observed in epidemiologic studies, with larger effect estimates reported for respiratory mortality than for cardiovascular mortality. While this finding is consistent with the demonstrated effects of $SO_2$ on respiratory morbidity, uncertainty remains with respect to the interpretation of these observed mortality associations due to potential confounding by various copollutants. Therefore, EPA has concluded that the overall evidence is suggestive of a causal relationship between short-term exposure to $SO_2$ and mortality.

### 5. Carbon Monoxide

Information on the health effects of carbon monoxide (CO) can be found in the January 2010 Integrated Science Assessment for Carbon Monoxide (CO ISA).[184] The CO ISA presents conclusions regarding the presence of causal relationships between CO exposure and categories of adverse health effects.[185] This section provides a summary of the health effects associated with exposure to ambient concentrations of CO, along with the CO ISA conclusions.[186]

Controlled human exposure studies of subjects with coronary artery disease show a decrease in the time to onset of exercise-induced angina (chest pain) and electrocardiogram changes following CO exposure. In addition, epidemiologic studies observed associations between short-term CO exposure and cardiovascular morbidity, particularly increased emergency room visits and hospital admissions for coronary heart disease (including ischemic heart disease, myocardial infarction, and angina). Some epidemiologic evidence is also available for increased hospital admissions and emergency room visits for congestive heart failure and cardiovascular disease as a whole. The CO ISA concludes that a causal relationship is likely to exist between short-term exposures to CO and cardiovascular morbidity. It also concludes that available data are inadequate to conclude that a causal relationship exists between long-term exposures to CO and cardiovascular morbidity.

Animal studies show various neurological effects with in-utero CO exposure. Controlled human exposure studies report central nervous system and behavioral effects following low-level CO exposures, although the findings have not been consistent across all studies. The CO ISA concludes that the evidence is suggestive of a causal relationship with both short- and long-term exposure to CO and central nervous system effects.

A number of studies cited in the CO ISA have evaluated the role of CO exposure in birth outcomes such as preterm birth or cardiac birth defects. There is limited epidemiologic evidence of a CO-induced effect on preterm births and birth defects, with weak evidence for a decrease in birth weight. Animal toxicological studies have found perinatal CO exposure to affect birth weight, as well as other developmental outcomes. The CO ISA concludes that the evidence is suggestive of a causal relationship between long-term exposures to CO and developmental effects and birth outcomes.

Epidemiologic studies provide evidence of associations between short-term CO concentrations and respiratory morbidity such as changes in pulmonary function, respiratory symptoms, and hospital admissions. A limited number of epidemiologic studies considered copollutants such as ozone, $SO_2$, and PM in two-pollutant models and found that CO risk estimates were generally robust, although this limited evidence makes it difficult to disentangle effects attributed to CO itself from those of the larger complex air pollution mixture. Controlled human exposure studies have not extensively evaluated the effect of CO on respiratory morbidity. Animal studies at levels of 50–100 ppm CO show preliminary evidence of altered pulmonary vascular remodeling and oxidative injury. The CO ISA concludes that the evidence is suggestive of a causal relationship between short-term CO exposure and respiratory morbidity, and inadequate to conclude that a causal relationship exists between long-term exposure and respiratory morbidity.

Finally, the CO ISA concludes that the epidemiologic evidence is suggestive of a causal relationship between short-term concentrations of CO and mortality. Epidemiologic evidence suggests an association exists between short-term exposure to CO and mortality, but limited evidence is available to evaluate cause-specific mortality outcomes associated with CO exposure. In addition, the attenuation of CO risk estimates which was often observed in copollutant models contributes to the uncertainty as to whether CO is acting alone or as an indicator for other combustion-related pollutants. The CO ISA also concludes that there is not likely to be a causal relationship between relevant long-term exposures to CO and mortality.

### 6. Diesel Exhaust

In EPA's 2002 Diesel Health Assessment Document (Diesel HAD), exposure to diesel exhaust was classified as likely to be carcinogenic to humans by inhalation from environmental exposures, in accordance with the revised draft 1996/1999 EPA

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[184] U.S. EPA, (2010). Integrated Science Assessment for Carbon Monoxide (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–09/019F, 2010. *http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=218686*.

[185] The ISA evaluates the health evidence associated with different health effects, assigning one of five ''weight of evidence'' determinations: causal relationship, likely to be a causal relationship, suggestive of a causal relationship, inadequate to infer a causal relationship, and not likely to be a causal relationship. For definitions of these levels of evidence, please refer to Section 1.6 of the ISA.

[186] Personal exposure includes contributions from many sources, and in many different environments. Total personal exposure to CO includes both ambient and non-ambient components; and both components may contribute to adverse health effects.

cancer guidelines.[187] [188] A number of other agencies (National Institute for Occupational Safety and Health, the International Agency for Research on Cancer, the World Health Organization, California EPA, and the U.S. Department of Health and Human Services) made similar hazard classifications prior to 2002. EPA also concluded in the 2002 Diesel HAD that it was not possible to calculate a cancer unit risk for diesel exhaust due to limitations in the exposure data for the occupational groups or the absence of a dose-response relationship.

In the absence of a cancer unit risk, the Diesel HAD sought to provide additional insight into the significance of the diesel exhaust cancer hazard by estimating possible ranges of risk that might be present in the population. An exploratory analysis was used to characterize a range of possible lung cancer risk. The outcome was that environmental risks of cancer from long-term diesel exhaust exposures could plausibly range from as low as $10^{-5}$ to as high as $10^{-3}$. Because of uncertainties, the analysis acknowledged that the risks could be lower than $10^{-5}$, and a zero risk from diesel exhaust exposure could not be ruled out.

Noncancer health effects of acute and chronic exposure to diesel exhaust emissions are also of concern to EPA. EPA derived a diesel exhaust reference concentration (RfC) from consideration of four well-conducted chronic rat inhalation studies showing adverse pulmonary effects. The RfC is 5 µg/m$^3$ for diesel exhaust measured as diesel particulate matter. This RfC does not consider allergenic effects such as those associated with asthma or immunologic or the potential for cardiac effects. There was emerging evidence in 2002, discussed in the Diesel HAD, that exposure to diesel exhaust can exacerbate these effects, but the exposure-response data were lacking at that time to derive an RfC based on these then-emerging considerations. The Diesel HAD states, ''With [diesel particulate matter] being a ubiquitous component of ambient PM, there is an uncertainty about the adequacy of the existing [diesel exhaust] noncancer database to identify all of the pertinent [diesel exhaust]-caused noncancer health hazards.'' The Diesel HAD also noted ''that acute exposure to [diesel exhaust] has been associated with irritation of the eye, nose, and throat, respiratory symptoms (cough and phlegm), and neurophysiological symptoms such as headache, lightheadedness, nausea, vomiting, and numbness or tingling of the extremities.'' The Diesel HAD notes that the cancer and noncancer hazard conclusions applied to the general use of diesel engines then on the market and as cleaner engines replace a substantial number of existing ones, the applicability of the conclusions would need to be reevaluated.

It is important to note that the Diesel HAD also briefly summarizes health effects associated with ambient PM and discusses EPA's then-annual $PM_{2.5}$ NAAQS of 15 µg/m$^3$.[189] There is a large and extensive body of human data showing a wide spectrum of adverse health effects associated with exposure to ambient PM, of which diesel exhaust is an important component. The $PM_{2.5}$ NAAQS is designed to provide protection from the noncancer health effects and premature mortality attributed to exposure to $PM_{2.5}$. The contribution of diesel PM to total ambient PM varies in different regions of the country and also, within a region, from one area to another. The contribution can be high in near-roadway environments, for example, or in other locations where diesel engine use is concentrated.

Since 2002, several new studies have been published which continue to report increased lung cancer risk associated with occupational exposure to diesel exhaust from older engines. Of particular note since 2011 are three new epidemiology studies that have examined lung cancer in occupational populations, including, truck drivers, underground nonmetal miners, and other diesel motor-related occupations. These studies reported increased risk of lung cancer related to exposure to diesel exhaust, with evidence of positive exposure-response relationships to varying degrees.[190] [191] [192] These newer studies (along with others that have appeared in the scientific literature) add to the evidence EPA evaluated in the 2002 Diesel HAD and further reinforce the concern that diesel exhaust exposure likely poses a lung cancer hazard. The findings from these newer studies do not necessarily apply to newer technology diesel engines (*i.e.,* heavy-duty highway engines from 2007 and later model years) since the newer engines have large reductions in the emission constituents compared to older technology diesel engines.

In light of the growing body of scientific literature evaluating the health effects of exposure to diesel exhaust, in June 2012 the World Health Organization's International Agency for Research on Cancer (IARC), a recognized international authority on the carcinogenic potential of chemicals and other agents, evaluated the full range of cancer-related health effects data for diesel engine exhaust. IARC concluded that diesel exhaust should be regarded as ''carcinogenic to humans.'' [193] This designation was an update from its 1988 evaluation that considered the evidence to be indicative of a ''probable human carcinogen.''

### 7. Air Toxics

Light- and medium-duty engine emissions contribute to ambient levels of air toxics that are known or suspected human or animal carcinogens, or that have noncancer health effects. These compounds include, but are not limited to, acetaldehyde, acrolein, benzene, 1,3-butadiene, ethylbenzene, formaldehyde, naphthalene, and polycyclic organic matter, which were all identified as national or regional cancer risk drivers or contributors in the 2018 AirToxScreen Assessment.[194] [195]

#### i. Acetaldehyde

Acetaldehyde is classified in EPA's IRIS database as a probable human carcinogen, based on nasal tumors in rats, and is considered toxic by the inhalation, oral, and intravenous

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[187] U.S. EPA. (1999). Guidelines for Carcinogen Risk Assessment. Review Draft. NCEA–F–0644, July. Washington, DC: U.S. EPA. Retrieved on March 19, 2009 from *http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=54932.*

[188] U.S. EPA (2002). Health Assessment Document for Diesel Engine Exhaust. EPA/600/8–90/057F Office of research and Development, Washington DC. Retrieved on March 17, 2009 from *http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=29060. pp. 1–1 1–2.*

[189] See Section II.B.1 for discussion of the current $PM_{2.5}$ NAAQS standard.

[190] Garshick, Eric, Francine Laden, Jaime E. Hart, Mary E. Davis, Ellen A. Eisen, and Thomas J. Smith. 2012. Lung cancer and elemental carbon exposure in trucking industry workers. Environmental Health Perspectives 120(9): 1301–1306.

[191] Silverman, D.T., Samanic, C.M., Lubin, J.H., Blair, A.E., Stewart, P.A., Vermeulen, R., & Attfield, M.D. (2012). The diesel exhaust in miners study: a nested case-control study of lung cancer and diesel exhaust. Journal of the National Cancer Institute.

[192] Olsson, Ann C., et al. ''Exposure to diesel motor exhaust and lung cancer risk in a pooled analysis from case-control studies in Europe and Canada.'' American journal of respiratory and critical care medicine 183.7 (2011): 941–948.

[193] IARC [International Agency for Research on Cancer]. (2013). Diesel and gasoline engine exhausts and some nitroarenes. IARC Monographs Volume 105. [Online at *http://monographs.iarc.fr/ENG/Monographs/vol105/index.php.*]

[194] U.S. EPA (2022) Technical Support Document EPA Air Toxics Screening Assessment. 2017AirToxScreen TSD. *https://www.epa.gov/system/files/documents/2022-03/airtoxscreen_2017tsd.pdf.*

[195] U.S. EPA (2022) 2018 AirToxScreen Risk Drivers. *https://www.epa.gov/AirToxScreen/airtoxscreen-risk-drivers.*

routes.[196] The inhalation unit risk estimate (URE) in IRIS for acetaldehyde is 2.2 × 10–6 per µg/m$^3$.[197] Acetaldehyde is reasonably anticipated to be a human carcinogen by the NTP in the 14th Report on Carcinogens and is classified as possibly carcinogenic to humans (Group 2B) by the IARC.[198] [199]

The primary noncancer effects of exposure to acetaldehyde vapors include irritation of the eyes, skin, and respiratory tract.[200] In short-term (4 week) rat studies, degeneration of olfactory epithelium was observed at various concentration levels of acetaldehyde exposure.[201] [202] Data from these studies were used by EPA to develop an inhalation reference concentration of 9 µg/m3. Some asthmatics have been shown to be a sensitive subpopulation to decrements in functional expiratory volume (FEV1 test) and bronchoconstriction upon acetaldehyde inhalation.[203] Children, especially those with diagnosed asthma, may be more likely to show impaired pulmonary function and symptoms of asthma than are adults following exposure to acetaldehyde.[204]

### ii. Acrolein

EPA most recently evaluated the toxicological and health effects literature related to acrolein in 2003 and concluded that the human carcinogenic potential of acrolein could not be determined because the available data were inadequate. No information was available on the carcinogenic effects of acrolein in humans and the animal data provided inadequate evidence of carcinogenicity.[205] In 2021, the IARC classified acrolein as probably carcinogenic to humans.[206]

Lesions to the lungs and upper respiratory tract of rats, rabbits, and hamsters have been observed after subchronic exposure to acrolein.[207] The agency has developed an RfC for acrolein of 0.02 µg/m$^3$ and an RfD of 0.5 µg/kg-day.[208]

Acrolein is extremely acrid and irritating to humans when inhaled, with acute exposure resulting in upper respiratory tract irritation, mucus hypersecretion and congestion. The intense irritancy of this carbonyl has been demonstrated during controlled tests in human subjects, who suffer intolerable eye and nasal mucosal sensory reactions within minutes of exposure.[209] These data and additional studies regarding acute effects of human exposure to acrolein are summarized in EPA's 2003 IRIS Human Health Assessment for acrolein.[210] Studies in humans indicate that levels as low as 0.09 ppm (0.21 mg/m$^3$) for five minutes may elicit subjective complaints of eye irritation with increasing concentrations leading to more extensive eye, nose and respiratory symptoms. Acute exposures in animal studies report bronchial hyper-responsiveness. Based on animal data (more pronounced respiratory irritancy in mice with allergic airway disease in comparison to non-diseased mice) [211] and demonstration of similar effects in humans (*e.g.,* reduction in respiratory rate), individuals with compromised respiratory function (*e.g.,* emphysema, asthma) are expected to be at increased risk of developing adverse responses to strong respiratory irritants such as acrolein. EPA does not currently have an acute reference concentration for acrolein. The available health effect reference values for acrolein have been summarized by EPA and include an ATSDR MRL for acute exposure to acrolein of 7 µg/m$^3$ for 1–14 days exposure; and Reference Exposure Level (REL) values from the California Office of Environmental Health Hazard Assessment (OEHHA) for one-hour and 8-hour exposures of 2.5 µg/m$^3$ and 0.7 µg/m$^3$, respectively.[212]

### iii. Benzene

EPA's Integrated Risk Information System (IRIS) database lists benzene as a known human carcinogen (causing leukemia) by all routes of exposure, and concludes that exposure is associated with additional health effects, including genetic changes in both humans and animals and increased proliferation of bone marrow cells in mice.[213] [214] [215] EPA states in its IRIS database that data indicate a causal relationship between benzene exposure and acute lymphocytic leukemia and suggest a

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[196] U.S. EPA (1991). Integrated Risk Information System File of Acetaldehyde. Research and Development, National Center for Environmental Assessment, Washington, DC. This material is available electronically at *https://cfpub.epa.gov/ncea/iris2/chemicalLanding.cfm?substance_nmbr=290.*

[197] U.S. EPA (1991). Integrated Risk Information System File of Acetaldehyde. This material is available electronically at *https://cfpub.epa.gov/ncea/iris2/chemicalLanding.cfm?substance_nmbr=290.*

[198] NTP (National Toxicology Program). 2016. Report on Carcinogens, Fourteenth Edition.; Research Triangle Park, NC: U.S. Department of Health and Human Services, Public Health Service. *https://ntp.niehs.nih.gov/go/roc14.*

[199] International Agency for Research on Cancer (IARC). (1999). Re-evaluation of some organic chemicals, hydrazine, and hydrogen peroxide. IARC Monographs on the Evaluation of Carcinogenic Risk of Chemical to Humans, Vol 71. Lyon, France.

[200] U.S. EPA (1991). Integrated Risk Information System File of Acetaldehyde. This material is available electronically at *https://cfpub.epa.gov/ncea/iris2/chemicalLanding.cfm?substance_nmbr=290.*

[201] U.S. EPA. (2003). Integrated Risk Information System File of Acrolein. Research and Development, National Center for Environmental Assessment, Washington, DC. This material is available electronically at *https://cfpub.epa.gov/ncea/iris2/chemicalLanding.cfm?substance_nmbr=364.*

[202] Appleman, L.M., R.A. Woutersen, and V.J. Feron. (1982). Inhalation toxicity of acetaldehyde in rats. I. Acute and subacute studies. Toxicology. 23: 293–297.

[203] Myou, S.; Fujimura, M.; Nishi K.; Ohka, T.; and Matsuda, T. (1993). Aerosolized acetaldehyde induces histamine-mediated bronchoconstriction in asthmatics. Am. Rev. Respir.Dis.148(4 Pt 1): 940–943.

[204] California OEHHA, 2014. TSD for Noncancer RELs: Appendix D. Individual, Acute, 8-Hour, and Chronic Reference Exposure Level Summaries. December 2008 (updated July 2014). *https://oehha.ca.gov/media/downloads/crnr/appendixd1final.pdf.*

[205] U.S. EPA. (2003). Integrated Risk Information System File of Acrolein. Research and Development, National Center for Environmental Assessment, Washington, DC. This material is available at *http://www.epa.gov/iris/subst/0364.htm.*

[206] International Agency for Research on Cancer (IARC). (2021). Monographs on the Identification of Carcinogenic Hazards to humans, Volume 128. Acrolein, Crotonaldehyde, and Arecoline, World Health Organization, Lyon, France.

[207] U.S. EPA. (2003). Integrated Risk Information System File of Acrolein. Office of Research and Development, National Center for Environmental Assessment, Washington, DC. This material is available at *http://www.epa.gov/iris/subst/0364.htm.*

[208] U.S. EPA. (2003). Integrated Risk Information System File of Acrolein. Office of Research and Development, National Center for Environmental Assessment, Washington, DC. This material is available at *http://www.epa.gov/iris/subst/0364.htm.*

[209] U.S. EPA. (2003). Toxicological review of acrolein in support of summary information on Integrated Risk Information System (IRIS) National Center for Environmental Assessment, Washington, DC. EPA/635/R–03/003. p. 10. Available online at: *http://www.epa.gov/ncea/iris/toxreviews/0364tr.pdf.*

[210] U.S. EPA. (2003). Toxicological review of acrolein in support of summary information on Integrated Risk Information System (IRIS) National Center for Environmental Assessment, Washington, DC. EPA/635/R–03/003. Available online at: *http://www.epa.gov/ncea/iris/toxreviews/0364tr.pdf.*

[211] Morris JB, Symanowicz PT, Olsen JE, et al. (2003). Immediate sensory nerve-mediated respiratory responses to irritants in healthy and allergic airway-diseased mice. J Appl Physiol 94(4):1563–1571.

[212] U.S. EPA. (2009). Graphical Arrays of Chemical-Specific Health Effect Reference Values for Inhalation Exposures (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–09/061, 2009. *http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=211003.*

[213] U.S. EPA. (2000). Integrated Risk Information System File for Benzene. This material is available electronically at: *https://cfpub.epa.gov/ncea/iris2/chemicalLanding.cfm?substance_nmbr=276.*

[214] International Agency for Research on Cancer. (1982). IARC monographs on the evaluation of carcinogenic risk of chemicals to humans, Volume 29, Some industrial chemicals and dyestuffs, International Agency for Research on Cancer, World Health Organization, Lyon, France 1982.

[215] Irons, R.D.; Stillman, W.S.; Colagiovanni, D.B.; Henry, V.A. (1992). Synergistic action of the benzene metabolite hydroquinone on myelopoietic stimulating activity of granulocyte/macrophage colony-stimulating factor in vitro, Proc. Natl. Acad. Sci. 89:3691–3695.

relationship between benzene exposure and chronic non-lymphocytic leukemia and chronic lymphocytic leukemia. EPA's IRIS documentation for benzene also lists a range of 2.2 × 10–6 to 7.8 × 10–6 per μg/m$^3$ as the unit risk estimate (URE) for benzene.[216] [217] The International Agency for Research on Cancer (IARC) has determined that benzene is a human carcinogen, and the U.S. Department of Health and Human Services (DHHS) has characterized benzene as a known human carcinogen.[218] [219]

A number of adverse noncancer health effects, including blood disorders such as preleukemia and aplastic anemia, have also been associated with long-term exposure to benzene.[220] [221] The most sensitive noncancer effect observed in humans, based on current data, is the depression of the absolute lymphocyte count in blood.[222] [223] EPA's inhalation reference concentration (RfC) for benzene is 30 μg/m$^3$. The RfC is based on suppressed absolute lymphocyte counts seen in humans under occupational exposure conditions. In addition, studies sponsored by the Health Effects Institute (HEI) provide evidence that biochemical responses occur at lower levels of benzene exposure than previously known.[224] [225] [226] [227] EPA's IRIS program has not yet evaluated these new data. EPA does not currently have an acute reference concentration for benzene. The Agency for Toxic Substances and Disease Registry (ATSDR) Minimal Risk Level (MRL) for acute exposure to benzene is 29 μg/m$^3$ for 1–14 days exposure.[228] [229]

There is limited information from two studies regarding an increased risk of adverse effects to children whose parents have been occupationally exposed to benzene.[230] [231] Data from animal studies have shown benzene exposures result in damage to the hematopoietic (blood cell formation) system during development.[232] [233] [234] Also, key changes related to the development of childhood leukemia occur in the developing fetus.[235] Several studies have reported that genetic changes related to eventual leukemia development occur before birth. For example, there is one study of genetic changes in twins who developed T cell leukemia at nine years of age.[236]

### iv. 1,3-Butadiene

EPA has characterized 1,3-butadiene as carcinogenic to humans by inhalation.[237] [238] The IARC has determined that 1,3-butadiene is a human carcinogen and the U.S. DHHS has characterized 1,3-butadiene as a known human carcinogen.[239] [240] [241] [242] There are numerous studies consistently demonstrating that 1,3-butadiene is metabolized into genotoxic metabolites by experimental animals and humans. The specific mechanisms of 1,3-butadiene-induced carcinogenesis are unknown; however, the scientific evidence strongly suggests that the carcinogenic effects are mediated by genotoxic metabolites. Animal data suggest that females may be more sensitive than males for cancer effects associated with 1,3-butadiene exposure; there are insufficient data in humans from which to draw conclusions about sensitive subpopulations. The URE for 1,3-butadiene is 3 × 10–5 per μg/m$^3$.[243]

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[216] A unit risk estimate is defined as the increase in the lifetime risk of cancer of an individual who is exposed for a lifetime to 1 μg/m$^3$ benzene in air.

[217] U.S. EPA. (2000). Integrated Risk Information System File for Benzene. This material is available electronically at: *https://cfpub.epa.gov/ncea/iris2/chemicalLanding.cfm?substance_nmbr=276.*

[218] International Agency for Research on Cancer (IARC, 2018. Monographs on the evaluation of carcinogenic risks to humans, volume 120. World Health Organization—Lyon, France. *http://publications.iarc.fr/Book-And-Report-Series/Iarc-Monographs-On-The-Identification-Of-Carcinogenic-Hazards-To-Humans/Benzene-2018.*

[219] NTP (National Toxicology Program). 2016. Report on Carcinogens, Fourteenth Edition.; Research Triangle Park, NC: U.S. Department of Health and Human Services, Public Health Service. *https://ntp.niehs.nih.gov/go/roc14.*

[220] Aksoy, M. (1989). Hematotoxicity and carcinogenicity of benzene. Environ. Health Perspect. 82: 193–197. EPA–HQ–OAR–2011–0135.

[221] Goldstein, B.D. (1988). Benzene toxicity. Occupational medicine. State of the Art Reviews. 3: 541–554.

[222] Rothman, N., G.L. Li, M. Dosemeci, W.E. Bechtold, G.E. Marti, Y.Z. Wang, M. Linet, L.Q. Xi, W. Lu, M.T. Smith, N. Titenko-Holland, L.P. Zhang, W. Blot, S.N. Yin, and R.B. Hayes. (1996). Hematotoxicity among Chinese workers heavily exposed to benzene. Am. J. Ind. Med. 29: 236–246.

[223] U.S. EPA (2002). Toxicological Review of Benzene (Noncancer Effects). Environmental Protection Agency, Integrated Risk Information System (IRIS), Research and Development, National Center for Environmental Assessment, Washington DC. This material is available electronically at *https://cfpub.epa.gov/ncea/iris/iris_documents/documents/toxreviews/0276tr.pdf.*

[224] Qu, O.; Shore, R.; Li, G.; Jin, X.; Chen, C.L.; Cohen, B.; Melikian, A.; Eastmond, D.; Rappaport, S.; Li, H.; Rupa, D.; Suramaya, R.; Songnian, W.; Huifant, Y.; Meng, M.; Winnik, M.; Kwok, E.; Li, Y.; Mu, R.; Xu, B.; Zhang, X.; Li, K. (2003). HEI Report 115, Validation & Evaluation of Biomarkers in Workers Exposed to Benzene in China.

[225] Qu, Q., R. Shore, G. Li, X. Jin, L.C. Chen, B. Cohen, et al. (2002). Hematological changes among Chinese workers with a broad range of benzene exposures. Am. J. Industr. Med. 42: 275–285.

[226] Lan, Qing, Zhang, L., Li, G., Vermeulen, R., et al. (2004). Hematotoxically in Workers Exposed to Low Levels of Benzene. Science 306: 1774–1776.

[227] Turtletaub, K.W. and Mani, C. (2003). Benzene metabolism in rodents at doses relevant to human exposure from Urban Air. Research Reports Health Effect Inst. Report No.113.

[228] U.S. Agency for Toxic Substances and Disease Registry (ATSDR). (2007). Toxicological profile for benzene. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service. *http://www.atsdr.cdc.gov/ToxProfiles/tp3.pdf.*

[229] A minimal risk level (MRL) is defined as an estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse noncancer health effects over a specified duration of exposure.

[230] Corti, M; Snyder, CA. (1996) Influences of gender, development, pregnancy and ethanol consumption on the hematotoxicity of inhaled 10 ppm benzene. Arch Toxicol 70:209–217.

[231] McKinney P.A.; Alexander, F.E.; Cartwright, R.A.; et al. (1991) Parental occupations of children with leukemia in west Cumbria, north Humberside, and Gateshead, Br Med J 302:681–686.

[232] Keller, KA; Snyder, CA. (1986) Mice exposed in utero to low concentrations of benzene exhibit enduring changes in their colony forming hematopoietic cells. Toxicology 42:171–181.

[233] Keller, KA; Snyder, CA. (1988) Mice exposed in utero to 20 ppm benzene exhibit altered numbers of recognizable hematopoietic cells up to seven weeks after exposure. Fundam Appl Toxicol 10:224–232.

[234] Corti, M; Snyder, CA. (1996) Influences of gender, development, pregnancy and ethanol consumption on the hematotoxicity of inhaled 10 ppm benzene. Arch Toxicol 70:209–217.

[235] U.S. EPA. (2002). Toxicological Review of Benzene (Noncancer Effects). National Center for Environmental Assessment, Washington, DC. Report No. EPA/635/R–02/001F. *https://cfpub.epa.gov/ncea/iris/iris_documents/documents/toxreviews/0276tr.pdf.*

[236] Ford, AM; Pombo-de-Oliveira, MS; McCarthy, KP; MacLean, JM; Carrico, KC; Vincent, RF; Greaves, M. (1997) Monoclonal origin of concordant T-cell malignancy in identical twins. Blood 89:281–285.

[237] U.S. EPA. (2002). Health Assessment of 1,3-Butadiene. Office of Research and Development, National Center for Environmental Assessment, Washington Office, Washington, DC. Report No. EPA600–P–98–001F. This document is available electronically at *https://cfpub.epa.gov/ncea/iris_drafts/recordisplay.cfm?deid=54499.*

[238] U.S. EPA. (2002) ''Full IRIS Summary for 1,3-butadiene (CASRN 106–99–0)'' Environmental Protection Agency, Integrated Risk Information System (IRIS), Research and Development, National Center for Environmental Assessment, Washington, DC *https://cfpub.epa.gov/ncea/iris2/chemicalLanding.cfm?substance_nmbr=139.*

[239] International Agency for Research on Cancer (IARC). (1999). Monographs on the evaluation of carcinogenic risk of chemicals to humans, Volume 71, Re-evaluation of some organic chemicals, hydrazine and hydrogen peroxide, World Health Organization, Lyon, France.

[240] International Agency for Research on Cancer (IARC). (2008). Monographs on the evaluation of carcinogenic risk of chemicals to humans, 1,3-Butadiene, Ethylene Oxide and Vinyl Halides (Vinyl Fluoride, Vinyl Chloride and Vinyl Bromide) Volume 97, World Health Organization, Lyon, France.

[241] NTP (National Toxicology Program). 2016. Report on Carcinogens, Fourteenth Edition.; Research Triangle Park, NC: U.S. Department of Health and Human Services, Public Health Service. *https://ntp.niehs.nih.gov/go/roc14.*

[242] International Agency for Research on Cancer (IARC). (2012). Monographs on the evaluation of carcinogenic risk of chemicals to humans, Volume 100F chemical agents and related occupations, World Health Organization, Lyon, France.

[243] U.S. EPA. (2002). ''Full IRIS Summary for 1,3-butadiene (CASRN 106–99–0)'' Environmental Protection Agency, Integrated Risk Information System (IRIS), Research and Development, National Center for Environmental Assessment, Washington, DC *https://cfpub.epa.gov/ncea/iris2/chemicalLanding.cfm?substance_nmbr=139.*

1,3-butadiene also causes a variety of reproductive and developmental effects in mice; no human data on these effects are available. The most sensitive effect was ovarian atrophy observed in a lifetime bioassay of female mice.[244] Based on this critical effect and the benchmark concentration methodology, an RfC for chronic health effects was calculated at 0.9 ppb (approximately 2 μg/m$^3$).

v. Ethylbenzene

EPA's inhalation RfC for ethylbenzene is 1 mg/m$^3$. This conclusion on a weight of evidence determination and RfC are contained in the 1991 IRIS file for ethylbenzene.[245] The RfC is based on developmental effects. A study in rabbits found reductions in live rabbit kits per litter at 1000 ppm. In addition, a study on rats found an increased incidence of supernumerary and rudimentary ribs at 1000 ppm, and elevated incidence of extra ribs at 100 ppm. In 1988, EPA concluded that data were inadequate to give a weight of evidence characterization for carcinogenic effects. EPA released an IRIS Assessment Plan for Ethylbenzene in 2017 [246] and EPA will be releasing the Systematic Review Protocol for ethylbenzene in 2023.[247]

California EPA completed a cancer risk assessment for ethylbenzene in 2007 and developed an inhalation unit risk estimate of 2.5 × 10–6.[248] This value was based on incidence of kidney cancer in male rats. California EPA also developed a chronic inhalation noncancer reference exposure level (REL) of 2000 μg/m$^3$, based on nephrotoxicity and body weight reduction in rats, liver cellular alterations, necrosis in mice, and hyperplasia of the pituitary gland in mice.[249]

ATSDR developed chronic Minimal Risk Levels (MRLs) for ethylbenzene of 0.06 ppm based on renal effects, and an acute MRL of 5 ppm based on auditory effects.

vi. Formaldehyde

In 1991, EPA concluded that formaldehyde is a Class B1 probable human carcinogen based on limited evidence in humans and sufficient evidence in animals.[250] An Inhalation URE for cancer and a Reference Dose for oral noncancer effects were developed by EPA and posted on the IRIS database. Since that time, the NTP and IARC have concluded that formaldehyde is a known human carcinogen.[251] [252] [253]

The conclusions by IARC and NTP reflect the results of epidemiologic research published since 1991 in combination with previous animal, human, and mechanistic evidence. Research conducted by the National Cancer Institute reported an increased risk of nasopharyngeal cancer and specific lymphohematopoietic malignancies among workers exposed to formaldehyde.[254] [255] [256] A National Institute of Occupational Safety and Health study of garment workers also reported increased risk of death due to leukemia among workers exposed to formaldehyde.[257] Extended follow-up of a cohort of British chemical workers did not report evidence of an increase in nasopharyngeal or lymphohematopoietic cancers, but a continuing statistically significant excess in lung cancers was reported.[258] Finally, a study of embalmers reported formaldehyde exposures to be associated with an increased risk of myeloid leukemia but not brain cancer.[259]

Health effects of formaldehyde in addition to cancer were reviewed by the Agency for Toxics Substances and Disease Registry in 1999, supplemented in 2010, and by the World Health Organization.[260] [261] [262] These organizations reviewed the scientific literature concerning health effects linked to formaldehyde exposure to evaluate hazards and dose response relationships and defined exposure concentrations for minimal risk levels (MRLs). The health endpoints reviewed included sensory irritation of eyes and respiratory tract, reduced pulmonary function, nasal histopathology, and immune system effects. In addition, research on reproductive and developmental effects and neurological effects were discussed along with several studies that suggest that formaldehyde may increase the risk of asthma—particularly in the young.

In June 2010, EPA released a draft Toxicological Review of Formaldehyde—Inhalation Assessment through the IRIS program for peer review by the National Research Council (NRC) and public comment.[263] That draft assessment reviewed more recent research from animal and human studies on cancer and other health effects. The NRC released their review report in April 2011.[264] EPA's draft

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[244] Bevan, C.; Stadler, J.C.; Elliot, G.S.; et al. (1996). Subchronic toxicity of 4-vinylcyclohexene in rats and mice by inhalation. Fundam. Appl. Toxicol. 32:1–10.

[245] U.S. EPA. (1991). Integrated Risk Information System File for Ethylbenzene. This material is available electronically at: *https://iris.epa.gov/ChemicalLanding/&substance_nmbr=51.*

[246] U.S. EPA (2017). IRIS Assessment Plan for Ethylbenzene. EPA/635/R–17/332. This document is available electronically at: *https://cfpub.epa.gov/ncea/iris_drafts/recordisplay.cfm?deid=337468.*

[247] U.S. EPA (2022). IRIS Program Outlook. June, 2022. This material is available electronically at: *https://www.epa.gov/system/files/documents/2022–06/IRIS%20Program%20Outlook_June22.pdf.*

[248] California OEHHA, 2007. Adoption of a Unit Risk Value for Ethylbenzene. This material is available electronically at: *https://oehha.ca.gov/air/report-hot-spots/adoption-unit-risk-value-ethylbenzene.*

[249] California OEHHA, 2008. Technical Supporting Document for Noncancer RELs, Appendix D3. This material is available electronically at: *https://oehha.ca.gov/media/downloads/crnr/appendixd3final.pdf.*

[250] EPA. Integrated Risk Information System. Formaldehyde (CASRN 50–00–0) *https://cfpub.epa.gov/ncea/iris2/chemicalLanding.cfm?substance_nmbr=419.*

[251] NTP (National Toxicology Program). 2016. Report on Carcinogens, Fourteenth Edition.; Research Triangle Park, NC: U.S. Department of Health and Human Services, Public Health Service. *https://ntp.niehs.nih.gov/go/roc14.*

[252] IARC Monographs on the Evaluation of Carcinogenic Risks to Humans Volume 88 (2006): Formaldehyde, 2-Butoxyethanol and 1-tert-Butoxypropan-2-ol.

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assessment, which addresses NRC recommendations, was suspended in 2018.[265] The draft assessment was unsuspended in March 2021, and an external review draft was released in April 2022.[266] This draft assessment is now undergoing review by the National Academy of Sciences.[267]

vii. Naphthalene

Naphthalene is found in small quantities in gasoline and diesel fuels. Naphthalene emissions have been measured in larger quantities in both gasoline and diesel exhaust compared with evaporative emissions from mobile sources, indicating it is primarily a product of combustion.

Acute (short-term) exposure of humans to naphthalene by inhalation, ingestion, or dermal contact is associated with hemolytic anemia and damage to the liver and the nervous system.[268] Chronic (long term) exposure of workers and rodents to naphthalene has been reported to cause cataracts and retinal damage.[269] Children, especially neonates, appear to be more susceptible to acute naphthalene poisoning based on the number of reports of lethal cases in children and infants (hypothesized to be due to immature naphthalene detoxification pathways).[270] EPA released an external review draft of a reassessment of the inhalation carcinogenicity of naphthalene based on a number of recent animal carcinogenicity studies.[271] The draft reassessment completed external peer review.[272] Based on external peer review comments received, EPA is developing a revised draft assessment that considers inhalation and oral routes of exposure, as well as cancer and noncancer effects.[273] The external review draft does not represent official agency opinion and was released solely for the purposes of external peer review and public comment. The NTP listed naphthalene as ''reasonably anticipated to be a human carcinogen'' in 2004 on the basis of bioassays reporting clear evidence of carcinogenicity in rats and some evidence of carcinogenicity in mice.[274] California EPA has released a new risk assessment for naphthalene, and the IARC has reevaluated naphthalene and re-classified it as Group 2B: possibly carcinogenic to humans.[275]

Naphthalene also causes a number of non-cancer effects in animals following chronic and less-than-chronic exposure, including abnormal cell changes and growth in respiratory and nasal tissues.[276] The current EPA IRIS assessment includes noncancer data on hyperplasia and metaplasia in nasal tissue that form the basis of the inhalation RfC of 3 $\mu g/m^3$.[277] The ATSDR MRL for acute and intermediate duration oral exposure to naphthalene is 0.6 mg/kg/day based on maternal toxicity in a developmental toxicology study in rats.[278] ATSDR also derived an ad hoc reference value of 6 × 10–2 mg/$m^3$ for acute (≤24-hour) inhalation exposure to naphthalene in a Letter Health Consultation dated March 24, 2014 to address a potential exposure concern in Illinois.[279] The ATSDR acute inhalation reference value was based on a qualitative identification of an exposure level interpreted not to cause pulmonary lesions in mice. More recently, EPA developed acute RfCs for 1-, 8-, and 24-hour exposure scenarios; the ≤24-hour reference value is 2 × 10–2 mg/$m^3$.[280] EPA's acute RfCs are based on a systematic review of the literature, benchmark dose modeling of naphthalene-induced nasal lesions in rats, and application of a PBPK (physiologically based pharmacokinetic) model.

viii. POM/PAHs

The term polycyclic organic matter (POM) defines a broad class of compounds that includes the polycyclic aromatic hydrocarbon compounds (PAHs). One of these compounds, naphthalene, is discussed separately in Section II.C.7.vii. POM compounds are formed primarily from combustion and are present in the atmosphere in gas and particulate form as well as in some fried and grilled foods. Epidemiologic studies have reported an increase in lung cancer in humans exposed to diesel exhaust, coke oven emissions, roofing tar emissions, and cigarette smoke; all of these mixtures contain POM compounds.[281] [282] In 1991 EPA classified seven PAHs (benzo[a]pyrene, benz[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[k]fluoranthene, dibenz[a,h]anthracene, and

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indeno[1,2,3-cd]pyrene) as Group B2, probable human carcinogens based on the 1986 EPA Guidelines for Carcinogen Risk Assessment.[283] Studies in multiple animal species demonstrate that benzo[a]pyrene is carcinogenic at multiple tumor sites (alimentary tract, liver, kidney, respiratory tract, pharynx, and skin) by all routes of exposure. An increasing number of occupational studies demonstrate a positive exposure-response relationship with cumulative benzo[a]pyrene exposure and lung cancer. The inhalation URE in IRIS for benzo[a]pyrene is 6 × 10–4 per μg/m$^3$ and the oral slope factor for cancer is 1 per mg/kg-day.[284]

Animal studies demonstrate that exposure to benzo[a]pyrene is also associated with developmental (including developmental neurotoxicity), reproductive, and immunological effects. In addition, epidemiology studies involving exposure to PAH mixtures have reported associations between internal biomarkers of exposure to benzo[a]pyrene (benzo[a]pyrene diol epoxide-DNA adducts) and adverse birth outcomes (including reduced birth weight, postnatal body weight, and head circumference), neurobehavioral effects, and decreased fertility. The inhalation RfC for benzo[a]pyrene is $2 \times 10^{-6}$ mg/m$^3$ and the RfD for oral exposure is $3 \times 10^{-4}$ mg/kg-day.[285]

### 8. Exposure and Health Effects Associated With Traffic

Locations in close proximity to major roadways generally have elevated concentrations of many air pollutants emitted from motor vehicles. Hundreds of studies have been published in peer-reviewed journals, concluding that concentrations of CO, $CO_2$, NO, $NO_2$, benzene, aldehydes, particulate matter, black carbon, and many other compounds are elevated in ambient air within approximately 300–600 meters (about 1,000–2,000 feet) of major roadways. The highest concentrations of most pollutants emitted directly by motor vehicles are found at locations within 50 meters (about 165 feet) of the edge of a roadway's traffic lanes.

A large-scale review of air quality measurements in the vicinity of major roadways between 1978 and 2008 concluded that the pollutants with the steepest concentration gradients in vicinities of roadways were CO, ultrafine particles, metals, elemental carbon (EC), NO, $NO_X$, and several VOCs.[286] These pollutants showed a large reduction in concentrations within 100 meters downwind of the roadway. Pollutants that showed more gradual reductions with distance from roadways included benzene, $NO_2$, $PM_{2.5}$, and $PM_{10}$. In reviewing the literature, Karner et al., (2010) reported that results varied based on the method of statistical analysis used to determine the gradient in pollutant concentration. More recent studies continue to show significant concentration gradients of traffic-related air pollution around major roads.[287] [288] [289] [290] [291] [292] [293] [294] [295] [296] There is evidence that EPA's regulations for vehicles have lowered the near-road concentrations and gradients.[297] Starting in 2010, EPA required through the NAAQS process that air quality monitors be placed near high-traffic roadways for determining concentrations of CO, $NO_2$, and $PM_{2.5}$ (in addition to those existing monitors located in neighborhoods and other locations farther away from pollution sources). The monitoring data for $NO_2$ indicate that in urban areas, monitors near roadways often report the highest concentrations of $NO_2$.[298] More recent studies of traffic-related air pollutants continue to report sharp gradients around roadways, particularly within several hundred meters.[299] [300]

For pollutants with relatively high background concentrations relative to near-road concentrations, detecting concentration gradients can be difficult. For example, many carbonyls have high background concentrations as a result of photochemical breakdown of precursors from many different organic compounds. However, several studies have measured carbonyls in multiple weather conditions and found higher concentrations of many carbonyls downwind of roadways.[301] [302] These

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findings suggest a substantial roadway source of these carbonyls.

In the past 30 years, many studies have been published with results reporting that populations who live, work, or go to school near high-traffic roadways experience higher rates of numerous adverse health effects, compared to populations far away from major roads.[303] In addition, numerous studies have found adverse health effects associated with spending time in traffic, such as commuting or walking along high-traffic roadways, including studies among children.[304][305][306][307] The health outcomes with the strongest evidence linking them with traffic-associated air pollutants are respiratory effects, particularly in asthmatic children, and cardiovascular effects.

Numerous reviews of this body of health literature have been published. In a 2022 final report, an expert panel of the Health Effects Institute (HEI) employed a systematic review focusing on selected health endpoints related to exposure to traffic-related air pollution.[308] The HEI panel concluded that there was a high level of confidence in evidence between long-term exposure to traffic-related air pollution and health effects in adults, including all-cause, circulatory, and ischemic heart disease mortality.[309] The panel also found that there is a moderate-to-high level of confidence in evidence of associations with asthma onset and acute respiratory infections in children and lung cancer and asthma onset in adults. This report follows on an earlier expert review published by HEI in 2010, where it found strongest evidence for asthma-related traffic impacts. Other literature reviews have been published with conclusions generally similar to the HEI panels'.[310][311][312][313] Additionally, in 2014, researchers from the U.S. Centers for Disease Control and Prevention (CDC) published a systematic review and meta-analysis of studies evaluating the risk of childhood leukemia associated with traffic exposure and reported positive associations between ''postnatal'' proximity to traffic and leukemia risks, but no such association for ''prenatal'' exposures.[314] The U.S. Department of Health and Human Services' National Toxicology Program (NTP) published a monograph including a systematic review of traffic-related air pollution and its impacts on hypertensive disorders of pregnancy. The NTP concluded that exposure to traffic-related air pollution is ''presumed to be a hazard to pregnant women'' for developing hypertensive disorders of pregnancy.[315]

Health outcomes with few publications suggest the possibility of other effects still lacking sufficient evidence to draw definitive conclusions. Among these outcomes with a small number of positive studies are neurological impacts (*e.g.,* autism and reduced cognitive function) and reproductive outcomes (*e.g.,* preterm birth, low birth weight).[316][317][318][319][320]

In addition to health outcomes, particularly cardiopulmonary effects, conclusions of numerous studies suggest mechanisms by which traffic-related air pollution affects health. For example, numerous studies indicate that near-roadway exposures may increase systemic inflammation, affecting organ systems, including blood vessels and lungs.[321][322][323][324] Additionally, long-term exposures in near-road environments have been associated with inflammation-associated conditions, such as atherosclerosis and asthma.[325][326][327]

Several studies suggest that some factors may increase susceptibility to

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[325] Adar, S.D.; Klein, R.; Klein, E.K.; et al. (2010). Air pollution and the microvasculature: a cross-sectional assessment of in vivo retinal images in the population-based Multi-Ethnic Study of Atherosclerosis. PLoS Med 7(11): E1000372. doi:10.1371/journal.pmed.1000372. Available at *http://dx.doi.org*.

[326] Kan, H.; Heiss, G.; Rose, K.M.; et al. (2008). Prospective analysis of traffic exposure as a risk factor for incident coronary heart disease: The Atherosclerosis Risk in Communities (ARIC) study. Environ Health Perspect 116: 1463–1468. doi:10.1289/ehp.11290. Available at *http://dx.doi.org*.

[327] McConnell, R.; Islam, T.; Shankardass, K.; et al. (2010). Childhood incident asthma and traffic-related air pollution at home and school. Environ Health Perspect 1021–1026.

the effects of traffic-associated air pollution. Several studies have found stronger respiratory associations in children experiencing chronic social stress, such as in violent neighborhoods or in homes with high family stress.[328] [329] [330]

The risks associated with residence, workplace, or schools near major roads are of potentially high public health significance due to the large population in such locations. The 2013 U.S. Census Bureau's American Housing Survey (AHS) was the last AHS that included whether housing units were within 300 feet of an ''airport, railroad, or highway with four or more lanes.'' [331] The 2013 survey reports that 17.3 million housing units, or 13 percent of all housing units in the U.S., were in such areas. Assuming that populations and housing units are in the same locations, this corresponds to a population of more than 41 million U.S. residents within 300 feet (approximately 90 meters) of high-traffic roadways or other transportation sources. According to the Central Intelligence Agency's World Factbook, based on data collected between 2012–2014, the United States had 6,586,610 km of roadways, 293,564 km of railways, and 13,513 airports. As such, highways represent the overwhelming majority of transportation facilities described by this factor in the AHS.

We analyzed national databases that allowed us to evaluate whether homes and schools were located near a major road and whether disparities in exposure may be occurring in these environments. Until 2009, the AHS included descriptive statistics of over 70,000 housing units across the nation and asked about transportation infrastructure near respondents' homes every two years.[332] [333] We also analyzed the U.S. Department of Education's Common Core of Data, which includes enrollment and location information for schools across the U.S.[334]

In analyzing the 2009 AHS, we focused on whether a housing unit was located within 300 feet of a ''4-or-more lane highway, railroad, or airport'' (this distance was used in the AHS analysis).[335] We analyzed whether there were differences between households in such locations compared with those in locations farther from these transportation facilities.[336] We included other variables, such as land use category, region of country, and housing type. We found that homes with a non-White householder were 22–34 percent more likely to be located within 300 feet of these large transportation facilities than homes with White householders. Homes with a Hispanic householder were 17–33 percent more likely to be located within 300 feet of these large transportation facilities than homes with non-Hispanic householders. Households near large transportation facilities were, on average, lower in income and educational attainment and more likely to be a rental property and located in an urban area compared with households more distant from transportation facilities.

In examining schools near major roadways, we used the Common Core of Data from the U.S. Department of Education, which includes information on all public elementary and secondary schools and school districts nationwide.[337] To determine school proximities to major roadways, we used a geographic information system (GIS) to map each school and roadways based on the U.S. Census's TIGER roadway file.[338] We estimated that about 10 million students attend public schools within 200 meters of major roads, about 20 percent of the total number of public school students in the U.S.[339] About 800,000 students attend public schools within 200 meters of primary roads, or about 2 percent of the total. We found that students of color were overrepresented at schools within 200 meters of primary roadways, and schools within 200 meters of primary roadways had a disproportionate population of students eligible for free or reduced-price lunches.[340] Black students represent 22 percent of students at schools located within 200 meters of a primary road, compared to 17 percent of students in all U.S. schools. Hispanic students represent 30 percent of students at schools located within 200 meters of a primary road, compared to 22 percent of students in all U.S. schools.

Research into the impact of traffic-related air pollution on school performance is tentative. Two reviews of this literature found some evidence that children exposed to higher levels of traffic-related air pollution show poorer academic performance than those exposed to lower levels of traffic-related air pollution.[341] [342] However, this evidence was judged to be weak due to limitations in the assessment methods.

EPA also conducted a study to estimate the number of people living near truck freight routes in the United States, which includes many large highways and other routes where light- and medium-duty vehicles operate.[343] [344] Based on a population

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[328] Islam, T.; Urban, R.; Gauderman, W.J.; et al. (2011). Parental stress increases the detrimental effect of traffic exposure on children's lung function. Am J Respir Crit Care Med.

[329] Clougherty, J.E.; Levy, J.I.; Kubzansky, L.D.; et al. (2007). Synergistic effects of traffic-related air pollution and exposure to violence on urban asthma etiology. Environ Health Perspect 115: 1140–1146.

[330] Chen, E.; Schrier, H.M.; Strunk, R.C.; et al. (2008). Chronic traffic-related air pollution and stress interact to predict biologic and clinical outcomes in asthma. Environ Health Perspect 116: 970–5.

[331] The variable was known as ''ETRANS'' in the questions about the neighborhood.

[332] U.S. Department of Housing and Urban Development, & U.S. Census Bureau. (n.d.). Age of other residential buildings within 300 feet. In American Housing Survey for the United States: 2009 (pp. A–1). Retrieved from *https://www.census.gov/programs-surveys/ahs/data/2009/ahs-2009-summary-tables0/h150-09.html.*

[333] The 2013 AHS again included the ''etrans'' question about highways, airports, and railroads within half a block of the housing unit but has not maintained the question since then.

[334] *http://nces.ed.gov/ccd/.*

[335] This variable primarily represents roadway proximity. According to the Central Intelligence Agency's World Factbook, in 2010, the United States had 6,506,204 km of roadways, 224,792 km of railways, and 15,079 airports. Highways thus represent the overwhelming majority of transportation facilities described by this factor in the AHS.

[336] Bailey, C. (2011) Demographic and Social Patterns in Housing Units Near Large Highways and other Transportation Sources. Memorandum to docket.

[337] *http://nces.ed.gov/ccd/.*

[338] Pedde, M.; Bailey, C. (2011) Identification of Schools within 200 Meters of U.S. Primary and Secondary Roads. Memorandum to the docket.

[339] Here, ''major roads'' refer to those TIGER classifies as either ''Primary'' or ''Secondary.'' The Census Bureau describes primary roads as ''generally divided limited-access highways within the Federal interstate system or under state management.'' Secondary roads are ''main arteries, usually in the U.S. highway, state highway, or county highway system.''

[340] For this analysis we analyzed a 200-meter distance based on the understanding that roadways generally influence air quality within a few hundred meters from the vicinity of heavily traveled roadways or along corridors with significant trucking traffic. See U.S. EPA, 2014. Near Roadway Air Pollution and Health: Frequently Asked Questions. EPA–420–F–14–044. For a surrogate of lower socioeconomic status (SES), we used student eligibility for the U.S. Department of Agriculture's (USDA) National School Lunch Program.

[341] Stenson, C.; Wheeler, A.J.; Carver, A.; et al. (2021) The impact of traffic-related air pollution on child and adolescent academic performance: a systematic review. Environ Intl 155: 106696. [Online at *https://doi.org/10.1016/j.envint.2021.106696.*]

[342] Gartland, N; Aljofi, H.E.; Dienes, K.; Munford, L.A.; Theakston, A.L.; van Tongeren, M. (2022) The effects of traffic air pollution in and around schools on executive function and academic performance in children: a rapid review. Int J Environ Res Public Health 10: 749. [Online at *https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8776123/.*]

[343] U.S. EPA (2021). Estimation of Population Size and Demographic Characteristics among People Living Near Truck Routes in the Conterminous United States. Memorandum to the Docket.

[344] FAF4 includes the following roadway types: interstate highways, other FHWA-designated routes

Continued

analysis using the U.S. Department of Transportation's (USDOT) Freight Analysis Framework 4 (FAF4) and population data from the 2010 decennial census, an estimated 72 million people live within 200 meters of these FAF4 roads, which are used by all types of vehicles.[345] [346] This analysis includes the population living within twice the distance of major roads compared with the analysis of housing units near major roads described earlier in this section. The larger distance and other methodological differences explain the difference in the two estimates for populations living near major roads. Relative to the rest of the population, people of color and those with lower incomes are more likely to live near FAF4 roads.

EPA's Exposure Factor Handbook also indicates that, on average, Americans spend more than an hour traveling each day, bringing nearly all residents into a high-exposure microenvironment for part of the day.[347] The duration of commuting results in another important contributor to overall exposure to traffic-related air pollution. Studies of health that address time spent in transit have found evidence of elevated risk of cardiac impacts.[348] [349] [350]

### *D. Welfare Effects Associated With Exposure to Criteria and Air Toxics Pollutants Impacted by the Proposed Standards*

This section discusses the welfare effects associated with pollutants affected by this rule, specifically particulate matter, ozone, $NO_X$, $SO_X$, and air toxics.

#### 1. Visibility

Visibility can be defined as the degree to which the atmosphere is transparent to visible light.[351] Visibility impairment is caused by light scattering and absorption by suspended particles and gases. It is dominated by contributions from suspended particles except under pristine conditions. Visibility is important because it has direct significance to people's enjoyment of daily activities in all parts of the country. Individuals value good visibility for the well-being it provides them directly, where they live and work, and in places where they enjoy recreational opportunities. Visibility is also highly valued in significant natural areas, such as national parks and wilderness areas, and special emphasis is given to protecting visibility in these areas. For more information on visibility see the final 2019 PMISA.[352]

EPA is working to address visibility impairment. Reductions in air pollution from implementation of various programs associated with the Clean Air Act Amendments of 1990 provisions have resulted in substantial improvements in visibility and will continue to do so in the future. Nationally, because trends in haze are closely associated with trends in particulate sulfate and nitrate due to the relationship between their concentration and light extinction, visibility trends have improved as emissions of $SO_2$ and $NO_X$ have decreased over time due to air pollution regulations such as the Acid Rain Program.[353] However, in the western part of the country, changes in total light extinction were smaller, and the contribution of particulate organic matter to atmospheric light extinction was increasing due to increasing wildfire emissions.[354]

In the Clean Air Act Amendments of 1977, Congress recognized visibility's value to society by establishing a national goal to protect national parks and wilderness areas from visibility impairment caused by manmade pollution.[355] In 1999, EPA finalized the regional haze program to protect the visibility in Mandatory Class I Federal areas.[356] There are 156 national parks, forests and wilderness areas categorized as Mandatory Class I Federal areas.[357] These areas are defined in CAA section 162 as those national parks exceeding 6,000 acres, wilderness areas and memorial parks exceeding 5,000 acres, and all international parks which were in existence on August 7, 1977.

EPA has also concluded that $PM_{2.5}$ causes adverse effects on visibility in other areas that are not targeted by the Regional Haze Rule, such as urban areas, depending on $PM_{2.5}$ concentrations and other factors such as dry chemical composition and relative humidity (*i.e.,* an indicator of the water composition of the particles). The secondary (welfare-based) PM NAAQS provide protection against visibility effects. In recent PM NAAQS reviews, EPA evaluated a target level of protection for visibility impairment that is expected to be met through attainment of the existing secondary PM standards.[358]

#### 2. Ozone Effects on Ecosystems

The welfare effects of ozone include effects on ecosystems, which can be observed across a variety of scales, *i.e.,* subcellular, cellular, leaf, whole plant, population, and ecosystem. Ozone effects that begin at small spatial scales, such as the leaf of an individual plant, when they occur at sufficient magnitudes (or to a sufficient degree) can result in effects being propagated along a continuum to higher and higher levels of biological organization. For example, effects at the individual plant level, such as altered rates of leaf gas exchange, growth, and reproduction, can, when widespread, result in broad changes in ecosystems, such as productivity, carbon storage, water

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in the National Highway System (NHS), National Network (NN) routes not part of the NHS, other rural and urban principal arterials, intermodal connectors, rural minor arterials for those counties not served by either NHS or NN routes, and urban bypass and streets as appropriate for network connectivity. Full documentation of the FAF4 road network is found at *https://fafdev.ornl.gov/fafweb/data/Final%20Report_FAF4_August_2016_BP.pdf.*

[345] FAF4 is a model from the USDOT's Bureau of Transportation Statistics (BTS) and Federal Highway Administration (FHWA), which provides data associated with freight movement in the U.S. It includes data from the 2012 Commodity Flow Survey (CFS), the Census Bureau on international trade, as well as data associated with construction, agriculture, utilities, warehouses, and other industries. FAF4 estimates the modal choices for moving goods by trucks, trains, boats, and other types of freight modes. It includes traffic assignments, including truck flows on a network of truck routes. *https://ops.fhwa.dot.gov/freight/freight_analysis/faf/.*

[346] The same analysis estimated the population living within 100 meters of a FAF4 truck route is 41 million.

[347] EPA. (2011) Exposure Factors Handbook: 2011 Edition. Chapter 16. Online at *https://www.epa.gov/expobox/about-exposure-factors-handbook.*

[348] Riediker, M.; Cascio, W.E.; Griggs, T.R.; et al. (2004) Particulate matter exposure in cars is associated with cardiovascular effects in healthy young men. Am J Respir Crit Care Med 169. [Online at *https://doi.org/10.1164/rccm.200310-1463OC.*]

[349] Peters, A.; von Klot, S.; Heier, M.; et al. (2004) Exposure to traffic and the onset of myocardial infarction. New Engl J Med 1721–1730. [Online at *https://doi.org/10.1056/NEJMoa040203.*]

[350] Adar, S.D.; Gold, D.R.; Coull, B.A.; (2007) Focused exposure to airborne traffic particles and heart rate variability in the elderly. Epidemiology 18: 95–103 [Online at 351: *https://doi.org/10.1097/01.ede.0000249409.81050.46.*]

[351] National Research Council, (1993). Protecting Visibility in National Parks and Wilderness Areas. National Academy of Sciences Committee on Haze in National Parks and Wilderness Areas. National Academy Press, Washington, DC. This book can be viewed on the National Academy Press website at *https://www.nap.edu/catalog/2097/protecting-visibility-in-national-parks-and-wilderness-areas.*

[352] U.S. EPA. Integrated Science Assessment (ISA) for Particulate Matter (Final Report, 2019). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–19/188, 2019.

[353] U.S. EPA. Integrated Science Assessment (ISA) for Particulate Matter (Final Report, 2019). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–19/188, 2019.

[354] Hand, JL; Prenni, AJ; Copeland, S; Schichtel, BA; Malm, WC. (2020). Thirty years of the Clean Air Act Amendments: Impacts on haze in remote regions of the United States (1990–2018). Atmos Environ 243: 117865.

[355] See Section 169(a) of the Clean Air Act.

[356] 64 FR 35714, July 1, 1999.

[357] 62 FR 38680–38681, July 18, 1997.

[358] On June 10, 2021, EPA announced that it will reconsider the decision to retain the PM NAAQS. *https://www.epa.gov/pm-pollution/national-ambient-air-quality-standards-naaqs-pm.*

cycling, nutrient cycling, and community composition.

Ozone can produce both acute and chronic injury in sensitive plant species depending on the concentration level and the duration of the exposure.[359] In those sensitive species,[360] effects from repeated exposure to ozone throughout the growing season of the plant can tend to accumulate, so even relatively low concentrations experienced for a longer duration have the potential to create chronic stress on vegetation.[361] [362] Ozone damage to sensitive plant species includes impaired photosynthesis and visible injury to leaves. The impairment of photosynthesis, the process by which the plant makes carbohydrates (its source of energy and food), can lead to reduced crop yields, timber production, and plant productivity and growth. Impaired photosynthesis can also lead to a reduction in root growth and carbohydrate storage below ground, resulting in other, more subtle plant and ecosystems impacts.[363] These latter impacts include increased susceptibility of plants to insect attack, disease, harsh weather, interspecies competition and overall decreased plant vigor. The adverse effects of ozone on areas with sensitive species could potentially lead to species shifts and loss from the affected ecosystems,[364] resulting in a loss or reduction in associated ecosystem goods and services. Additionally, visible ozone injury to leaves can result in a loss of aesthetic value in areas of special scenic significance like national parks and wilderness areas and reduced use of sensitive ornamentals in landscaping.[365] In addition to ozone effects on vegetation, newer evidence suggests that ozone affects interactions between plants and insects by altering chemical signals (*e.g.,* floral scents) that plants use to communicate to other community members, such as attraction of pollinators.

The Ozone ISA presents more detailed information on how ozone affects vegetation and ecosystems.[366] [367] The Ozone ISA reports causal and likely causal relationships between ozone exposure and a number of welfare effects and characterizes the weight of evidence for different effects associated with ozone.[368] The ISA concludes that visible foliar injury effects on vegetation, reduced vegetation growth, reduced plant reproduction, reduced productivity in terrestrial ecosystems, reduced yield and quality of agricultural crops, alteration of below-ground biogeochemical cycles, and altered terrestrial community composition are causally associated with exposure to ozone. It also concludes that increased tree mortality, altered herbivore growth and reproduction, altered plant-insect signaling, reduced carbon sequestration in terrestrial ecosystems, and alteration of terrestrial ecosystem water cycling are likely to be causally associated with exposure to ozone.

### 3. Deposition

The Integrated Science Assessment for Oxides of Nitrogen, Oxides of Sulfur, and Particulate Matter—Ecological Criteria documents the ecological effects of the deposition of these criteria air pollutants.[369] It is clear from the body of evidence that oxides of nitrogen, oxides of sulfur, and particulate matter contribute to total nitrogen (N) and sulfur (S) deposition. In turn, N and S deposition cause either nutrient enrichment or acidification depending on the sensitivity of the landscape or the species in question. Both enrichment and acidification are characterized by an alteration of the biogeochemistry and the physiology of organisms, resulting in harmful declines in biodiversity in terrestrial, freshwater, wetland, and estuarine ecosystems in the U.S. Decreases in biodiversity mean that some species become relatively less abundant and may be locally extirpated. In addition to the loss of unique living species, the decline in total biodiversity can be harmful because biodiversity is an important determinant of the stability of ecosystems and their ability to provide socially valuable ecosystem services.

Terrestrial, wetland, freshwater, and estuarine ecosystems in the U.S. are affected by N enrichment/eutrophication caused by N deposition. These effects have been consistently documented across the U.S. for hundreds of species. In aquatic systems increased nitrogen can alter species assemblages and cause eutrophication. In terrestrial systems nitrogen loading can lead to loss of nitrogen-sensitive lichen species, decreased biodiversity of grasslands, meadows and other sensitive habitats, and increased potential for invasive species. For a broader explanation of the topics treated here, refer to the description in Chapter 9 of the DRIA.

The sensitivity of terrestrial and aquatic ecosystems to acidification from nitrogen and sulfur deposition is predominantly governed by geology. Prolonged exposure to excess nitrogen and sulfur deposition in sensitive areas acidifies lakes, rivers, and soils. Increased acidity in surface waters creates inhospitable conditions for biota and affects the abundance and biodiversity of fishes, zooplankton and macroinvertebrates and ecosystem function. Over time, acidifying deposition also removes essential nutrients from forest soils, depleting the capacity of soils to neutralize future acid loadings and negatively affecting forest sustainability. Major effects in forests include a decline in sensitive tree species, such as red spruce (Picea rubens) and sugar maple (Acer saccharum).

Building materials including metals, stones, cements, and paints undergo natural weathering processes from exposure to environmental elements (*e.g.,* wind, moisture, temperature fluctuations, sunlight, etc.). Pollution can worsen and accelerate these effects. Deposition of PM is associated with both physical damage (materials damage effects) and impaired aesthetic qualities (soiling effects). Wet and dry deposition of PM can physically affect materials, adding to the effects of natural weathering processes, by potentially promoting or accelerating the corrosion of metals, by degrading paints and by deteriorating building materials such as

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[359] 73 FR 16486, March 27, 2008.

[360] 73 FR 16491, March 27, 2008. Only a small percentage of all the plant species growing within the U.S. (over 43,000 species have been catalogued in the USDA PLANTS database) have been studied with respect to ozone sensitivity.

[361] U.S. EPA. Integrated Science Assessment (ISA) for Ozone and Related Photochemical Oxidants (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–20/012, 2020.

[362] The concentration at which ozone levels overwhelm a plant's ability to detoxify or compensate for oxidant exposure varies. Thus, whether a plant is classified as sensitive or tolerant depends in part on the exposure levels being considered.

[363] 73 FR 16492, March 27, 2008.

[364] 73 FR 16493–16494, March 27, 2008. Ozone impacts could be occurring in areas where plant species sensitive to ozone have not yet been studied or identified.

[365] 73 FR 16490–16497, March 27, 2008.

[366] U.S. EPA. Integrated Science Assessment (ISA) for Ozone and Related Photochemical Oxidants (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–20/012, 2020.

[367] U.S. EPA. Integrated Science Assessment (ISA) for Ozone and Related Photochemical Oxidants (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–20/012, 2020.

[368] The Ozone ISA evaluates the evidence associated with different ozone related health and welfare effects, assigning one of five ''weight of evidence'' determinations: causal relationship, likely to be a causal relationship, suggestive of a causal relationship, inadequate to infer a causal relationship, and not likely to be a causal relationship. For more information on these levels of evidence, please refer to Table II of the ISA.

[369] U.S. EPA. Integrated Science Assessment (ISA) for Oxides of Nitrogen, Oxides of Sulfur and Particulate Matter Ecological Criteria (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–20/278, 2020.

stone, concrete, and marble.[370] The effects of PM are exacerbated by the presence of acidic gases and can be additive or synergistic due to the complex mixture of pollutants in the air and surface characteristics of the material. Acidic deposition has been shown to have an effect on materials including zinc/galvanized steel and other metal, carbonate stone (as monuments and building facings), and surface coatings (paints).[371] The effects on historic buildings and outdoor works of art are of particular concern because of the uniqueness and irreplaceability of many of these objects. In addition to aesthetic and functional effects on metals, stone, and glass, altered energy efficiency of photovoltaic panels by PM deposition is also becoming an important consideration for impacts of air pollutants on materials.

#### 4. Welfare Effects Associated With Air Toxics

Emissions from producing, transporting, and combusting fuel contribute to ambient levels of pollutants that contribute to adverse effects on vegetation. VOCs, some of which are considered air toxics, have long been suspected to play a role in vegetation damage.[372] In laboratory experiments, a wide range of tolerance to VOCs has been observed.[373] Decreases in harvested seed pod weight have been reported for the more sensitive plants, and some studies have reported effects on seed germination, flowering, and fruit ripening. Effects of individual VOCs or their role in conjunction with other stressors (*e.g.,* acidification, drought, temperature extremes) have not been well studied. In a recent study of a mixture of VOCs including ethanol and toluene on herbaceous plants, significant effects on seed production, leaf water content and photosynthetic efficiency were reported for some plant species.[374]

Research suggests an adverse impact of vehicle exhaust on plants, which has in some cases been attributed to aromatic compounds and in other cases to $NO_X$.[375] [376] [377] The impacts of VOCs on plant reproduction may have long-term implications for biodiversity and survival of native species near major roadways. Most of the studies of the impacts of VOCs on vegetation have focused on short-term exposure and few studies have focused on long-term effects of VOCs on vegetation and the potential for metabolites of these compounds to affect herbivores or insects.

## III. EPA Proposal for Light- and Medium-Duty Vehicle Standards for Model Years 2027 and Later

### *A. Introduction and Background*

This Preamble Section III outlines the proposed GHG and criteria pollutant standards and related provisions that are included in the proposal.

Throughout this section and elsewhere in this NPRM, EPA uses the following conventions to identify specific vehicle technology types. More information about these vehicle technologies may be found in the 2016 EPA Draft Technical Assessment Report.[378]

- ICE vehicle: an internal combustion engine (ICE) vehicle with no powertrain electrification
- BEV: Battery Electric Vehicle
- PHEV: Plug-in Hybrid Electric Vehicle
- PEV: Plug-in Electric Vehicle (refers collectively to BEVs and PHEVs)
- HEV: Hybrid Electric Vehicle (or strong hybrid) [379]
- MHEV: Mild Hybrid Electric Vehicle [380]
- Hybrid: refers collectively to HEVs (or strong hybrid) and MHEVs
- FCEV: Fuel Cell Electric Vehicle
- Electrified: any of the preceding vehicle types with an electric drive, including FCEV
- ZEV: Zero-Emission Vehicle (used primarily in reference to the California ZEV program)

Because ZEV has a specific meaning under the California program, EPA in this proposal is generally refraining from using the term except in reference to the California program. Executive Order (E.O.) 14037 also uses the term ''zero-emission vehicle'' to refer generally to BEVs, FCEVs, and PHEVs, so EPA may also use ''ZEV'' when referencing the E.O.

Additionally, in the context of the criteria pollutant program, the abbreviation LDV refers to light-duty vehicles that are not otherwise designated as a light-duty truck (LDT) or medium-duty passenger vehicle (MDPV).[381] In this proposal, the new nomenclature ''medium-duty vehicle'' (MDV) refers to Class 2b and 3 vehicles, as described in the following section.

#### 1. What vehicle categories and pollutants are covered by the proposal?

EPA is proposing emissions standards for both light-duty vehicles and medium-duty (Class 2b and 3) vehicles. The light-duty vehicle category includes passenger cars, light trucks, and medium-duty passenger vehicles (MDPVs), consistent with previous EPA GHG and criteria pollutant rules.[382] In this proposed rule, Class 2b and 3 vehicles are referred to as ''medium-duty vehicles'' (MDVs) to distinguish them from Class 4 and higher vehicles that remain under the heavy-duty program in 40 CFR parts 1036 and 1037. EPA has not previously used the MDV nomenclature, referring to these larger vehicles in prior rules as either heavy-duty Class 2b and 3 vehicles or heavy-duty pickups and vans.[383] The MDV category includes large pickups, vans, and incomplete vehicles, but excludes MDPVs. Examples of vehicles in this

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[370] U.S. EPA. Integrated Science Assessment (ISA) for Particulate Matter (Final Report, 2019). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R–19/188, 2019.

[371] Irving, P.M., e.d. 1991. Acid Deposition: State of Science and Technology, Volume III, Terrestrial, Materials, Health, and Visibility Effects, The U.S. National Acid Precipitation Assessment Program, Chapter 24, page 24–76.

[372] U.S. EPA. (1991). Effects of organic chemicals in the atmosphere on terrestrial plants. EPA/600/3–91/001.

[373] Cape JN, ID Leith, J Binnie, J Content, M Donkin, M Skewes, DN Price AR Brown, AD Sharpe. (2003). Effects of VOCs on herbaceous plants in an open-top chamber experiment. Environ. Pollut. 124:341–343.

[374] Cape JN, ID Leith, J Binnie, J Content, M Donkin, M Skewes, DN Price AR Brown, AD Sharpe. (2003). Effects of VOCs on herbaceous plants in an open-top chamber experiment. Environ. Pollut. 124:341–343.

[375] Viskari E–L. (2000). Epicuticular wax of Norway spruce needles as indicator of traffic pollutant deposition. Water, Air, and Soil Pollut. 121:327–337.

[376] Ugrekhelidze D, F Korte, G Kvesitadze. (1997). Uptake and transformation of benzene and toluene by plant leaves. Ecotox. Environ. Safety 37:24–29.

[377] Kammerbauer H, H Selinger, R Rommelt, A Ziegler-Jons, D Knoppik, B Hock. (1987). Toxic components of motor vehicle emissions for the spruce Picea abies. Environ. Pollut. 48:235–243.

[378] Draft Technical Assessment Report, EPA–420–D–16–900, July 2016.

[379] Strong hybrids typically operate at high voltage (greater than 60 volts and most often up to several hundred volts) to provide significant engine assist and regenerative braking, and most commonly occur in what are known as P2 and power-split or other parallel/series drive configurations. See also Draft Technical Assessment Report, EPA–420–D–16–900, July 2016, pp. 5–11 and 5–12.

[380] Mild hybrids most commonly operate at or about 48 volts and provide idle-stop capability and launch assistance. See also Draft Technical Assessment Report, EPA–420–D–16–900, July 2016, p. 5–11.

[381] Title 40 CFR 86.1803.

[382] Light-duty trucks (LDTs) that have gross vehicle weight ratings above 6,000 pounds and all MDVs are considered ''heavy-duty vehicles'' under the CAA. See section 202(b)(3)(C). For regulatory purposes, we generally refer to those LDTs which are above 6,000 pounds GVWR and at or below 8,500 pounds GVWR as ''heavy light-duty trucks'' made up of LDT3s and LDT4s, and we have defined MDPVs primarily as vehicles between 8,501 and 10,000 pounds GVWR designed primarily for the transportation of persons. See 40 CFR 86.1803–01.

[383] See 76 FR 57106 and 79 FR 23414. Heavy-duty vehicles subject to standards under 40 CFR part 86, subpart S, are defined at 40 CFR 86.1803–01 to include all vehicles above 8,500 pounds GVWR, and also incomplete vehicles with lower GVWR if they have curb weight above 6,000 pounds or basic vehicle frontal area greater than 45 square feet.

category include GM or Stellantis 2500 and 3500 series, and Ford 250 and 350 series, pickups and vans. EPA notes that it is proposing that certain Class 2b and 3 vehicles would be subject to engine-based criteria pollutant emissions standards under EPA's heavy-duty engine standards rather than being included in the MDV category, as discussed in Section III.C.

EPA is proposing new standards for emissions of GHGs and hydrocarbons, oxides of nitrogen ($NO_X$), and particulate matter (PM). EPA's proposed standards are based on an assessment of all available and potential vehicle emissions control technologies, including advancements in gasoline vehicle technologies, strong hybridization, and zero-emission technologies over the model years affected by the proposal.

2. Light-Duty and Medium-Duty Vehicle Standards: Background and History

Previously, EPA has addressed medium-duty vehicle emissions as part of regulatory programs for GHG emissions along with the heavy-duty sector, and for criteria pollutant emissions along with the light-duty sector. As a result, the program structure for medium-duty vehicles is similar to that of the light-duty program for criteria pollutants but differs from that of light-duty program for GHG emissions. This section provides a brief overview of the rules and the standards structures for EPA's light-duty GHG emissions standards, MDV GHG emissions standards, and criteria pollutant emissions standards. While the current proposal is addressing both light- and medium-duty vehicles under a single umbrella rulemaking, EPA is proposing standards for each class and for each pollutant pursuant to the relevant statutory provisions for each class and pollutant based on its assessment of the feasibility of more stringent standards for each class and pollutant, and the programs would continue to follow the basic structures EPA has previously adopted.

i. GHG Standards

EPA has issued four rules establishing light-duty vehicle GHG standards, which EPA refers to in this proposal based on the year in which the previous final rule was issued, as shown in Table 20.[384]

TABLE 20—PREVIOUS GHG LIGHT-DUTY VEHICLES STANDARDS RULES

| Rule | MYs covered | Title | **Federal Register** citation |
|---|---|---|---|
| 2010 Rule | Initial 2010 rule established standards for MYs 2012–2016 and later. | Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards. | 75 FR 25324, May 7, 2010. |
| 2012 Rule | Set more stringent standards for MYs 2017–2025 and later. | 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards. | 77 FR 62624, October 15, 2012. |
| 2020 Rule | Revised the standards for MYs 2022–2025 to make them less stringent and established a new standard for MYs 2026 and later. | The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks. | 85 FR 24174, April 30, 2020. |
| 2021 Rule | Revised the standards for MYs 2023–2026 to make them more stringent, with the MY 2026 standards being the most stringent GHG standards established by EPA to date. | Revised 2023 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions Standards. | 86 FR 74434, December 30, 2021. |

The GHG standards have all been based on fleet average $CO_2$ emissions. Each vehicle model is assigned a $CO_2$ target based on the vehicle's "footprint" in square feet ($ft^2$), generally consisting of the area of the rectangle formed by the four points at which the tires rest on the ground. Generally, vehicles with larger footprints have higher assigned $CO_2$ emissions targets. The most recent set of footprint curves established by the 2021 rule for model years 2023–2026 are shown in Figure 4 and Figure 5, along with the curves for MYs 2021–2022, included for comparison. As shown, passenger cars and light trucks have separate footprint standards curves, which result in separate fleet average standards for the two sets of vehicles. The fleet-average standards are the production-weighted fleet average of the footprint targets for all the vehicles in a manufacturer's fleet for a given model year. As a result, the footprint-based fleet average standards, which manufacturers are required to meet on an annual basis, will vary for each manufacturer based on its actual production of vehicles in a given model year. Individual vehicles are not required to meet their footprint-based $CO_2$ targets, although they are required to demonstrate compliance with applicable in-use standards.

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[384] The first three rules were issued jointly with NHTSA, while EPA issued the 2021 Rule in coordination with NHTSA but not as a joint rulemaking.

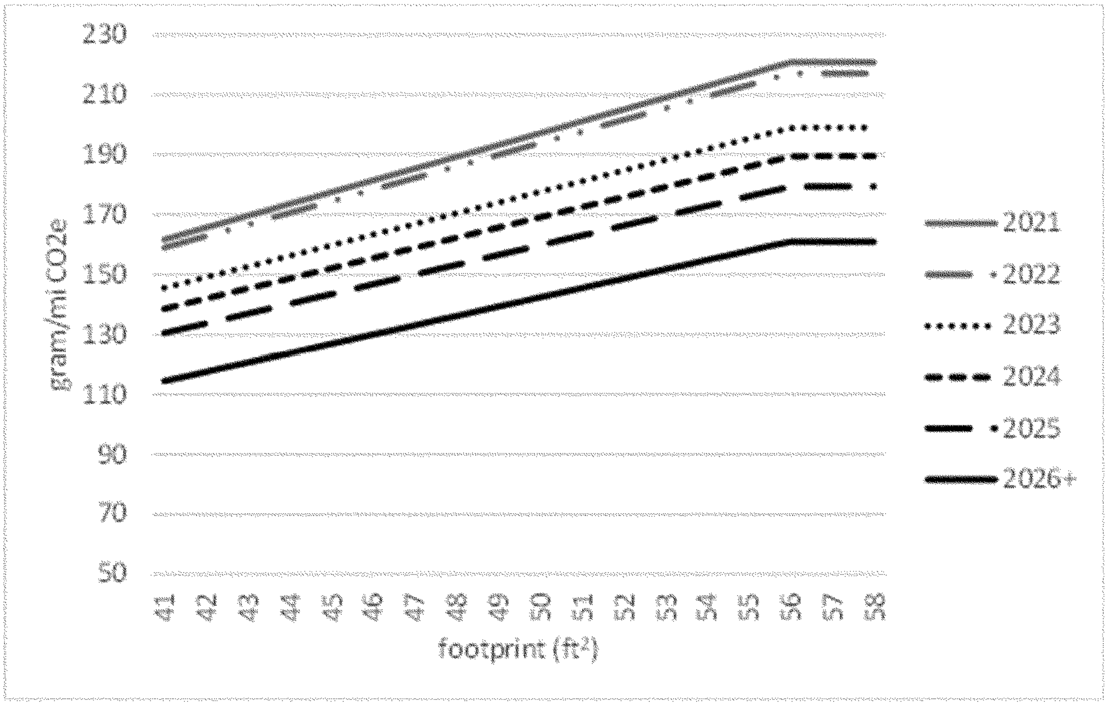

**Figure 4. Car footprint curves for MYs 2021-2026.**

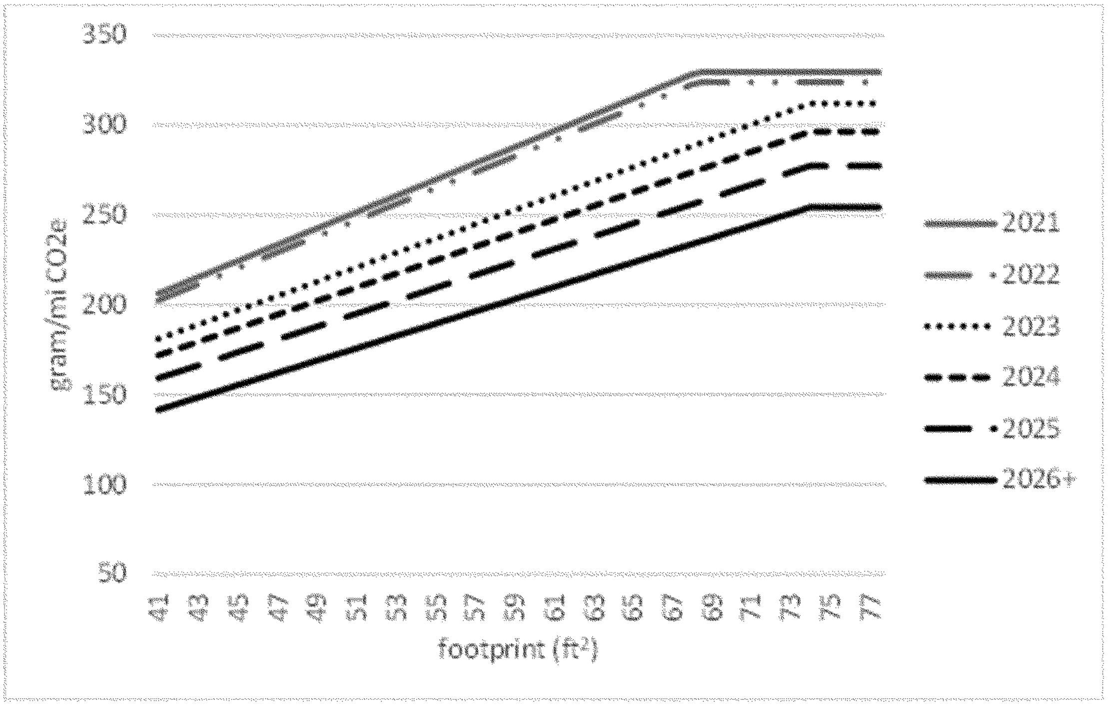

**Figure 5. Truck footprint curves for MYs 2021-2026.**

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For medium-duty vehicles,[385] EPA has established GHG standards previously as part of our heavy-duty vehicle GHG Phase 1 and 2 rules, shown in Table 21.

vehicle GHG Phase 1 and 2 rules, shown in Table 21.

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[385] Note, the HD GHG rules referred to MDVs as HD pickups and vans.

TABLE 21—PRIOR HEAVY-DUTY GHG RULES COVERING MDVS

| Rule | MYs covered | Title | **Federal Register** citation |
|---|---|---|---|
| HD Phase 1 | Initial MDV standards phased in over MYs 2014–2018. | Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles. | 76 FR 57106, September 15, 2011. |
| HD Phase 2 | More stringent MDV standards phased in over MYs 2021–2027. | Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles—Phase 2. | 81 FR 73478, October 25, 2016. |

The MDV standards are also attribute-based. However, they are based on a ‘‘work factor’’ attribute rather than the footprint attribute used in the light-duty vehicle program. Work-based measures such as payload and towing capability are two key factors that characterize differences in the design of vehicles, as well as differences in how the vehicles are expected to be regularly used. The work factor attribute combines vehicle payload capacity and vehicle towing capacity, in pounds (lb), with an additional fixed adjustment for four-wheel drive vehicles. This adjustment accounts for the fact that four-wheel drive, critical to enabling heavy-duty work (payload or trailer towing) in certain road conditions, adds roughly 500 pounds to the vehicle weight. The work factor is calculated as follows:

75 percent maximum payload + 25 percent of maximum towing + 375 lb if four-wheel drive.

—Maximum payload is calculated as GVWR minus curb weight

—Maximum towing is calculated as Gross Combined Weight Rating (GCWR) minus GVWR

Under this approach, GHG targets are determined for each vehicle with a unique work factor (analogous to a target for each discrete vehicle footprint in the light-duty vehicle rules). These targets are then production weighted and summed to derive a manufacturer's annual fleet average standard for its MDVs. The current program includes separate standards for gasoline and diesel-fueled vehicles.[386] The Phase 2 work factors are shown in Figure 6 and Figure 7.

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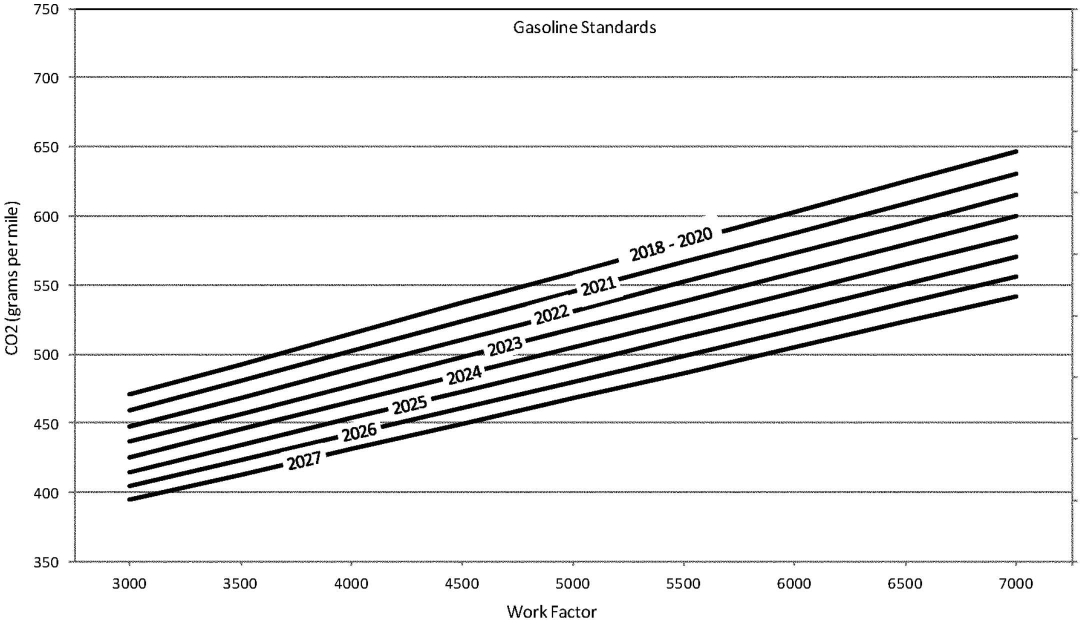

**Figure 6. EPA Phase 2 $CO_2$ work factor targets for gasoline fueled MDVs.**

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[386] See 81 FR 73736–73739.

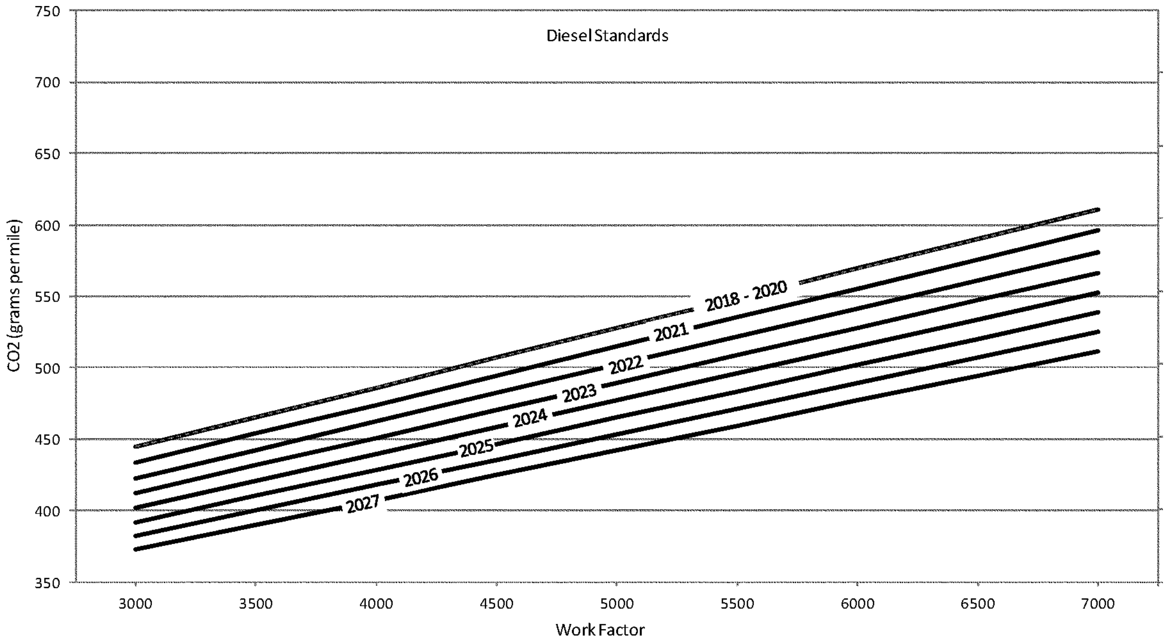

**Figure 7. EPA Phase 2 $CO_2$ work factor targets for diesel fueled MDVs.**

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ii. Criteria and Toxic Pollutant Emissions Standards

Over the last several decades, EPA has set progressively more stringent vehicle emissions standards for criteria pollutants. Most recently, in 2014, EPA adopted Tier 3 emissions standards. Unlike GHG standards, criteria pollutant standards are not attribute-based. The Tier 3 rule included standards for both light-duty and medium-duty vehicles. Similar to the prior Tier 2 standards, Tier 3 established "bins" of Federal Test Procedure (FTP) standards, shown in Table 22. Each bin contains a milligrams per mile (mg/mile) standard for non-methane organic gases (NMOG) plus oxides of nitrogen ($NO_X$) or NMOG+$NO_X$, particulate matter (PM), carbon monoxide (CO), and formaldehyde (HCHO).

TABLE 22—TIER 3 FTP STANDARDS FOR LDVS AND MDPVS

[mg/mile]

| | NMOG+$NO_X$ | PM | CO | HCHO |
|---|---|---|---|---|
| Bin 160 | 160 | 3 | 4.2 | 4 |
| Bin 125 | 125 | 3 | 2.1 | 4 |
| Bin 70 | 70 | 3 | 1.7 | 4 |
| Bin 50 | 50 | 3 | 1.7 | 4 |
| Bin 30 | 30 | 3 | 1.0 | 4 |
| Bin 20 | 20 | 3 | 1.0 | 4 |
| Bin 0 | 0 | 0 | 0 | 0 |

Manufacturers select, or assign, a standards bin to each vehicle model and vehicles must meet all of the standards in that bin over the vehicle's full useful life. Each manufacturer must also meet a fleet average NMOG + $NO_X$ standard each model year, which declines over a phase-in period for the Tier 3 final standards. The declining NMOG+$NO_X$ standards are shown in Table 23. As shown, the fleet is split between two categories: (1) Passenger cars and small light trucks and (2) larger light trucks and MDPVs, with final NMOG+$NO_X$ fleet average standards of 30 mg/mile for both vehicle categories.[387]

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[387] Small light trucks are those vehicles in the LDT1 class, while larger light trucks are those in the LDT2–4 classes.

TABLE 23—TIER 3 NMOG+NO$_X$ FLEET AVERAGE FTP STANDARDS FOR LIGHT-DUTY VEHICLES AND MDPVS

[mg/mile]

| | Model year | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 and later |
| Passenger cars and small trucks | 86 | 79 | 72 | 65 | 58 | 51 | 44 | 37 | 30 |
| Large light trucks and MDPVs | 101 | 93 | 83 | 74 | 65 | 56 | 47 | 38 | 30 |

The Tier 3 rule also established more stringent criteria pollutant emissions standards for MDVs. The Tier 3 MDV standards are also based on a bin structure, but with generally less stringent bin standards and with less stringent NMOG+NO$_X$ fleet average standards. As discussed in Section III.A.1, the MDV category consists of vehicles with gross vehicle weight ratings (GVWR) between 8,501–14,000 pounds. For Tier 3, EPA set separate standards for two sub-categories of vehicles, Class 2b (8,501–10,000 pounds GVWR) and Class 3 (10,001–14,000 pounds GVWR) vehicles. Table 24 provides the final Tier 3 FTP standards bins for MDVs and Table 25 provides the NMOG+NO$_X$ fleet average standards that apply to these vehicles in MYs 2018 and later. It is important to note that MDVs are tested at a higher test weight than light-duty vehicles, as discussed in Section III.B.3, and as such the numeric standards are not directly comparable across the light-duty and MDV categories.

TABLE 24—MDV TIER 3 FTP FINAL STANDARDS BINS

| | NMOG+NO$_X$ | PM | CO | HCHO |
|---|---|---|---|---|
| **Class 2b (10,001–14,000 lb GVWR)** | | | | |
| Bin 250 | 250 | 8 | 6.4 | 6 |
| Bin 200 | 200 | 8 | 4.2 | 6 |
| Bin 170 | 170 | 8 | 4.2 | 6 |
| Bin 150 | 150 | 8 | 3.2 | 6 |
| Bin 0 | 0 | 0 | 0 | 0 |
| **Class 3 (8.501–10,000 lb GVWR)** | | | | |
| Bin 400 | 400 | 10 | 7.3 | 6 |
| Bin 270 | 270 | 10 | 4.2 | 6 |
| Bin 230 | 230 | 10 | 4.2 | 6 |
| Bin 200 | 200 | 10 | 3.7 | 6 |
| Bin 0 | 0 | 0 | 0 | 0 |

TABLE 25—MDV FINAL FLEET AVERAGE NMOG+NO$_X$ STANDARDS

[mg/mile]

| | 2018 | 2019 | 2020 | 2021 | 2022 and later |
|---|---|---|---|---|---|
| Class 2b | 278 | 253 | 228 | 203 | 178 |
| Class 3 | 451 | 400 | 349 | 298 | 247 |

EPA has also established supplemental Federal test procedure (SFTP) standards for light and medium-duty vehicles, as well as cold temperature standards for CO and HC. These standards address emissions outside of the FTP test conditions such as at high vehicle speeds and differing ambient temperatures. EPA is not reopening the current SFTP standards in this rulemaking.

### 3. EPA's Statutory Authority Under the Clean Air Act (CAA)

Title II of the Clean Air Act provides for comprehensive regulation of mobile sources, authorizing EPA to regulate emissions of air pollutants from all mobile source categories, including motor vehicles under CAA section 202(a). EPA is setting standards under multiple provisions of CAA section 202(a). GHG standards for all motor vehicles and light duty criteria pollutant standards are set under section 202(a)(1)–(2). Criteria pollutant standards for larger light-duty trucks and MDVs, which are considered ''heavy-duty vehicles'' under the CAA by virtue of having GVWR above 6,000 pounds, are being set pursuant to section 202(a)(3), which requires that standards applicable to emissions of hydrocarbons, NO$_X$, CO, and PM from heavy-duty vehicles (which includes MDVs) reflect the greatest degree of emission reduction available for the model year to which such standards apply, giving appropriate consideration to cost, energy, and safety. In turn, CAA section 216(2) defines ''motor vehicle'' as ''any self-propelled vehicle designed for transporting persons or property on a street or highway.'' Congress has intentionally and consistently used the broad term ''any self-propelled vehicle'' since the Motor Vehicle Control Act of 1965 so as not to limit standards adopted under CAA section 202 to vehicles running on a particular fuel, power source, or system of propulsion. Congress's focus was on emissions from classes of motor vehicles and the ''requisite technologies'' that could feasibly reduce those emissions giving appropriate consideration to cost of compliance and lead time, as opposed to being limited to any particular type of vehicle.

Section 202(a)(1) of the CAA states that ''the Administrator shall 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 . . . which in his judgment cause, or contribute to, air pollution which may reasonably be anticipated to endanger public health or welfare.'' CAA section 202(a)(1) also requires that any standards promulgated thereunder ''shall be applicable to such vehicles and engines for their useful life (as determined under [CAA section 202(d)], relating to useful life of vehicles for purposes of certification), whether such vehicle and engines are designed as complete systems or incorporate devices to prevent or control such pollution.''

While emission standards set by the EPA under CAA section 202(a)(1) generally do not mandate use of particular technologies, they are technology-based, as the levels chosen must be premised on a finding of technological feasibility. Thus, standards promulgated under CAA section 202(a) are to take effect only ''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.'' CAA section 202(a)(2); see also *NRDC* v. *EPA*, 655 F. 2d 318, 322 (D.C. Cir. 1981). EPA must consider costs to those entities which are directly subject to the standards. *Motor & Equipment Mfrs. Ass'n Inc.* v. *EPA*, 627 F. 2d 1095, 1118 (D.C. Cir. 1979). Thus, ''the [s]ection 202(a)(2) reference to compliance costs encompasses only the cost to the motor-vehicle industry to come into compliance with the new emission standards, and does not mandate consideration of costs to other entities not directly subject to the proposed standards.'' Coalition for Responsible Regulation, 684 F.3d at 128. EPA is afforded considerable discretion under section 202(a) when assessing issues of technical feasibility and availability of lead time to implement new technology. Such determinations are ''subject to the restraints of reasonableness,'' which ''does not open the door to 'crystal ball' inquiry.'' NRDC, 655 F. 2d at 328, quoting *International Harvester Co.* v. *Ruckelshaus*, 478 F. 2d 615, 629 (D.C. Cir. 1973). However, ''EPA is not obliged to provide detailed solutions to every engineering problem posed in the perfection of [a particular device]. In the absence of theoretical objections to the technology, the agency need only identify the major steps necessary for development of the device and give plausible reasons for its belief that the industry will be able to solve those problems in the time remaining. EPA is not required to rebut all speculation that unspecified factors may hinder 'real world' emission control.'' NRDC, 655 F. 2d at 333–34. In developing such technology-based standards, EPA has the discretion to consider different standards for appropriate groupings of vehicles (''class or classes of new motor vehicles''), or a single standard for a larger grouping of motor vehicles. NRDC, 655 F.2d at 338.[388]

Although standards under CAA section 202(a)(1) are technology-based, they are not based exclusively on technological capability. Pursuant to the broad grant of authority in section 202, when setting emission standards for light duty vehicles EPA may also consider other factors and has done so previously when setting such standards. For instance, in recent light duty greenhouse gas rules, EPA has also considered such issues as: Technology effectiveness; its cost (per vehicle, per manufacturer, and per consumer); the feasibility and practicability of potential standards in light of the lead time available to implement the technology; the impacts of potential standards on emissions reductions of both GHGs and criteria pollutants; the impacts of standards on oil conservation and energy security; the impacts of standards on fuel savings by consumers; as well as other relevant factors such as safety.

In addition, EPA has clear authority to set standards under CAA section 202(a)(1)–(2) that are technology-forcing when EPA considers that to be appropriate but is not required to do so (as compared to standards under section 202(a)(3), which require the greatest degree of emissions reduction achievable, giving appropriate consideration to cost, energy and safety factors). CAA section 202(a) does not specify the degree of weight to apply to each factor, and EPA accordingly has discretion in choosing an appropriate balance among factors. See *Sierra Club* v. *EPA*, 325 F.3d 374, 378 (D.C. Cir. 2003) (even where a provision is technology-forcing, the provision ''does not resolve how the Administrator should weigh all [the statutory] factors in the process of finding the 'greatest emission reduction achievable' ''); *National Petrochemical and Refiners Ass'n* v. *EPA*, 287 F.3d 1130, 1135 (D.C. Cir. 2002) (EPA decisions, under CAA provision authorizing technology-forcing standards, based on complex scientific or technical analysis are accorded particularly great deference); see also *Husqvarna AB* v. *EPA*, 254 F. 3d 195, 200 (D.C. Cir. 2001) (great discretion to balance statutory factors in considering level of technology-based standard, and statutory requirement ''to [give appropriate] consideration to the cost of applying . . . technology'' does not mandate a specific method of cost analysis); *Hercules Inc.* v. *EPA*, 598 F. 2d 91, 106 (D.C. Cir. 1978) (''In reviewing a numerical standard we must ask whether the agency's numbers are within a zone of reasonableness, not whether its numbers are precisely right.'').[389]

With regard to the specific technologies that could be used to meet the emission standards promulgated under the relevant statutory authorities, EPA's rules have historically not required the use of any particular technology, but rather have allowed manufacturers to use any technology that demonstrates the engines or vehicles meet the standards over the applicable test procedures. Similarly, in determining the standards, EPA appropriately considers updated data and analysis on pollution control technologies, without a priori limiting its consideration to a particular set of technologies. Given the continuous development of pollution control technologies since the early days of the CAA, this approach means that EPA routinely considers novel and projected technologies developed or refined since the time of the CAA's enactment, including, for instance, electric vehicle technologies. This forward-looking regulatory approach keeps pace with real-world technological developments and comports with Congressional intent.

Section 202 does not specify or expect any particular type of motor vehicle propulsion system to remain prevalent, and it was clear as early as the 1960s that ICE vehicles might be inadequate to achieve the country's air quality goals. In 1967, the Senate Committees on Commerce and Public Works held five days of hearings on ''electric vehicles and other alternatives to the internal

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[388] Additionally, with respect to regulation of vehicular greenhouse gas emissions, EPA is not ''required to treat NHTSA's . . . regulations as establishing the baseline for the [section 202(a) standards].'' Coalition for Responsible Regulation, 684 F.3d at 127 (noting that the section 202(a) standards provide ''benefits above and beyond those resulting from NHTSA's fuel-economy standards'').

[389] See also; *Permian Basin Area Rate Cases,* 390 U.S. 747, 797 (1968) (same); *Federal Power Commission* v. *Conway Corp.,* 426 U.S. 271, 278 (1976) (same); *Exxon Mobil Gas Marketing Co.* v. *Federal Energy Regulatory Comm'n,* 297 F. 3d 1071, 1084 (D.C. Cir. 2002) (same).

combustion engine,'' which Chairman Magnuson opened by saying ''The electric will help alleviate air pollution. . . . The electric car does not mean a new way of life, but rather it is a new technology to help solve the new problems of our age.'' [390] In a 1970 message to Congress seeking a stronger CAA, President Nixon stated he was initiating a program to develop ''an unconventionally powered, virtually pollution free automobile'' because of the possibility that ''the sheer number of cars in densely populated areas will begin outrunning the technological limits of our capacity to reduce pollution from the internal combustion engine.'' [391]

Since the earliest days of the CAA, Congress has emphasized that the goal of section 202 is to address air quality hazards from motor vehicles, not to simply reduce emissions from internal combustion engines to the extent feasible. In the Senate Report accompanying the 1970 CAA Amendments, Congress made clear the EPA ''is expected to press for the development and application of improved technology rather than be limited by that which exists'' and identified several unconventional technologies that could successfully meet air quality-based emissions targets for motor vehicles.[392] In the 1970 amendments Congress further demonstrated its recognition that developing new technology to ensure that pollution control keeps pace with economic development is not merely a matter of refining the ICE, but requires considering new types of motor vehicle propulsion. Congress provided EPA with authority to fund the development of ''low emission alternatives to the present internal combustion engine'' as well as a program to encourage Federal purchases of ''low-emission vehicles.'' See CAA section 104(a)(2) (previously codified as CAA section 212). Congress also adopted section 202(e) expressly to grant the Administrator discretion regarding the certification of vehicles and engines based on ''new power source[s] or propulsion system[s],'' that is to say, power sources and propulsion systems beyond the existing internal combustion engine and fuels available at the time of the statute's enactment, if those vehicles emit pollutants which the Administrator judges contribute to dangerous air pollution but has not yet established standards for under section 202(a). As the D.C. Circuit held in 1973, ''We may also note that it is the belief of many experts–both in and out of the automobile industry–that air pollution cannot be effectively checked until the industry finds a substitute for the conventional automotive power plant–the reciprocating internal combustion (*i.e.,* ''piston'') engine. . . . It is clear from the legislative history that Congress expected the Clean Air Amendments to force the industry to broaden the scope of its research–to study new types of engines and new control systems.'' *International Harvester Co.* v. *Ruckelshaus*, 478 F.2d 615, 634–35 (D.C. Cir. 1973).

Since that time, Congress has continued to emphasize the importance of technology development to achieving the goals of the CAA. In the 1990 amendments, Congress instituted a clean fuel vehicles program to promote further progress in emissions reductions and the adoption of new technologies and alternative fuels, which also applied to motor vehicles as defined under section 216, see CAA section 241(1), and explicitly defined motor vehicles qualifying under the program as including vehicles running on an alternative fuel or ''power source (including electricity),'' CAA section 241(2). Congress also directed EPA to phase-in certain section 202(a) standards, see CAA section 202(g), which confirms EPA's authority to promulgate standards, such as fleet averages, phase-ins, and averaging, banking, and trading programs, that are fulfilled through compliance over an entire fleet, or a portion thereof, rather than through compliance by individual vehicles.[393]

The recently enacted Inflation Reduction Act [394] ''reinforces the longstanding authority and responsibility of [EPA] to regulate GHGs as air pollutants under the Clean Air Act,'' [395] and ''the IRA clearly and deliberately instructs EPA to use'' this authority by ''combin[ing] economic incentives to reduce climate pollution with regulatory drivers to spur greater reductions under EPA's CAA authorities.'' [396] The IRA specifically affirms Congress's previously articulated statements that non-ICE technologies will be a key component of achieving emissions reductions from the mobile source sector, and Congress provided a number of significant financial incentives for PEVs and the infrastructure necessary to support them.[397] The Congressional Record reflects that ''Congress recognizes EPA's longstanding authority under CAA section 202 to adopt standards that rely on zero emission technologies, and Congress expects that future EPA regulations will increasingly rely on and incentivize zero-emission vehicles as appropriate.'' [398]

Consistent with Congress's intent, EPA's CAA Title II emission standards have been based on and stimulated the development of a broad set of advanced automotive technologies, such as on-board computers and fuel injection systems, which have been the building blocks of automotive designs and have yielded not only lower pollutant emissions, but improved vehicle performance, reliability, and durability. Beginning in 2010, EPA has set standards under section 202 for GHGs and manufacturers have responded by continuing to develop and deploy a wide range of technologies, including more fuel-efficient engine designs, transmissions, aerodynamics, tires, materials improvements for mass reduction, as well as various levels of electrified vehicle technologies including mild hybrids, strong and plug-in hybrids, battery electric vehicles, and fuel cell electric vehicles. In addition, the continued application of performance-based standards with fleet-wide averaging provides an opportunity for all technology improvements and innovation to be reflected in a vehicle manufacturer's compliance results.

### i. Testing Authority

Under section 203 of the CAA, sales of vehicles are prohibited unless the

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[390] *Electric Vehicles and Other Alternatives to the Internal Combustion Engine: Joint Hearings before the Comm. on Commerce and the Subcomm. on Air and Water Pollution of the Comm. on Pub. Works,* 90th Cong. (1967).

[391] Richard Nixon, Special Message to the Congress on Environmental Quality (Feb. 10, 1970), *https://www.presidency.ucsb.edu/documents/special-message-the-congress-environmental-quality.*

[392] S. Rep. No. 91–1196, at 24–27 (1970).

[393] EPA has a long history of exercising its authority to include compliance flexibilities in standards. As early as 1983, manufacturers could comply with criteria-pollutant standards using averaging. EPA introduced banking and trading in 1990. Fleet average standards were adopted for light duty vehicles in 2000. All of these flexibilities have likewise been part of EPA's GHG standards program since the program's inception in 2010, and consistently since then. Averaging, banking, and trading is discussed further in Section III.B.4 and additional history is discussed in EPA's Answering Brief in *Texas* v. *EPA* (D.C. Cir., 22–1031).

[394] *See* Inflation Reduction Act, Public Law 117–169, at §§ 13403, 13404, 13501, 13502, 60101, 136 Stat. 1818, (2022), available at *https://www.congress.gov/117/bills/hr5376/BILLS-117hr5376enr.pdf.*

[395] 168 Cong. Rec. E868–02 (daily ed. Aug. 12, 2022) (statement of Rep. Pallone).

[396] 168 Cong. Rec. E879–02, at 880 (daily ed. Aug. 26, 2022) (statement of Rep. Pallone).

[397] *See* Inflation Reduction Act, Public Law 117–169, at §§ 13403, 13404, 13501, 13502, 60101, 136 Stat. 1818, (2022), available at *https://www.congress.gov/117/bills/hr5376/BILLS-117hr5376enr.pdf.*

[398] 168 Cong. Rec. E879–02, at 880 (daily ed. Aug. 26, 2022) (statement of Rep. Pallone).

vehicle is covered by a certificate of conformity. EPA issues certificates of conformity pursuant to section 206 of the CAA, based on (necessarily) pre-sale testing conducted either by EPA or by the manufacturer. The Federal Test Procedure (FTP or ''city'' test) and the Highway Fuel Economy Test (HFET or ''highway'' test) are used for this purpose. Compliance with standards is required not only at certification but throughout a vehicle's useful life, so that testing requirements may continue post-certification. To assure each vehicle complies during its useful life, EPA may apply an adjustment factor to account for vehicle emission control deterioration or variability in use (section 206(a)).

EPA establishes the test procedures under which compliance with the CAA emissions standards is measured. EPA's testing authority under the CAA is broad and flexible. EPA has also developed tests with additional cycles (the so-called 5-cycle tests) which are used for purposes of fuel economy labeling, SFTP standards, and extending off-cycle credits under the light-duty vehicle GHG program.

#### ii. Compliance and Enforcement Authority

EPA oversees testing, collects and processes test data, and performs calculations to determine compliance with CAA standards. CAA standards apply not only at certification but also throughout the vehicle's useful life. The CAA provides for penalties should manufacturers fail to comply with their fleet average standards, and there is no option for manufacturers to pay fines in lieu of compliance with the standards. Under the CAA, penalties for violation of a fleet average standard are typically determined on a vehicle-specific basis by determining the number of a manufacturer's highest emitting vehicles that cause the fleet average standard violation. Penalties for reporting requirements under Title II of the CAA apply per day of violation, and other violations apply on a per vehicle, or a per part or component basis. See CAA sections 203(a) and 205(a) and 40 CFR 19.4.

Section 207 of the CAA grants EPA broad authority to require manufacturers to remedy vehicles if EPA determines there are a substantial number of noncomplying vehicles. In addition, under CAA section 207, manufacturers are required to provide emission-related warranties. CAA section 207(i) specifies that the warranty period for light-duty vehicles is 2 years or 24,000 miles of use (whichever first occurs), except for specified major emission control components, for which the warranty period is 8 years or 80,000 miles of use (whichever first occurs).

## *B. Proposed GHG Standards for Model Years 2027 and Later*

### 1. Overview

This Section III.B provides details regarding EPA's proposed GHG standards and related program provisions. EPA is proposing significantly more stringent GHG standards for light and medium-duty vehicles for MYs 2027 and later. For light-duty, the proposed standards would further reduce the fleet average GHG emissions target levels by 56 percent from the MY 2026 standards, the final year of standards established in the 2021 rule. For MDVs, the standards would represent a reduction of 37 percent compared to the MY 2027 standards, the final phase year of the previously established Phase 2 standards for those vehicles.

Section III.B.2 provides details regarding the structure and level of the proposed light-duty vehicle standards while Section III.B.3 provides details regarding EPA's proposed GHG standards for MDVs. Additional GHG program provisions are discussed in Sections III.B.4–III.B.9, including averaging, banking, and trading, proposed air conditioning system requirements, proposed phase out of off-cycle credits, proposed treatment of PEVs and FCEVs in the GHG fleet average, and proposed alternative standards for small volume manufacturers.

### 2. Proposed Light-Duty Vehicle GHG Standards

#### i. Structure of the Existing Light-Duty Vehicle $CO_2$ Standards

Since MY 2012, EPA has adopted attribute-based standards for passenger cars and light trucks. The CAA has no requirement to promulgate attribute-based standards, though in past rules EPA has relied on both universal and attribute-based standards (*e.g.,* for nonroad engines, EPA uses the attribute of horsepower). However, given the advantages of using attribute-based standards, from MY 2012 onward EPA has adopted and maintained vehicle footprint as the attribute for the GHG standards. Footprint is defined as a vehicle's wheelbase multiplied by its track width—in other words, the area enclosed by the points at which the wheels meet the ground.

EPA has implemented footprint-based standards since MY 2012 by establishing two kinds of standards—fleet average standards determined by a manufacturer's fleet makeup, and in-use standards that will apply to the individual vehicles that make up the manufacturer's fleet. Under the footprint-based standards, each manufacturer has a $CO_2$ emissions performance target unique to its fleet, depending on the footprints of the vehicles produced by that manufacturer. While a manufacturer's fleet average standard could be estimated throughout the model year based on projected production volume of its vehicle fleet, the fleet average standard to which the manufacturer must comply is based on its final model year production figures. Each vehicle in the fleet has a compliance value which is used to calculate both the in-use standard applicable to that vehicle and the fleet average emissions. A manufacturer's calculation of fleet average emissions at the end of the model year will thus be based on the production-weighted average emissions of each vehicle in its fleet. EPA is not reopening the footprint-based structure for the standards or seeking comment on any alternatives to this structure.

Each manufacturer has separate footprint-based standards for cars and for trucks. EPA is not reopening the existing regulatory definitions of passenger cars and light trucks; we propose to continue to reference the NHTSA regulatory class definitions as EPA has done since the inception of the GHG program. Similarly, EPA is not requesting comment on alternatives to the regulatory class definitions which are being maintained.

#### ii. How did EPA determine the proposed slopes and relative stringencies of the car and truck footprint standards curves?

In this proposal, EPA is retaining vehicle footprint, the existing car/truck regulatory class definitions, and separate standards curves for each regulatory class, as in previous rulemakings. However, we propose to adjust the relative slope and offset between the car and truck footprint standards curves as described in this section.

We analyzed the fleet and found that most light-duty vehicles (which do not tow or haul) are used to move passengers and their nominal cargo and could be represented by a single curve. However, within our analysis we identified a subset of light trucks that provide additional towing and hauling capabilities which are more appropriately controlled with a modified set of standards.[399] We have accommodated those vehicles by providing an additional GHG offset for this increased utility which is embodied in the truck curve. In this way, we maintain two curves—one for cars and one for trucks—that are closely related from an analytical perspective.

When setting GHG standards, EPA recognizes the current diversity and distribution of vehicles in the market and that Americans have widely varying preferences in vehicles and that GHG control technology is feasible for a wide variety of vehicles. This is one of the primary reasons for adopting attribute-based standards and is also an important consideration in choosing specific attribute-based standards (*i.e.,* the footprint curves). Over time, vehicle footprint sizes have steadily increased.[400] This has partially offset gains in fuel economy and reductions in emissions. For example, in MY 2021, average fuel economy and emissions were essentially flat (despite improvements in emissions for all classes of vehicles) because of increases in the sizes of vehicles purchased. In developing footprint curves for this proposal, EPA's intent was to establish slopes that would not (of their own accord) initiate overall fleet upsizing or downsizing as a compliance strategy. A slope too flat would incentivize overall fleet downsizing, while a steep slope would foster upsizing. Fuller details on the analysis that was used to determine a ''neutral'' slope determination is provided in DRIA Chapter 1.1.3.

The slopes proposed in this rulemaking, especially the car curves, are flatter than those of prior rulemakings. This is by design and reflects our projection of the likelihood that a future fleet will be characterized by a greatly increased penetration of BEVs, even in a no-action scenario. Consider that for the 2012 LD GHG rulemaking, the footprint-based curves were originally developed for a fleet that was completely made up of internal combustion engine (ICE) vehicles. From a physics perspective, a positive footprint slope for ICE vehicles makes sense because as a vehicle's size increases, its mass, road loads, and required power (and corresponding tailpipe $CO_2$ emissions) will increase accordingly. However, because the proposed standards are based on tailpipe emissions (and upstream emissions are not included as part of a manufacturer's compliance calculation) for all vehicle types and BEVs emit zero tailpipe emissions, a fleet of all BEVs would emit 0 g/mi, regardless of their respective footprints. As the percentage of BEVs increases, the percentage of ICE vehicles (those vehicles correlated to a positive slope) decrease. Mathematically, the slope of the average footprint targets should trend towards zero as the percentage of BEVs increases.

All-wheel drive (AWD) is one of the defining features for crossover vehicles to be classified as light trucks,[401] and for this reason the offset in tailpipe emissions targets (*i.e.,* between the car and truck regulatory classes) for these vehicles should be appropriately set. The design differences for many cross-over vehicle models that are offered in both a two-wheel drive (2WD) and an AWD version (aside from their driveline) are difficult to detect. They often have the same engine, similar curb weight (except for the additional weight of an AWD system), and similar operating features (although AWD versions might be offered at a premium trim level that is not required of the drivetrain). EPA analyzed empirical data for models that were offered in both 2WD and AWD versions to quantify the average increase in tailpipe emissions due to addition of AWD for an otherwise identical vehicle model.

The light truck classification consists of crossovers (ranging from compact up through large crossovers), sport utility vehicles and pickup trucks. Many crossover vehicles and SUVs exhibit similar towing capability between their 2WD and AWD versions (there are some exceptions in cases where AWD is packaged with a larger more powerful engine than the base 2WD version). However, full size pickup trucks are the light-duty market segment with the most towing and hauling capability. The purpose of maintaining a unique truck curve is centered around accounting for the utility of these vehicles in particular.

EPA is therefore proposing that the truck curve be based on the car curve (to represent the base utility across all vehicles for carrying people and their light cargo), but with the additional allowance of increased utility that distinguishes these vehicles used for more work-like activity. EPA determined a relationship between gross combined weight rating (GCWR) (which combines the cumulative utility for hauling and towing to a vehicle's curb weight) and required engine torque. EPA then used its ALPHA model to predict how the tailpipe emissions at equivalent test weight (ETW) (curb weight + 300 pounds) would increase as a function of increased utility (GCWR) based on required engine torque and assumed modest increases in vehicle weight and road loads commensurate with a more tow-capable vehicle.

EPA also assessed the relative magnitude of tow rating across the light truck fleet as a function of footprint. Vehicles with the greatest utility are full size pickup trucks, while light trucks with the least utility tend to be the smaller crossovers, with an increased tow or haul rating near zero. As a result, EPA proposes a simple offset for the truck curve, compared to the car curve, that increases with footprint.

The offsets for AWD and utility were then scaled as a function of the nominal fleet-wide BEV penetrations anticipated to be achieved under the proposed stringency levels. For example, in our feasibility assessment we would project approximately 50 percent BEV penetration on average across the fleet by MY 2030 and thus, the AWD offset and the utility-based offset for the MY 2030 were each multiplied by 50 percent to reflect the share of the new vehicle sales that are projected to remain as ICE vehicles for that year.

In summary, the truck curve is, mathematically, the sum of the scaled AWD and utility-based offsets to the car curve. A more thorough description of the truck curve as it relates to the car curve, and a discussion of the empirical and modeling data used in developing these offsets is presented in DRIA Chapter 1.1.3.2. EPA solicits comments on the proposed changes to the shape of the footprint curves, including the flattening of the car curve and our approach for deriving the truck curve from the car curve.

### iii. How did EPA determine the proposed cutpoints for the footprint standards curves?

The cutpoints are defined as the footprint boundaries (low and high) within which the sloped portion of the footprint curve resides. Above the high, and below the low, cutpoints, the curves are flat. The rationale for the setting of the original cutpoints for the 2017–2025 rule was based on analysis of the distribution of vehicle footprint for the 2008 fleet and is discussed in the 2012

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[399] This analysis is described in a Memo to Docket ID No. EPA–HQ–OAR–2022–0829 titled ''Fleet and Vehicle Attribute Analysis for the Development of Standard Curves.''

[400] The 2022 EPA Automotive Trends Report, *https://www.epa.gov/system/files/documents/2022-12/420r22029.pdf.*

[401] We use the term AWD to include all types of four-wheel drive systems, consistent with SAE standard J1952.

proposal[402] and the Technical Support Document (TSD).[403]

EPA is proposing to increase the lower cutpoint for the car and truck curves by 1 square foot per year from MY 2027 through MY 2030 from 41 to 45 square feet. This will provide slightly less stringent standards for the smallest vehicles and may encourage more vehicle model offerings by manufacturers of these vehicles, which are already among the cleanest vehicles and which may be more accessible to lower-income households. At a minimum, EPA believes the structure of the footprint standards should not disincentivize manufacturers from offering these smallest vehicles, as the continuation of offerings in this segment is an important affordability consideration.

EPA is also proposing to gradually reduce the upper cutpoint for trucks, which will be 74.0 square feet starting in 2023 through 2026, and then decreasing by 1.0 square foot per year from MY 2027 through MY 2030 (down to 70.0 square feet by MY 2030). As the upper cutpoint for trucks has increased from 66.0 square feet in 2016 to 69.0 square feet in 2020, we have witnessed a corresponding trend towards larger full size pickup trucks which are subject to less stringent $CO_2$ targets. The proposed MY 2030 upper truck cutpoint of 70.0 square feet (consistent with the sales-weighted average footprint of current full-size pickups) is intended to help ensure no loss of emissions reductions in the future through upsizing. However, we do not view the cutpoints as a primary driver for significant additional emissions reductions beyond those achieved by the year-over-year change in the curves. Both the truck size trend and an analysis of truck footprint vs. $CO_2$ are detailed in DRIA Chapter 1.3. The upper cutpoint for cars (56 feet) will remain unchanged.

EPA requests comments on the proposed cutpoints and may consider different cutpoints based on comments in the final rule.

### iv. What are the proposed light-duty vehicle $CO_2$ standards?

### a. What $CO_2$ footprint standards curves is EPA proposing?

EPA is proposing separate car and light truck standards—that is, vehicles defined as passenger vehicles (''cars'') would have one set of footprint-based standards curves, and vehicles defined as light trucks would have a different set.[404] In general, for a given footprint, the $CO_2$ g/mile target[405] for trucks is higher than the target for a car with the same footprint. The curves are described mathematically in EPA's regulations by a family of piecewise linear functions (with respect to vehicle footprint) that gradually and continually ramp down from the MY 2026 curves established in the 2021 rule. EPA's proposed minimum and maximum footprint targets and the corresponding cutpoints are provided for cars and trucks, respectively, in Table 26 and Table 27 for MYs 2027–2032 along with the slope and intercept defining the linear function for footprints falling between the minimum and maximum footprint values. For footprints falling between the minimum and maximum, the targets are calculated as follows: Slope × Footprint + Intercept = Target.

TABLE 26—PROPOSED FOOTPRINT-BASED STANDARD CURVE COEFFICIENTS FOR CARS

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| MIN $CO_2$ (g/mi) | 130.9 | 114.1 | 96.9 | 89.5 | 81.2 | 71.8 |
| MAX $CO_2$ (g/mi) | 139.8 | 121.3 | 102.5 | 94.2 | 85.5 | 75.6 |
| Slope (g/mi/ft2) | 0.64 | 0.56 | 0.47 | 0.43 | 0.39 | 0.35 |
| Intercept (g/mi) | 104.0 | 90.2 | 76.3 | 70.1 | 63.6 | 56.2 |
| MIN footprint (ft2) | 42 | 43 | 44 | 45 | 45 | 45 |
| MAX footprint (ft2) | 56 | 56 | 56 | 56 | 56 | 56 |

TABLE 27—PROPOSED FOOTPRINT-BASED STANDARD CURVE COEFFICIENTS FOR LIGHT TRUCKS

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| MIN $CO_2$ (g/mi) | 133.0 | 117.5 | 101.0 | 94.4 | 85.6 | 75.7 |
| MAX $CO_2$ (g/mi) | 212.3 | 181.7 | 151.5 | 137.3 | 124.5 | 110.1 |
| Slope (g/mi/ft2) | 2.56 | 2.22 | 1.87 | 1.72 | 1.56 | 1.38 |
| Intercept (g/mi) | 25.6 | 22.2 | 18.7 | 17.2 | 15.6 | 13.8 |
| MIN footprint (ft2) | 42 | 43 | 44 | 45 | 45 | 45 |
| MAX footprint (ft2) | 73 | 72 | 71 | 70 | 70 | 70 |

Figure 8 and Figure 9 show the car and truck curves, respectively, for MY 2027 through MY 2032. Included for reference is the original MY 2026 curve for each. However, to compare tailpipe stringency between MY 2026 with the proposed standards, it was necessary to adjust the MY 2026 curve to reflect the proposed reduction in allowable AC and off-cycle credits[406] effective in MY 2027. In the figures, the adjusted MY 2026 curve has been increased by the amount of the total credits reduced from MY 2026 to MY 2027. The magnitude of this adjustment is calculated in Table 28.

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[402] Preamble, II.C.6.a,b.

[403] 2017–2025 TSD.

[404] See 49 CFR part 523. Generally, passenger cars include cars and smaller crossovers and SUVs, while the truck category includes larger crossovers and SUVs, minivans, and pickup trucks.

[405] Because compliance is based on a sales-weighting of the full range of vehicles in a manufacturer's car and truck fleets, the foot-print based $CO_2$ emission levels of specific vehicles within the fleet are referred to as targets, rather than standards.

[406] As proposed, AC efficiency and off-cycle credits are only eligible to ICE vehicles for MY 2027 and beyond. The AC and off-cycle credits in Table 28 for MY 2027 reflect scaling of a projected reduced number of ICE vehicles.

TABLE 28—OFF-CYCLE AND AIR CONDITIONING (AC) CREDIT ADJUSTMENTS MADE TO NORMALIZE MY 2026 STANDARDS

| Reg class | MY 2026 (no action) | | | | MY 2027 (proposed) | | | | 2026 Adjust g/mi |
|---|---|---|---|---|---|---|---|---|---|
| | Off-cycle | AC eff | AC refrig | Total | Off-cycle | AC eff | AC refrig | Total | |
| Car | 10.0 | 5.0 | 13.8 | 28.8 | 6.0 | 3.0 | 0 | 9.0 | 19.8 |
| Truck | 10.0 | 7.2 | 17.2 | 34.4 | 6.0 | 4.3 | 0 | 10.3 | 24.1 |

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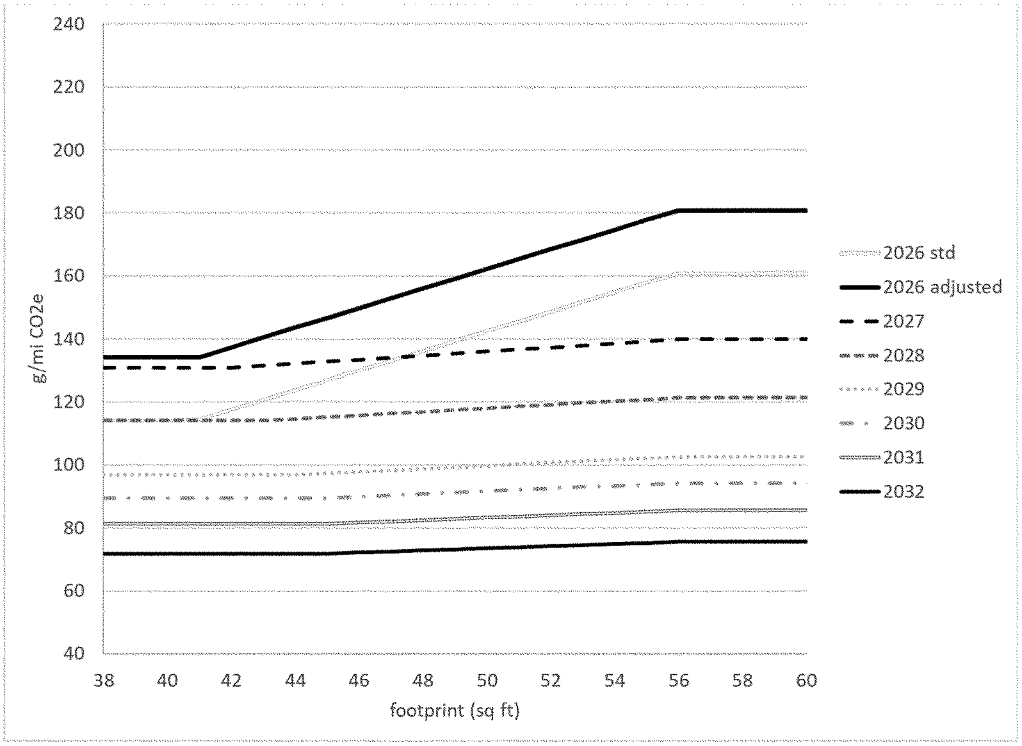

Figure 8. Proposed standards for cars, MY 2027-2032.

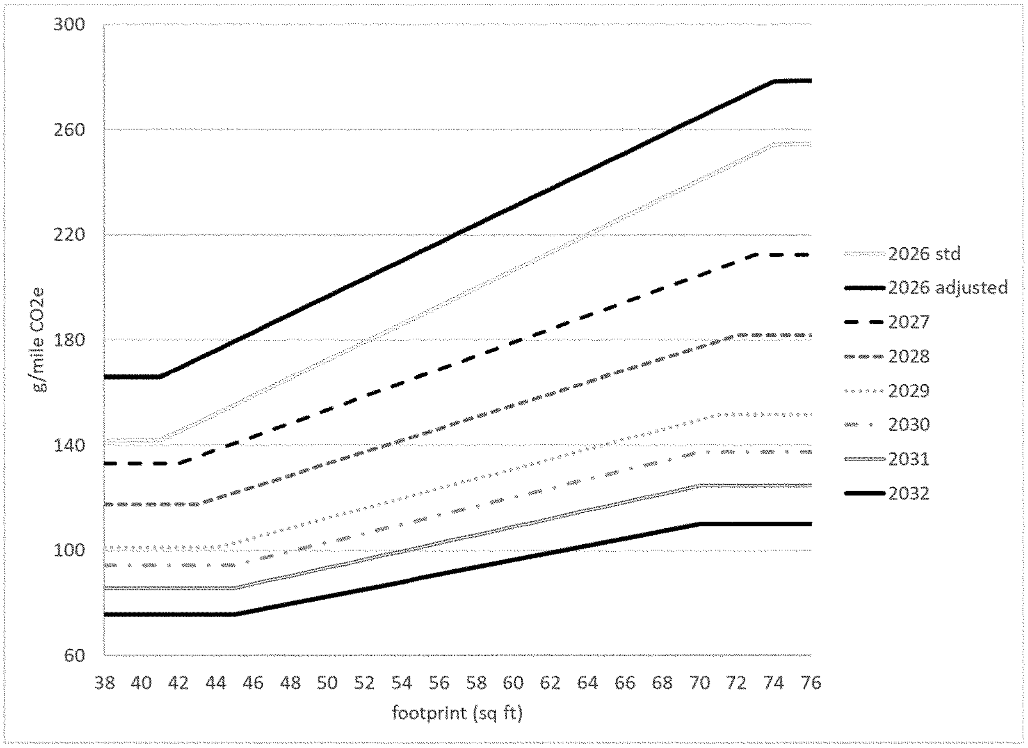

**Figure 9. Proposed standards for trucks, MY 2027-2032.**

As discussed in Section III.B.2.ii, the slope of the car curve is significantly flatter in 2027 and continues to flatten progressively each year through 2032. The truck curve, largely driven by the allowance for towing utility, has a similar shape as in past rulemakings although its slope also flattens progressively each year from 2027 through 2032.

b. What fleet-wide $CO_2$ emissions levels correspond to the standards?

EPA is proposing more stringent standards for MYs 2027–2032 that are projected to result in an industry-wide average target for the light-duty fleet of 82 g/mile of $CO_2$ in MY 2032. The projected average annual decrease in combined industry average targets from the current standards in MY 2026 to the new standards in MY 2032 is 12.8 percent per year. Compared to past rulemakings the annual percentage reductions are significantly higher; however, EPA's feasibility assessments in past rulemakings were predominantly based on ICE-based technologies that provided incremental tailpipe GHG reductions. Since then, advancements in BEV technology and the increasing feasibility of BEVs as an available and reasonable-cost compliance technology have changed the magnitude of the emissions reductions that will be achievable during the timeframe of this rulemaking compared to prior rules. The combination of economic incentives provided in the IRA and the auto manufacturers' stated plans for producing significant volumes of zero and near-zero emission vehicles in the timeframe of this rule makes it possible for EPA to propose standards at a level of stringency greater than was feasible in past rules. While tailpipe emissions controls for criteria pollutants from conventional ICE-based vehicles can have effectiveness values greater than 90 percent under certain circumstances, electrification provides 100 percent effectiveness under all operating and environmental conditions. This is nearly two orders of magnitude more effective than the historical improvements in GHG emission reductions.

EPA is not reopening its current approach of having separate standards for cars and light trucks under existing program definitions. The 82 g/mile estimated industry-wide target for MY 2032 noted in the previous paragraph is based on EPA's current fleet mix projections for MY 2032 (approximately 40 percent cars and 60 percent trucks, assuming only slight variations from MY 2026). As is the nature of attribute-based standards, the final fleet average standards for each manufacturer ultimately will depend on each manufacturer's actual rather than projected production in each MY from MY 2027 to MY 2032 under the sales-weighted footprint-based standard curves for the car and truck regulatory classes. Figure 10 shows the projected industry-average $CO_2$ targets based on projected fleet mix through MY 2032.

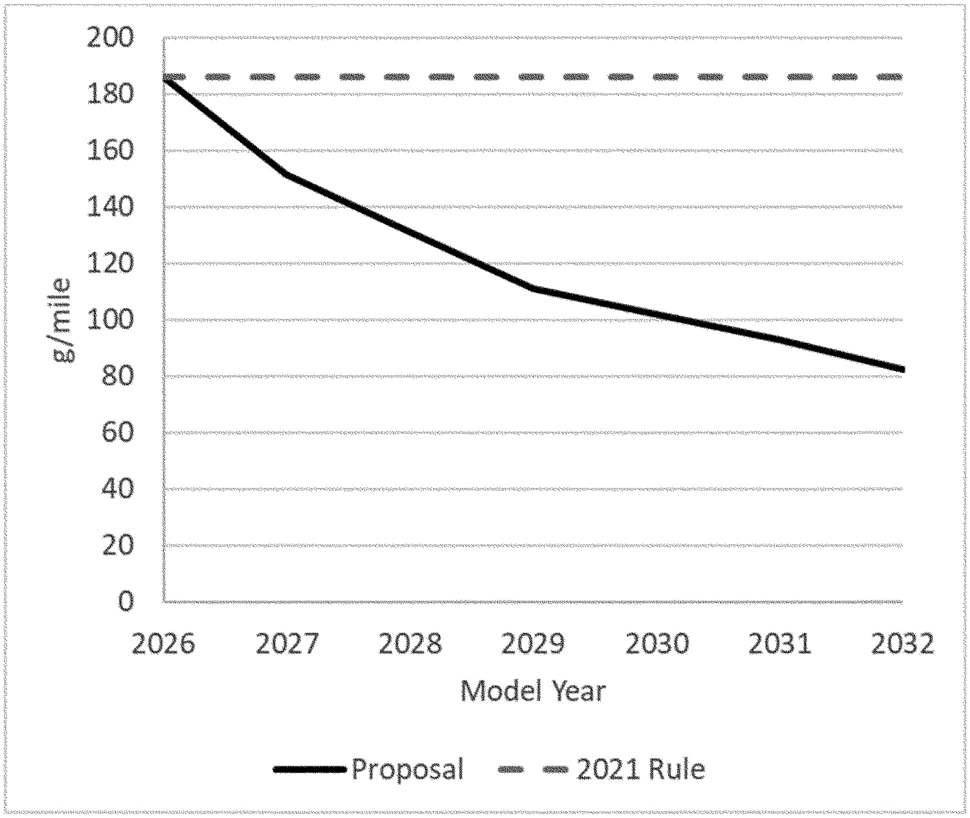

**Figure 10. Projected industry average targets under the proposed 2027-2032 standards compared to the current MY 2026 standards (adjusted).**

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Prior EPA standards have been based in part on EPA's projection of average industry wide $CO_2$-equivalent emission reductions from AC improvements, where the footprint curves were made numerically more stringent by an amount equivalent to this projection of AC refrigerant leakage credits. As discussed in Section III.B.5–6, EPA is proposing to end refrigerant-based credits in MY 2027, to limit off-cycle credits and AC efficiency credits to vehicles equipped with an IC engine, and to phase-out off-cycle credits.

Table 29 shows overall fleet average target levels for both cars and light trucks that are projected for the proposed standards. A more detailed manufacturer by manufacturer break down of the projected $CO_2$ targets and achieved levels is provided in DRIA Chapter 13. The actual fleet-wide average g/mile level that would be achieved in any year for cars and trucks will depend on the actual production of vehicles for that year, as well as the use of the various credit and averaging, banking, and trading provisions. For example, in any year, manufacturers would be able to generate credits from cars and use them for compliance with the truck standard, or vice versa. In DRIA Chapter 9.6, EPA discusses the year-by-year estimate of GHG emissions reductions that are projected to be achieved by the proposed standards.

In general, the structure of the proposed standards allows an incremental phase-in to the MY 2032 level and reflects consideration of the appropriate lead time for manufacturers to take actions necessary to meet the proposed standards. The technical feasibility of the standards is discussed in Section IV.A and in the DRIA. Note that MY 2032 is the final MY in which the proposed $CO_2$ standards would become more stringent. The MY 2032 standards would remain in place for later MYs, unless and until revised by EPA in a future rulemaking for those MYs.

EPA is requesting comments on whether the standards should increase in stringency beyond MY 2032. EPA seeks comment on whether the trajectory (*i.e.,* the levels of year-over-year stringency rates) of the proposed standards for MYs 2027 through 2032 should be extended through 2033, 2034 or 2035, or whether EPA should consider additional approaches to the trajectory of any standards that were to continue increasing in stringency beyond 2032. EPA is interested in stakeholders' feedback on any additional data and information that could inform EPA's consideration of potential standards beyond MY 2032. This request for comment on standards beyond MY 2032 is not specific to the light-duty GHG program but also for the medium-duty GHG program and the criteria pollutant standards as well.

EPA has estimated the overall fleet-wide $CO_2$ emission levels that correspond with the attribute-based footprint standards, based on projections of the composition of each manufacturer's fleet in each year of the program. As shown in Table 29, for passenger cars, the proposed MY 2032 standards are projected to result in $CO_2$ fleet-average levels of 73 g/mi in MY 2032, which is 52 percent lower than that of the (adjusted) MY 2026 standards. For trucks, the projected MY 2032 fleet average $CO_2$ target is 89 g/mi which is 57 percent lower than that of the (adjusted) MY 2026 standards. The projected MY 2032 combined fleet target of 82 g/mi is 56 percent lower than that of the (adjusted) MY 2026 standards.

The derivation of the 82 g/mile estimate is described in Section IV.D. EPA aggregated the estimates for individual manufacturers based on projected production volumes into the fleet-wide averages for cars, trucks, and the entire fleet.[407] The combined fleet estimates are based on a projected fleet mix of cars and trucks that varies over the MY 2027–2032 timeframe.

TABLE 29—ESTIMATED FLEET-WIDE $CO_2$ TARGETS CORRESPONDING TO THE PROPOSED STANDARDS [408] [409]

| Model year | Cars $CO_2$ (g/mile) | Trucks $CO_2$ (g/mile) | Fleet $CO_2$ (g/mile) |
|---|---|---|---|
| 2026 adjusted | 152 | 207 | 186 |
| 2027 | 134 | 163 | 152 |
| 2028 | 116 | 142 | 131 |
| 2029 | 99 | 120 | 111 |
| 2030 | 91 | 110 | 102 |
| 2031 | 82 | 100 | 93 |
| 2032 and later | 73 | 89 | 82 |

EPA is proposing standards that set increasingly stringent levels of $CO_2$ control from MY 2027 though MY 2032. Applying the $CO_2$ footprint curves applicable in each MY to the vehicles (and their footprint distributions) expected to be sold in each MY produces progressively more stringent estimates of fleet-wide $CO_2$ emission standards. EPA believes manufacturers can achieve the proposed standards' important $CO_2$ emissions reductions through the application of available control technology at reasonable cost, as well as the use of program averaging, credit banking and trading, and optional air conditioning efficiency credits and off-cycle credits, as available.

While EPA believes the proposed standards are appropriate for light-duty vehicle manufacturers on an overall industry basis, we recognize that some companies have made public announcements for plans for zero emission vehicle product launches (as discussed in Section I.A.2.ii) that may lead to $CO_2$ emissions even lower than those projected under the proposed standards. The existing program's averaging, banking, and trading provisions allow manufacturers to earn credits for overcompliance with the standards that can be banked for the company's future use (up to five model years) or traded to other companies (as discussed further in Section III.B.4). Beyond these credit banking and trading provisions, EPA is interested in public comments on whether there could be additional ways in which the program could provide for alternative pathways that could encourage manufacturers to achieve even lower $CO_2$ emissions earlier in the program; for example, by producing higher volumes of zero-emission vehicles earlier than would be necessitated under the proposed standards. Such an alternative pathway could be one way to recognize the environmental benefits of earlier introductions of even greater volumes of the cleanest vehicles. EPA seeks public comment on the potential merits of such an alternative pathway concept, whether it would be advantageous for both the GHG as well as the criteria pollutant standards program, and how it might be structured.

The existing program includes several provisions that we are not reopening and so would continue during the implementation timeframe of this proposed rule. Consistent with the requirement of CAA section 202(a)(1) that standards be applicable to vehicles ''for their useful life,'' the proposed MY 2027–2032 vehicle standards will apply for the useful life of the vehicle.[410] EPA is proposing one test procedure change and that is the use of Tier 3 test fuel to demonstrate GHG compliance as described in Section III.B.2.iv.c; criteria pollutant standard demonstration already require the use of Tier 3 fuel. No other changes are proposed to the test procedures over which emissions are measured and weighted to determine compliance with the GHG standards. These procedures are the Federal Test Procedure (FTP or ''city'' test) and the Highway Fuel Economy Test (HFET or ''highway'' test). While EPA may consider requiring the use of test procedures other than the 2-cycle test procedures in a future rulemaking, EPA is not considering any test procedure changes in this rulemaking.

EPA has analyzed the feasibility of achieving the proposed $CO_2$ standards through the application of currently available technologies, based on projections of the technology and technology penetration rates to reduce emissions of $CO_2$, during the normal redesign process for cars and trucks, taking into account the effectiveness and cost of the technology. The results of the analysis are discussed in detail in Section IV, and in the DRIA. EPA also presents the overall estimated costs and benefits of the proposed car and truck $CO_2$ standards in Section VIII.

c. What test fuel is EPA proposing?

Within the structure of the footprint-based GHG standards, EPA is also proposing that gasoline powered vehicle compliance with the proposed standards be demonstrated on Tier 3 test fuel. The current GHG standards for light-duty gasoline vehicles are set on the required use of Indolene, or Tier 2 test fuel. Tier 3 test fuel more closely represents the typical market fuel available to consumers in that it contains 10 percent ethanol. EPA proposed an adjustment factor to allow demonstration of compliance with the existing GHG standards using Tier 3 test fuel but has not yet adopted those changes (85 FR 28564, May 13, 2020). This proposal does not include an adjustment factor for tailpipe GHG emissions but rather requires manufacturers to test on Tier 3 test fuel and use the resultant tailpipe emissions directly in their compliance calculation. Such an adjustment factor is not required because the technology penetrations, feasibility, and cost

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[407] Due to rounding during calculations, the estimated fleet-wide $CO_2$ levels may vary by plus or minus 1 gram.

[408] MY 2026 targets are provided for reference, based on for fleet mix (40% cars and 60% trucks) and then adjusted (upward) by 20 g/mi for cars, 24 g/mi for trucks, and 22 g/mi total for the fleet, to normalize as a point of comparison to reflect the reduced available off-cycle and AC credits as proposed for MY 2027.

[409] Fleet $CO_2$ targets are calculated based on projected car and truck share. Truck share for the fleet is expected at 60% for MY 2026–2029, and 59% for MY 2030 and later.

[410] The GHG emission standards apply for a useful life of 10 years or 120,000 miles for LDVs and LLDTs and 11 years or 120,000 miles for HLDTs and MDPVs. See 40 CFR 86.1805–17.

estimates in this proposal are based on compliance using Tier 3 test fuel.

Both the current and proposed criteria pollutant standards were set based on vehicle performance with Tier 3 test fuel; as a result, manufacturers currently use two different test fuels to demonstrate compliance with GHG and criteria pollutant standards. Setting new GHG standards based on Tier 3 test fuel is intended to address concern for test burden related to using two different test fuels.

The difference in GHG emissions between the two fuels is small but significant. EPA estimates that testing on Tier 3 test fuel will result in about 1.5 percent lower $CO_2$ emissions.[411] Because this difference in GHG emissions between the two fuels is significant in the context of measuring compliance with existing GHG standards, but small relative to the change in stringency of the proposed GHG standards, and because the cost of compliance on Tier 3 test fuel is reflected in this analysis for this proposal, EPA believes that this rulemaking and the associated proposed new GHG standards create an opportune time to shift compliance to Tier 3 fuel.

EPA is proposing to apply the change from Indolene to Tier 3 test fuel for demonstrating compliance with GHG standards starting in model year 2027. Manufacturers may optionally carry-over Indolene-based for test results for model years 2027 through 2029. We accordingly propose to allow manufacturers to continue to rely on the interim provisions adopted in 40 CFR 600.117 through model year 2029. These interim provisions address various testing concerns related to the arrangement for using different test fuels for different purposes.

For manufacturers that rely on testing with Indolene in model years 2027 through 2029, we propose to allow manufacturers to use good engineering judgment to apply a downward adjustment of 1.0166 percent to GHG emission test results as a correction to correlate with test results that would be expected when testing with Tier 3 test fuel. We separately proposed to apply an analogous correction for the opposite arrangement—testing with Tier 3 test fuel to demonstrate compliance with a GHG standard referenced to Indolene test fuel (85 FR 28564; May 13, 2020). We did not separately finalize the provisions in that proposed rule.

Similar considerations apply for measuring fuel economy, both to meet Corporate Average Fuel Economy requirements and to determine values for fuel economy labeling. EPA is proposing to apply the corrections described in the 2020 proposal. Those changes include: (1) New test fuel specifications for specific gravity and carbon weight fraction to properly calculate emissions in a way that accounts for the fuel properties of ethanol, (2) a revised equation for calculating fuel economy that uses an ''R-factor'' of 0.81 to account for the greater energy content of Indolene, and (3) amended instructions for calculating fuel economy label values based on 5-cycle values and derived 5-cycle values. Our overall goal is for manufacturers to transition to fuel economy testing with Tier 3 test fuel on the same schedule as described for demonstrating compliance with GHG standards in the preceding paragraphs. We will be reevaluating comments received on the 2020 proposal as well as the comments for this proposal and considering if any corrections and adjustments are required, with any appropriate modifications based on the comments received and on the changing circumstances reflected in the current proposed rule for setting new standards for MY 2027 and later vehicles. The proposed change to Tier 3 test fuel impacts the demonstration of compliance with GHG and fuel economy standards and the fuel economy label. In addition, several vehicle manufacturers have requested to move to Tier 3 test fuel in advance of the MY 2027 start of this proposed program.

For the GHG compliance program, we are proposing to evaluate GHG compliance with standards that are set using Tier 3 fuel starting in MY 2027; therefore, any vehicles that continue to be tested on Indolene, would need to have the results adjusted to be consistent with results on Tier 3 fuel. For the CAFE fuel economy standards, we are proposing to continue to evaluate fuel economy compliance with standards that are established on Indolene; therefore, any vehicles that are tested on Tier 3 fuel would need to have the results adjusted to be consistent with results on Indolene. Similar to the CAFE fuel economy standards, we are proposing to keep the fuel economy label consistent with the current program; therefore, any vehicles that are tested on Tier 3 fuel would need to have the results adjusted to be consistent with results on Indolene.

Supported by the data and analysis in the 2020 proposal, EPA proposes the following (Table 30) to address fuel-related testing and certification requirements through the transition to the proposed standards. Vehicle manufacturers may choose to test their vehicles with either Indolene or Tier 3 test fuel through MY 2029. Manufacturers must certify all vehicles to GHG standards using Tier 3 test fuel starting in MY 2027; however, manufacturers may continue to meet fuel economy requirements through MY 2029 for any appropriate vehicles based on carryover data from testing performed before MY 2027.

TABLE 30—PROPOSED FUEL-RELATED TESTING AND CERTIFICATION REQUIREMENTS

| Test fuel | GHG standards | | | Fuel economy standards | | | Fuel economy and environment label values | | |
|---|---|---|---|---|---|---|---|---|---|
| | Pre-MY 2027 | MYs 2027–2029 | MY 2030 and beyond | Pre-MY 2027 | MYs 2027–2029 | MY 2030 and beyond | Pre-MY 2027 | MYs 2027–2029 | MY 2030 and beyond |
| Indolene | No adjustment required. | Carry-over test results only; divide test results by 1.0166. | Not allowed | No adjustment required. | Carry-over results only; no adjustment required. | Not allowed | No adjustment required. | Carry-over results only; no adjustment required. | Not allowed. |
| Tier 3 | Multiply test results by 1.0166. | No adjustment required | | Apply revised FE equation proposed in 2020 rule | | | Apply revised FE equation proposed in 2020 rule. Apply proposed $CO_2$ adjustment (multiply test results by 1.0166). | | |

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[411] EPA–420–R–18–004, ''Tier 3 Certification Fuel Impacts Test Program,'' January 2018.

EPA requests comment regarding the implementation of this test fuel change and whether the change to Tier 3 test fuel should apply to GHG standards only or to GHG standards, fuel economy standards and fuel economy and environmental label combined, as described in Table 30.

### 3. Proposed Medium-Duty Vehicle GHG Standards

#### i. What $CO_2$ standards curves is EPA proposing?

Medium-duty vehicles (8,501 to 14,000 pounds GVWR) that are not categorized as MDPVs utilize a ''work-factor'' metric for determining GHG targets. Unlike the light-duty attribute metric of footprint, which is oriented around a vehicle's usage for personal transportation, the work-factor metric is designed around work potential for commercially oriented vehicles and accounts for a combination of payload, towing and 4-wheel drive equipment.

Our proposed GHG standards for MDVs are entirely chassis-dynamometer based and continue to be work-factor-based as with the previous heavy-duty Phase 2 standards. The standards also continue to use the same work factor (WF) and GHG target definitions (81 FR 73478, October 25, 2016). However, for MDVs above 22,000 pounds GCWR, we are proposing to limit the GCWR input into the work factor equation to 22,000 pounds GCWR in order to prevent increases in the GHG emissions target standards that are not fully captured within the loads and operation reflected during chassis dynamometer GHG emissions testing. The testing methodology does not directly incorporate any GCWR (*i.e.,* trailer towing) related direct load or weight increases; however, they are reflected in the higher target standards when calculating the GHG targets using GCWR values above 22,000 pounds Without some limiting ''cap,'' the resulting high target standards relative to actual measured performance are unsupported and may generate windfall compliance credits for higher GCWR ratings.

$CO_2e$ Target (g/mi) = [a × WF] + b

WF = Work Factor = [0.75 × [Payload Capacity + xwd] + [0.25 × Towing Capacity]

Payload Capacity = GVWR (lb.) − Curb Weight (lb.)

xwd = 500 lb. if equipped with 4-wheel-drive, otherwise 0 lb.

Towing Capacity = GCWR (lb.) − GVWR (lb.)

and with a and b as defined in Table 31:

TABLE 31—PROPOSED COEFFICIENTS FOR MDV TARGET GHG STANDARDS

| Model year | a | b |
|---|---|---|
| 2027 | 0.0348 | 268 |
| 2028 | 0.0339 | 261 |
| 2029 | 0.0310 | 239 |
| 2030 | 0.0280 | 216 |
| 2031 | 0.0251 | 193 |
| 2032 | 0.0221 | 170 |

The MDV target GHG standards are compared to the current HD Phase 2 gasoline standards in Figure 11. Note that the standards continue beyond the data markers shown in Figure 11. The data markers within the figure reflect the approximate transition from light-duty trucks to MDVs at a WF of approximately 3,000 pounds and the approximate location of 22,000 pounds GCWR in work factor space (*e.g.,* a WF of approximately 5,500 pounds). Beginning in 2027, the MDV GHG program moves gasoline, diesel, and PEV MDVs to fuel-neutral standards, *i.e.,* identical standards regardless of the fuel or energy source used. We consider these standards feasible taking into consideration the opportunities for increased MDV electrification, primarily within the van segment.

The smaller displacement diesel engines remaining within the MDV program are currently within the van segment and are all derived from passenger car or other light-duty applications. The gasoline MDVs have also historically used engines derived from light-duty applications. The larger displacement (6L and above) diesel engines in Class 2b and Class 3 applications all have GCWR above (in some cases, significantly above) 22,000 pounds and were not derived from light-duty applications.

**BILLING CODE 6560–50–P**

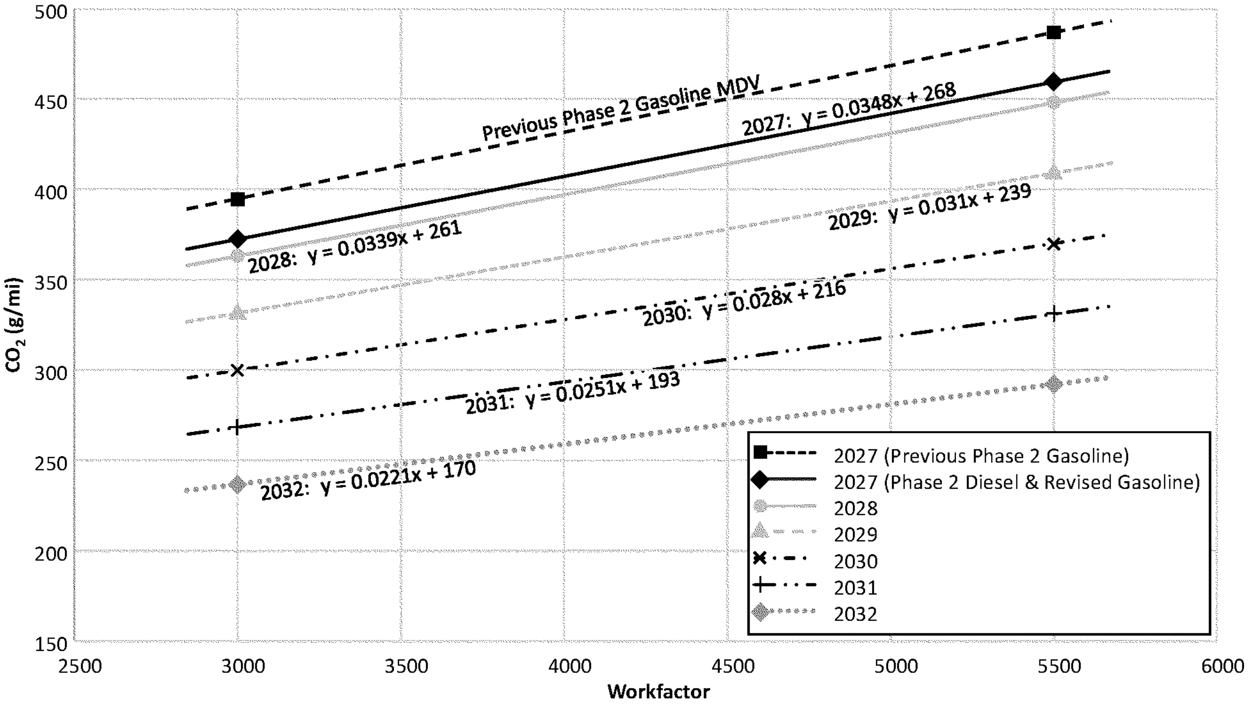

**Figure 11: Proposed MDV GHG standards.**

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The agency seeks comment on the proposed target standards for MDV for the different model years and the approach of a single target for all propulsion fuels including zero emission technologies. The agency also seeks comment on the appropriateness of the proposed GCWR input limit to the work factor equation to more accurately capture the work performed as tested.

ii. What fleet-wide $CO_2$ emissions levels correspond to the standards?

Table 32 shows overall fleet average target levels for both medium-duty vans and pickup trucks that are projected for the proposed standards. A more detailed break-down of the projected $CO_2$ targets and achieved levels is provided in DRIA Chapter 13. The actual fleet-wide average g/mile level that would be achieved in any year for medium-duty vans and pickup trucks will depend on the actual production of vehicles for that year, as well as the use of the credit averaging, banking, and trading provisions.

TABLE 32—PROJECTED TARGETS FOR PROPOSED MDV STANDARDS, BY BODY STYLE

| Model year | Vans $CO_2$ (g/mile) | Pickups $CO_2$ (g/mile) | Combined $CO_2$ (g/mile) |
|---|---|---|---|
| 2027 | 393 | 462 | 438 |
| 2028 | 379 | 452 | 427 |
| 2029 | 345 | 413 | 389 |
| 2030 | 309 | 374 | 352 |
| 2031 | 276 | 331 | 312 |
| 2032 and later | 243 | 292 | 275 |

iii. MDV Incentive Multipliers

In HD GHG Phase 1, EPA provided advanced technology credits for heavy-duty vehicles and engines, including for MDVs. EPA included incentive multipliers in Phase 1 for hybrid powertrains, all-electric vehicles, and fuel cell electric vehicles to promote the implementation of advanced technologies that were not included in our technical basis of the feasibility of the Phase 1 emission standards (see 40 CFR 86.1819–14(k)(7), 1036.150(h), and 1037.150(p)). For MDV, the HD GHG Phase 2 $CO_2$ emission standards that followed Phase 1 were premised on the use of mild hybrid powertrains and we removed mild hybrid powertrains as an option for advanced technology credits. At the time of the HD GHG Phase 2 final rule, we believed the HD GHG Phase 2 standards themselves provided sufficient incentive to develop those specific technologies. However, none of the HD GHG Phase 2 standards for MDV were based on projected utilization of the other, even more-advanced Phase 1 advanced credit technologies (*e.g.,* plug-in hybrid electric vehicles, all-electric vehicles, and fuel cell electric vehicles). For HD GHG Phase 2, EPA promulgated advanced technology credit multipliers through MY 2027, as shown in Table 33 (see also 40 CFR 1037.150(p)).

TABLE 33—ADVANCED TECHNOLOGY MULTIPLIERS IN EXISTING HD GHG PHASE 2 FOR MYS 2021 THROUGH 2027

| Technology | Multiplier |
|---|---|
| Plug-in hybrid electric vehicles | 3.5 |
| All-electric vehicles | 4.5 |
| Fuel cell electric vehicles | 5.5 |

As stated in the HD GHG Phase 2 rulemaking, our intention with these multipliers was to create a meaningful incentive for those manufacturers considering developing and applying these qualifying advanced technologies into their vehicles. The multipliers under the existing program are consistent with values recommended by CARB in their HD GHG Phase 2 comments.[412] CARB's values were based on a cost analysis that compared the costs of these advanced technologies to costs of other GHG-reducing technologies. CARB's cost analysis showed that multipliers in the range we ultimately promulgated as part of the HD GHG Phase 2 final rule would make these advanced technologies more competitive with the other GHG-reducing technologies and could allow manufacturers to more easily generate a viable business case to develop these advanced technologies for HD vehicles and bring them to market at a competitive price.

In establishing the multipliers in the HD GHG Phase 2 final rule, we also considered the tendency of the HD sector to lag behind the light-duty sector in the adoption of a number of advanced technologies. There are many possible reasons for this, such as:

—HD vehicles are more expensive than light-duty vehicles, which makes it a greater monetary risk for purchasers to invest in new technologies.
—These vehicles are primarily work vehicles, which makes predictable reliability of existing technologies and versatility important.
—Sales volumes are much lower for HD vehicles, especially for some specialized vehicles applications.

At the time of the HD GHG Phase 2 rulemaking, we concluded that as a result of factors such as these, and the fact that adoption rates for the aforementioned advanced technologies in HD vehicles were essentially non-existent in 2016, it seemed unlikely that market adoption of these advanced technologies would grow significantly within the next decade without additional incentives.

As we stated in the HD GHG Phase 2 final rule preamble, our determination that it was appropriate to provide large multipliers for these advanced technologies, at least in the short term, was because these advanced technologies have the potential to lead to very large reductions in GHG emissions and fuel consumption, and advance technology development substantially in the long term. However, because the credit multipliers are so large, we also stated that they should not be made available indefinitely. Therefore, they were included in the HD GHG Phase 2 final rule as an interim program continuing only through MY 2027.

The HD GHG Phase 2 advanced technology credit multipliers represent a tradeoff between incentivizing new advanced technologies that could have significant benefits well beyond what is required under the standards and providing credits that do not reflect real world reductions in emissions, which could allow higher emissions from credit-using engines and vehicles. At low adoption levels, we believe the balance between the benefits of encouraging additional electrification as compared to any negative emissions impacts of multipliers would be appropriate and would justify maintaining the current advanced technology multipliers. At the time we finalized the HD GHG Phase 2 program in 2016, we balanced these factors based on our estimate that there would be very little market penetration of ZEVs in the heavy-duty market in the MY 2021 to MY 2027 timeframe, during which the advanced technology credit multipliers would be in effect. Additionally, the primary technology packages in our technical assessment of the feasibility of the HD GHG Phase 2 standards did not include any ZEVs.

In our assessment conducted during the development of HD GHG Phase 2, we found only one manufacturer had certified HD BEVs through MY 2016, and we projected "limited adoption of all-electric vehicles into the market" for MYs 2021 through 2027.[413] However, as discussed in Section IV, we are now in a transitional period where manufacturers are actively increasing their PHEV and BEV vehicle offerings and are being further supported through the IRA tax credits, and we expect this growth to continue through the remaining timeframe for the HD GHG Phase 2 program and into the time frame of the proposed program.

While we did anticipate some growth in electrification would occur due to the credit incentives in the HD GHG Phase 2 final rule when we finalized the rule, we did not expect the level of innovation since observed, or the IRA or BIL incentives. Based on this new information, we believe the existing advanced technology multiplier credit levels for MDVs are no longer appropriate for maintaining the balance between encouraging manufacturers to continue to invest in new advanced technologies over the long term and potential emissions increases in the short term. We believe that, if left as is, the MDV multiplier credits may allow for backsliding of emission reductions expected from ICE vehicles for some manufacturers in the near term (*i.e.,* the generation of excess credits which could delay the introduction of technology in the near or mid-term) as sales of advanced technology MDVs which can generate the incentive credit continue to increase. In light of the rapid increase in vehicle electrification in the MDV market, EPA proposes to remove the BEV, PHEV, and FCEV multipliers for MY 2027 (EPA is not proposing revisions or requesting comment in this proposed rulemaking on the Phase 2 multipliers for the vocational vehicle and tractor vehicle segments of the heavy-duty Phase 2 program). We also request comment on phasing out the multipliers over multiple model years by revising the multipliers to reduce their magnitude for model years prior to MY 2027, for example for MYs 2025–2026. We note that we did not rely on credits generated from credit multipliers in developing the proposed MDV GHG standards, nor did EPA assess the

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[412] Letter from Michael Carter, CARB, to Gina McCarthy, Administrator, EPA and Mark Rosekind, Administrator, NHTSA, June 16, 2016. EPA Docket ID EPA–HQ–OAR–2014–0827 attachment 2.

[413] 81 FR 75300 (October 25, 2016).

impacts of the Phase 2 multipliers on our feasibility assessment. We request comment, including data & analysis, regarding the potential impact of Phase 2 MDV multipliers on our proposed standards in this action, and how EPA should consider such comments in the determining the continued appropriateness of the Phase 2 multipliers for MDVs.

### 4. Averaging, Banking, and Trading Provisions for GHG Standards

Averaging, banking, and trading (ABT) is an important compliance flexibility that has long been built into various highway engine and vehicle programs (and nonroad engine and equipment programs) to support emissions standards that, through the introduction and application of new technologies, result in reductions in air pollution. EPA's first mobile source program to feature averaging was issued in 1983 and included averaging for diesel light-duty vehicles to provide flexibility in meeting new PM standards.[414] EPA introduced $NO_X$ and PM averaging for highway heavy-duty vehicles in 1985.[415] EPA introduced credit banking and trading in 1990 with new more stringent highway heavy-duty $NO_X$ and PM standards to provide additional compliance flexibility for manufacturers.[416] Since those early rules, EPA has included ABT in many programs across a wide range of mobile sources.[417] For light-duty vehicles, EPA has included ABT in several criteria pollutant emissions standards rules including in the National Low Emissions Vehicle (NLEV) program,[418] the Tier 2 standards,[419] and the Tier 3 standards.[420] ABT has also been a key feature of all GHG rules for both light-duty and heavy-duty vehicles.[421]

ABT is important because it can help to address issues of technological feasibility and lead-time, as well as considerations of cost. In many cases, ABT resolves issues of lead-time or technical feasibility, enabling automakers to comply with standards that are more economically efficient and with less lead time. This provides important environmental benefits and at the same time it increases flexibility and reduces costs for the regulated industry. Furthermore, by encouraging automakers to exceed minimum requirements where possible, the ABT program encourages technological innovation, which makes further reductions in fleetwide emissions possible. The light-duty ABT program for GHG standards includes existing provisions initially established in the 2010 rule for how credits may be generated and used within the program.[422] These provisions include credit carry-forward, credit carry-back (also called deficit carry-forward), credit transfers (within a manufacturer), and credit trading (across manufacturers). The MDV GHG program includes similar ABT provisions. EPA is explaining the ABT provisions of the GHG program for the public's convenience and information but is not proposing changes or reopening these provisions.

Credit carry-forward refers to banking (saving) credits for future use, after satisfying any needs to offset prior MY debits within a vehicle category (car fleet or truck fleet). Credit carry-back refers to using credits to offset any deficit in meeting the fleet average standards that had accrued in a prior MY. A manufacturer may have a deficit at the end of a MY (after averaging across its fleet using credit transfers between cars and trucks)—that is, a manufacturer's fleet average emissions level may fail to meet the manufacturer's required fleet average standard for the MY, for a limited number of model years, as provided in the regulations. The CAA does not specify or limit the duration of such credit provisions. In previous rules, EPA chose to generally adopt 5-year credit carry-forward and 3-year credit carry-back provisions[423] as a reasonable approach that maintained consistency between EPA's GHG and NHTSA CAFE regulatory provisions.[424] While some stakeholders had suggested that light-duty GHG credits should have an unlimited credit life, EPA did not adopt that suggestion for the light-duty GHG program because it would pose enforcement challenges and could lead to some manufacturers accumulating large banks of credits that could interfere with the program's goal to develop and transition to progressively more advanced emissions control technologies in the future.

Transferring credits in the GHG program refers to exchanging credits between the two averaging sets—passenger cars and light trucks—within a manufacturer. For example, credits accrued by overcompliance with a manufacturer's car fleet average standard can be used to offset debits accrued due to that manufacturer not meeting the truck fleet average standard in a given model year.[425] MDVs are a separate averaging set and credits are not allowed to be transferred between vehicles meeting the light and medium-duty GHG standards due to the very different standards structure, vehicle testing differences (*e.g.,* MDVs are tested at an adjusted loaded vehicle weight of vehicle curb weight plus half payload whereas light-duty vehicles are tested at an estimated test weight of curb weight plus 300 pounds) and marketplace competitiveness issues.[426] This prohibition includes traded credits such that, once traded, credits may not be transferred between the light and medium-duty fleets. Finally, accumulated credits may be traded to another manufacturer. Credit trading has occurred on a regular basis in EPA's light-duty vehicle program.[427] Manufacturers acquiring credits may offset credit shortfalls and bank credits for use toward future compliance within the carry-forward constraints of the program.

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[414] 48 FR 33456, July 21, 1983.

[415] 50 FR 30584, March 15, 1985.

[416] 55 FR 30584, July 26, 1990.

[417] We note that in upholding the first HD final rule that included averaging, the D.C. Circuit rejected petitioner's challenge that Congress meant to prohibit averaging in standards promulgated under section 202(a). *NRDC* v. *Thomas*, 805 F.2d 410, 425 (D.C. Cir. 1986). In the 1990 Clean Act Amendments, Congress, noting *NRDC* v. *Thomas*, opted to let the existing law ''remain in effect,'' reflecting that ''[t]he intention was to retain the status quo,'' *i.e.,* EPA's existing authority to allow averaging for standards under section 202(a). 136 Cong. Rec. 36,713, 1990 WL 1222468 at *1136 Cong. Rec. 35,367, 1990 WL 1222469 at *1.

[418] 62 FR 31192, June 6, 1997.

[419] 65 FR 6698, February 10, 2000.

[420] 79 FR 23414, April 28, 2014.

[421] The **Federal Register** citations for previous vehicle GHG rules are provided in Section III.A.2.

[422] 40 CFR 86.1865–12.

[423] Although the existing credit carry-forward and carry-back provisions generally remained in place for MY 2017 and later standards, EPA finalized provisions in the 2012 rule allowing all unused (banked) credits generated in MYs 2010–2015 (but not MY 2009 early credits) to be carried forward through MY 2021. See 77 FR 62788. In addition, in the 2021 rule, EPA adopted a targeted one-year extension (6 years total carry-forward) of credit carry-forward for MY 2017 and 2018 credits. See 86 FR 74453.

[424] The EPCA/EISA statutory framework for the CAFE program limits credit carry-forward to 5 years and credit carry-back to 3 years.

[425] There is a VMT factor included in the credit calculations such that light trucks generate and use more credits than passenger cars based on higher lifetime VMT projections for light trucks compared to passenger cars. The lifetime VMT used for passenger cars and light trucks are 195,264 and 225,865, respectively.

[426] Only a small subset of manufacturers produce both light and medium-duty vehicles and allowing credits to be transferred between the two categories could provide additional flexibility to those manufacturers not available to manufacturer of only light-duty vehicles.

[427] EPA provides general information on credit trades annually as part of its annual Automotive Trends and GHG Compliance Report. The latest report is available at: *https://www.epa.gov/automotive-trends* and in the docket for this rulemaking.

The ABT provisions are an integral part of the vehicle GHG program, and the agency expects that manufacturers will continue to utilize these provisions into the future. EPA's annual Automotive Trends Report provides details on the use of these provisions in the GHG program.[428] ABT allows EPA to consider standards more stringent than we would otherwise consider by giving manufacturers an important tool to resolve any potential lead time and cost issues. EPA is not proposing any revisions to the GHG program ABT provisions or reopening them.

### 5. Proposed Vehicle Air Conditioning System Related Provisions

EPA has included air conditioning (AC) system credits in its light-duty GHG program since the initial program adopted in the 2010 rule. Although the use of AC credits has been voluntary, EPA has consistently adjusted the level of the $CO_2$ standards downward, making them more stringent, to reflect the availability of the credits. Manufacturers opting not to use the AC credits would need to meet the standards through additional $CO_2$ reductions. EPA is proposing to revise the AC credits program for light-duty vehicles in two ways. First, for AC system efficiency credits, EPA is proposing to limit the eligibility for voluntary credits for tailpipe $CO_2$ emissions control to ICE vehicles starting in MY 2027 (*i.e.,* BEVs would not earn AC efficiency credits). Second, for AC refrigerant leakage control, EPA is proposing to remove the credit. EPA is also proposing to sunset the refrigerant-related provisions applicable to MDV standards. EPA requests comment on its proposed changes to the AC credit program.

#### i. Background on AC Credits in Current Programs

There are two mechanisms by which AC systems contribute to the emissions of GHGs: Through leakage of hydrofluorocarbon refrigerants into the atmosphere (sometimes called ''direct emissions'') and through the consumption of fuel to provide mechanical power to the AC system (sometimes called ''indirect emissions'').[429] When EPA established the current light-duty refrigerant credits in the 2012 rule, the most common refrigerant was hydrofluorocarbon (HFC) 134a which has a global warming potential of 1430. The high global warming potential of HFC–134a, means that leakage of a gram of HFC134(a) would have 1430 times the global warming potential of a gram of $CO_2$. Since the 2012 rule, manufacturers have reduced the impacts of refrigerant leakage significantly by using systems that incorporate leak-tight components, or, ultimately, by using a refrigerant with a lower global warming potential. Manufacturers have steadily increased their use of low GWP refrigerant HFO–1234yf which has a GWP of 4, much lower than the GWP of the HFC refrigerant it replaces. The AC system also contributes to increased tailpipe $CO_2$ emissions through the additional work required to operate the compressor, fans, and blowers. This additional power demand is ultimately met by using additional fuel, which is converted into $CO_2$ by the engine during combustion and exhausted through the tailpipe. These emissions can be reduced by increasing the overall efficiency of an AC system, thus reducing the additional load on the engine from AC operation, which in turn means a reduction in fuel consumption and a commensurate reduction in $CO_2$ emissions.

EPA has consistently adjusted the stringency of the light-duty $CO_2$ footprint curves to reflect the availability of AC credits by shifting the footprint curves downward. In the 2012 rule and again in subsequent rules, EPA increased the stringency of the footprint curves by a total of 19 g/mile for cars and 24 g/mile for trucks to reflect the availability and anticipated use of the relatively low-cost AC credit opportunities.

For MDVs, EPA adopted a somewhat different approach to address AC refrigerant emissions. In the Phase 1 rule, EPA adopted a refrigerant leakage standard rather than a voluntary credit program.[430] This approach eliminated the need to adjust the $CO_2$ work factor-based standards to account for the availability of refrigerant-based credit, as EPA has done in setting the prior light-duty standards. EPA projected that manufacturers would meet the leakage standard either through the use of leak tight components or through the use of alternative refrigerants. In the Phase 2 rule, EPA revised the refrigerant leakage standard to be refrigerant neutral.[431] The MDV program does not include AC efficiency related credits or requirements.[432]

#### ii. Proposed Modifications to the AC Efficiency Credits

The current light-duty vehicle AC indirect emissions reduction credits in 40 CFR 86.1868–12, which EPA also commonly refers to as AC efficiency credits, are based on a technology menu with a testing component to confirm that the technologies provide emissions reductions when installed as a system on vehicles. The menu includes credits for improved system components and air recirculation settings designed to reduce the AC load on the IC engine.[433] The AC efficiency credits are capped at 5.0 g/mile for passenger cars and 7.2 g/mile for light trucks. In addition, a limited amount of vehicle tailpipe testing (*i.e.,* the ''AC17'' test) is required for manufacturers claiming credits to verify anticipated emissions reductions are occurring. The credits have been effective in incentivizing AC efficiency improvements since the program's inception, and manufacturers' use of AC menu credits has steadily increased over time. In MY 2021, 17 of 20 manufacturers reported efficiency credits resulting in an average credit of 5.7 g/mile.[434]

EPA is proposing to retain AC efficiency credits but, starting with MY 2027, limit eligibility to only vehicles equipped with IC engines. Thus, BEVs would no longer be eligible for these credits after MY 2026. The AC efficiency credits are based on emissions reductions from ICE vehicles. Currently, BEVs are generating credits even though the credits are based solely on improvements to ICE vehicles, and not representative of emissions reductions for BEVs. When EPA adopted this construct in the MY 2012 rule, BEV sales were relatively small, and the 0 g/mile accounting was temporary with upstream net emissions accounting part of the final standards. However, as discussed in Section III.B.7, EPA is proposing to continue the 0 g/mile treatment of PEV electric operation (by removing the MY 2027 date currently specified in the regulations for including upstream emissions in

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[428] ''The 2022 EPA Automotive Trends Report, Greenhouse Gas Emissions, Fuel Economy, and Technology since 1975,'' EPA–420–R–22–029, December 2022.

[429] 40 CFR 1867–12 and 40 CFR 86.1868–12.

[430] 76 FR 57194 and 73525.

[431] Under the Phase 2 program, loss of refrigerant from air conditioning systems may not exceed a total leakage rate of 11.0 grams per year or a percent leakage rate of 1.50 percent per year, whichever is greater. See 81 FR 73742 and 40 CFR 1037.115(e).

[432] In the previous heavy-duty GHG rules, EPA discussed but did not propose or finalize AC efficiency credits for MDVs. For further discussion see 76 FR 57196 and 81 FR 73742.

[433] Joint Technical Support Document, Final Rulemaking for 2017–2025 Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards, EPA–420–R–12–901, August 2012.

[434] ''The 2022 EPA Automotive Trends Report, Greenhouse Gas Emissions, Fuel Economy, and Technology since 1975,'' EPA–420–R–22–029, December 2022.

compliance calculations for BEVs). Another BEV related issue is that BEVs have generated g/mile AC credits even though they have been counted as 0 g/mile in the fleet average calculations. This accounting has contributed to manufacturers reporting BEV emissions as less than zero, which is not representative of actual vehicle emissions and can be a source of confusion. For example, in the latest Trends report, Tesla, which sells only BEVs, reported a fleet average performance value of negative 126 g/mile including 18.8 g/mile of AC credits.[435] Initially, when BEV sales were very low, these issues and their impacts were small, and the AC efficiency credits in turn provided some amount of incentive for more efficient BEVs overall and resulting upstream emission reductions. However, EPA has reconsidered the appropriateness of applying AC efficiency credits to BEVs in light of the increasing level of BEVs anticipated in future model years and the proposal to indefinitely exclude upstream emissions from BEV compliance calculations. For all these reasons, EPA believes limiting eligibility for AC efficiency credits to only ICE vehicles in the longer term is appropriate. EPA notes that the stringency of the proposed standards have been adjusted to reflect the inclusion of AC credits only for ICE equipped vehicles, as discussed in Section III.B.2.

In the 2012 rule, as a condition for claiming credits, EPA required manufacturers to conduct a limited number of emissions tests to help confirm that projected emissions reductions based on the menu are occurring with actual vehicles.[436] The test procedure used for testing is the ''AC17'' test and consists of the SC03 driving cycle (part of fuel economy label 5-cycle testing, where vehicles are tested under high temperature conditions), the fuel economy highway cycle, a preconditioning cycle, and a solar peak period (4-hour duration).[437] The AC17 test is mandatory for MYs 2017 and later (with the exception that manufacturers are not required to test BEVs).[438] Testing is at a limited ''AC grouping'' level, rather than the every model type level required for the $CO_2$ footprint standards. In MYs 2017–2019, AC17 test data was required to be reported to EPA but was not used to determine the credit levels for vehicles. Starting in MY 2020, the AC17 test results factor into ''qualifying/adjusting'' the level of credits through an A to B comparison with a baseline system. In cases where the test results do not support full menu credits, proportional credits may be generated based on the test results. Testing is limited in any given model year to no more than one vehicle from each vehicle platform that generates credits. Manufacturers with vehicles in a platform that are generating credits must choose a different vehicle model each year, starting with the highest sales volume vehicle, then the next highest the following year and so on until all models are tested or the platform undergoes a major redesign. EPA is not proposing to change the AC17 testing provisions from their current form for manufacturers claiming AC efficiency credits.

EPA notes that its proposed approaches for AC efficiency credits and off-cycle credits, discussed in detail in Section III.B.6, differ even though the types of emissions the credits are designed to address (*i.e.,* emissions not considered on the 2-cycle compliance test cycles) are similar. As discussed in Section III.B.6, while EPA is proposing to phase out the off-cycle credits entirely after MY 2030, EPA is not proposing to phase out AC efficiency credits for ICE vehicles or reopening them because the AC efficiency credits program is more robust as it includes a check of vehicle emissions performance through AC17 testing. EPA established the AC17 testing requirements as part of the 2012 rule to provide an assurance that the AC systems earning credits were providing anticipated emissions reductions. The off-cycle credits program includes no such mechanism to check performance. EPA is not reopening or proposing any changes to the existing AC17 testing provisions as part of this rule; therefore, the AC17 testing requirements of manufacturers earning AC efficiency credits would remain in effect under the MY 2027 and later program.

EPA's MDV work factor-based program does not include AC system efficiency provisions[439] and EPA is not reopening or considering new provisions for MDVs in this proposed rule.

iii. Proposed Removal of AC Credits for Reduced Refrigerant Leakage

The current light-duty vehicle AC credits program in 40 CFR 86.1867–12 that was adopted in the 2012 rule also includes credits for low refrigerant leakage systems and/or the use of alternative low global warming potential (GWP) refrigerants rather than hydrofluorocarbons (HFCs). The potential available AC leakage credits are larger than the AC efficiency credits. The program caps refrigerant related credits for passenger cars and light trucks, respectively, at 13.8 and 17.2 g/mile when an alternative refrigerant is used and 6.3 and 7.8 g/mile in cases where an alternative refrigerant is not used. Although the credits program has been voluntary since its inception, it has been effective in helping to incentivize the use of low GWP refrigerants. Since EPA established the voluntary refrigerant-based credits, low GWP refrigerant HFO–1234yf has been successfully used by many manufacturers to claim the full refrigerant replacement credits. As of MY 2021, 95 percent of new vehicles used the low GWP refrigerant.[440] EPA adopted a somewhat different approach for MDVs by including in the program a refrigerant leakage standard rather than a voluntary credit.[441]

In December 2020, the American Innovation and Manufacturing (AIM) Act (42 U.S.C. 7675) was enacted. The AIM Act, among other things, authorizes EPA to phase down production and consumption of HFCs in specific sectors and subsectors, including their use in vehicle AC systems. The AIM Act has sent a strong signal to all vehicle manufacturers that there is no future for using high GWP refrigerants in new vehicles. In December 2022, in response to the AIM Act, EPA proposed to restrict the use of high GWP refrigerants such as HFCs in vehicle applications.[442] The new restriction on refrigerant use, if finalized as proposed, would be effective in MY 2025 for light-duty vehicles and MY 2026 for MDVs, well ahead of the start of the new $CO_2$ vehicle standards EPA is proposing.[443]

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[435] ''The 2022 EPA Automotive Trends Report, Greenhouse Gas Emissions, Fuel Economy, and Technology since 1975,'' EPA–420–R–22–029, December 2022.

[436] See 77 FR 62721.

[437] Joint Technical Support Document, Final Rulemaking for 2017–2025 Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards, Chapter 5, EPA–420–R–12–901, August 2012.

[438] 77 FR 62722.

[439] See 81 FR 73742, October 25, 2016.

[440] ''The 2022 EPA Automotive Trends Report, Greenhouse Gas Emissions, Fuel Economy, and Technology since 1975,'' EPA–420–R–22–029, December 2022.

[441] See 40 CFR 1037.115(e) and 81 FR 73726, October 25, 2016.

[442] 87 FR 76738.

[443] EPA is not reopening or proposing to eliminate the refrigerant-based credits for MYs 2025–2026 because such an action would need to be accompanied by a proposal to revise the stringency of the footprint curves for those model years, established in the 2021 rule to account for the absence of the availability of refrigerant-based

Continued

Auto manufacturers have already successfully developed and employed HFO–1234–yf low GWP refrigerants across the large majority of the fleet and there is no reason at this time to believe that manufacturers would redesign those systems again under the AIM Act, in the absence of EPA vehicle-based credits, to develop and use systems equipped with a higher GWP refrigerant. In light of the proposed high GWP phase out and the fact that EPA has been directed by the AIM Act to do so, EPA believes sunsetting the voluntary refrigerant-related credits in MY 2027 in its vehicles GHG program is appropriate and reasonable. This would avoid duplicative programs established under two different statutes, simplify EPA's vehicles program, and reduce manufacturer reporting burden associated with claiming the voluntary credits. For all these reasons, EPA is also ending the MDV refrigerant leakage standard in MY 2027. EPA requests comment on its AC refrigerant-related proposals. While EPA does not believe continuing the light-duty and medium-duty vehicle refrigerants provisions in this program is necessary, EPA requests comments on whether there is any value in retaining its current provisions. EPA notes that for light-duty vehicles the footprint-based standards would need to be adjusted to be made more stringent to account for the availability and use of refrigerant credits if they are retained, consistent with previous light-duty vehicle GHG rules.

### 6. Off-Cycle Credits Program

#### i. Background on the Off-Cycle Credits Provisions

Starting with MY 2008, EPA started employing a ''five-cycle'' test methodology to measure fuel economy for purposes of new car window stickers (labels) to give consumers better information on the fuel economy they could more reasonably expect under real-world driving conditions.[444] However, for GHG compliance, EPA continues to use the established ''two-cycle'' (city and highway test cycles, also known as the FTP and HFET) test methodology.[445] As learned through development of the ''five-cycle'' methodology and prior rulemakings, there are technologies that provide real-world GHG emissions improvements, but whose improvements are not fully reflected on the ''two-cycle'' test. EPA established the off-cycle credit program in 40 CFR 86.1869–12 to provide an appropriate level of $CO_2$ credit for technologies that achieve $CO_2$ reductions but may not otherwise be chosen as a GHG control strategy, as their GHG benefits are not measured on the specified 2-cycle test. For example: High efficiency lighting is not measured on EPA's 2-cycle tests because lighting is not turned on as part of the test procedure, but it reduces $CO_2$ emissions by decreasing the electrical load on the alternator and engine. Both light-duty and medium-duty vehicles may generate off-cycle credits, but the program is much more limited in the medium-duty work factor-based program.

Under EPA's existing regulations, there are three pathways by which a manufacturer may accrue light-duty vehicle off-cycle technology credits.[446] The first pathway is a predetermined list or ''menu'' of credit values for specific off-cycle technologies that was effective starting in MY 2014.[447] This pathway allows manufacturers to use credit values established by EPA for a wide range of off-cycle technologies, with minimal or no data submittal or testing requirements. The menu includes a fleetwide cap on credits to address the uncertainty of a one-size-fits-all credit level for all vehicles and the limitations of the data and analysis used as the basis of the menu credits. The menu cap is 10 g/mile except for a temporary increased cap of 15 g/mile available only for MYs 2023–2026, adopted by EPA in the 2021 rule.[448] The existing menu technologies and associated credits are summarized in Table 34 and Table 35.[449]

TABLE 34—EXISTING OFF-CYCLE TECHNOLOGIES AND CREDITS FOR CARS AND LIGHT TRUCKS

| Technology | Credit for cars (g/mile) | Credit for light trucks (g/mile) |
|---|---|---|
| High Efficiency Alternator (at 73%; scalable) | 1.0 | 1.0. |
| High Efficiency Exterior Lighting (at 100W) | 1.0 | 1.0. |
| Waste Heat Recovery (at 100W; scalable) | 0.7 | 0.7. |
| Solar Roof Panels (for 75W, battery charging only) | 3.3 | 3.3. |
| Solar Roof Panels (for 75W, active cabin ventilation plus battery charging) | 2.5 | 2.5. |
| Active Aerodynamic Improvements (scalable) | 0.6 | 1.0. |
| Engine Idle Start-Stop with heater circulation system | 2.5 | 4.4. |
| Engine Idle Start-Stop without heater circulation system | 1.5 | 2.9. |
| Active Transmission Warm-Up | 1.5 | 3.2. |
| Active Engine Warm-Up | 1.5 | 3.2 |
| Solar/Thermal Control | Up to 3.0 | Up to 4.3. |

TABLE 35—EXISTING OFF-CYCLE TECHNOLOGIES AND CREDITS FOR SOLAR/THERMAL CONTROL TECHNOLOGIES FOR CARS AND LIGHT TRUCKS

| Thermal control technology | Car credit (g/mile) | Truck credit (g/mile) |
|---|---|---|
| Glass or Glazing | Up to 2.9 | Up to 3.9 |

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credits. EPA is not proposing to revisit the standards it established for MYs 2023–2026.

[444] *https://www.epa.gov/vehicle-and-fuel-emissions-testing/dynamometer-drive-schedules.* See also 75 FR 25439 for a discussion of 5-cycle testing.

[445] The city and highway test cycles, commonly referred to together as the ''2-cycle tests'' are laboratory compliance tests that are effectively required by law for CAFE, and also used for determining compliance with the GHG standards. 49 U.S.C. 32904(c).

[446] ''The 2022 EPA Automotive Trends Report, Greenhouse Gas Emissions, Fuel Economy, and Technology since 1975,'' EPA–420–R–22–029, December 2022, for information regarding the use of each pathway by manufacturers.

[447] See 40 CFR 86.1869–12(b).

[448] See 86 FR 74465.

[449] See 40 CFR 86.1869–12(b). See also ''Joint Technical Support Document: Final Rulemaking for 2017–2025 Light-duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards for the Final Rule,'' EPA–420–R–12–901, August 2012, for further information on the definitions and derivation of the credit values.

TABLE 35—EXISTING OFF-CYCLE TECHNOLOGIES AND CREDITS FOR SOLAR/THERMAL CONTROL TECHNOLOGIES FOR CARS AND LIGHT TRUCKS—Continued

| Thermal control technology | Car credit (g/mile) | Truck credit (g/mile) |
|---|---|---|
| Active Seat Ventilation | 1.0 | 1.3 |
| Solar Reflective Paint | 0.4 | 0.5 |
| Passive Cabin Ventilation | 1.7 | 2.3 |
| Active Cabin Ventilation | 2.1 | 2.8 |

A second pathway allows manufacturers of light-duty vehicles to use 5-cycle testing to demonstrate and justify off-cycle $CO_2$ credits.[450] The additional emissions tests allow emission benefits to be demonstrated over some elements of real-world driving not captured by the GHG compliance tests, including high speeds, rapid accelerations, and cold temperatures. Under this pathway, manufacturers submit test data to EPA, and EPA determines whether there is sufficient technical basis to approve the off-cycle credits. The third pathway allows manufacturers to seek EPA approval, through a notice and comment process, to use an alternative methodology other than the menu or 5-cycle methodology for determining the off-cycle technology $CO_2$ credits.[451] This option is only available if the benefit of the technology cannot be adequately demonstrated using the 5-cycle methodology. For MDVs, the manufacturers may use the public process or 5-cycle pathways for generating credits.[452] There is no off-cycle credits menu for MDVs.

EPA designed the off-cycle program to provide an incentive for new and innovative technologies that reduce real world $CO_2$ emissions primarily outside of the 2-cycle test procedures (*i.e.,* off-cycle) such that most of the emissions reductions are not reflected or ''captured'' during certification testing. The program also provides flexibility to manufacturers since off-cycle credits may be used to meet their emissions reduction obligations. In past rules, EPA has not adjusted the standards levels to reflect the availability of off-cycle credits like we did in the case of AC credits. However, in the 2021 rule, we did include use of off-cycle credits by manufacturers in our cost analysis. Specifically, we assumed in our modeling for the 2021 rule that 10 g/mile of off-cycle credits would be used at an incremental cost of $42/grams/mile.[453] The menu credit levels are based on estimated $CO_2$ reductions from ICE vehicles. However, the current program also allows BEVs to generate menu credits. Allowing vehicles with tailpipe values of 0 g/mile to generate off-cycle credits has resulted in emissions compliance values of less than 0 g/mile.

Since MY 2012, the program has successfully encouraged the introduction and use of a variety of off-cycle technologies, especially menu technologies under the light-duty program. The use of several menu technologies has steadily increased over time, including engine stop-start, active aerodynamics, high efficiency alternators, high efficiency lighting, and thermal controls that reduce AC energy demand. The program has allowed manufacturers to reduce emissions by applying off-cycle technologies, at lower overall costs, compared to the technologies that would have otherwise been used to provide reductions over the 2-cycle test, consistent with the intent of the program. Since 2012, the quantity of off-cycle credits generated by manufacturers steadily increased over time. In 2021, the industry averaged 8.7 g/mile of credits with more than 95 percent of those credits based on the menu. Seven manufacturers (BMW, Ford, GM, Honda, Jaguar Land Rover, Stellantis, and VW) claimed the maximum menu credit available of 10 g/mile, while Honda claimed the highest level of off-cycle credits overall at 10.6 g/mile.[454] Several manufacturers used at least some off-cycle technologies on 80–100 percent of vehicles.

The program has had mixed results for 5-cycle and public process pathways. There have been few 5-cycle credit demonstrations, and the public process pathway has been challenging due to the complexity of demonstrating real-world emissions reductions for technologies not listed on the menu. The public process pathway was used successfully by several manufacturers for high efficiency alternators, resulting in EPA adding them to the off-cycle menu beginning in MY 2021.[455] The program has resulted in a number of concepts for potential off-cycle technologies over the years, but few have been implemented, at least partly due to the difficulty in demonstrating the quantifiable real-world emissions reductions associated with using the technology. Many credits sought by manufacturers have been relatively small (less than 1 g/mile). Manufacturers have commented several times that the process takes too long, but the length of time is often associated with the need for additional data and information or issues regarding whether a technology is eligible for credits.

### ii. Proposed Phase Out of Off-Cycle Credits

EPA is proposing to sunset the off-cycle program for both light and medium-duty vehicles as follows: (1) EPA proposes to phase out menu-based credits in the light-duty vehicle program by reducing the menu credit cap year-over-year until it is fully phased out in MY 2031. Specifically, EPA is proposing a declining menu cap starting with the 10 g/mile cap currently in place for MY 2027 and then phasing down to 8.0/6.0/3.0/0.0 g/mile over MYs 2028–2031 such that MY 2030 would be the last year manufacturers could generate credits; (2) EPA proposes to eliminate the 5-cycle and public process pathways starting in MY 2027; and (3) EPA proposes to limit eligibility for off-cycle credits to vehicles with tailpipe emissions greater than zero (*i.e.,* vehicles equipped with IC engines) starting in MY 2027. There are several factors that have led EPA to propose phasing out the off-cycle credits program in this manner, as discussed in this section.

EPA believes phasing out the off-cycle program is generally consistent with EPA's proposed standards and the direction the industry is headed in

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[450] See 40 CFR 86.1869–12(c).

[451] See 40 CFR 86.1869–12(d).

[452] See 40 CFR 86.1819–14(d)(13).

[453] ''Revised 2023 and Later Model Year Light-Duty Vehicle GHG Emissions Standards: Regulatory Impact Analysis,'' EPA–420–R–21–028, December 2021.

[454] ''The 2022 EPA Automotive Trends Report, Greenhouse Gas Emissions, Fuel Economy, and Technology since 1975,'' EPA–420–R–22–029, December 2022.

[455] 85 FR 25236.

changing their vehicle mix away from ICE technologies toward vehicle electrification technologies. EPA originally created the off-cycle program both to provide flexibility to manufacturers and to encourage the development of new and innovative technologies that might not otherwise be used because their benefits were not captured on the 2-cycle test. EPA believes the off-cycle credits program has successfully served these purposes. However, the credits were based on estimated emissions improvements for ICE vehicle which at the time accounted for the vast majority of vehicles produced. Now with the industry focusing most R&D resources on vehicle electrification technology development and increasing production, as discussed in Section I.A.2,[456] [457] [458] off-cycle credits are not likely to be a key area of focus for manufacturers. In addition, EPA believes that it is not likely that manufacturers would invest resources on off-cycle technology in the future for their ICE vehicle fleet that is likely to become a smaller part of their overall vehicle mix over the next several years. For example, in MY 2021, credits per technology generated under the public process pathway were all well below 1 g/mile [459] and there is little reason to expect the program to drive significant new innovation in the future. The public process pathway has been in place since the 2010 rule and manufacturers have had ample opportunity to consider potential off-cycle technologies. Also, manufacturers would be recouping any investment in off-cycle technologies, with relatively small emission reductions, over a decreasing number of vehicles as ICE vehicle production declines.

In addition, the off-cycle credits were initially small relative to the average fleet emissions and standards. For example, in the 2012 rule, EPA established menu credits of up to 10 g/mile, a relatively small value compared to a projected fleet-wide average compliance value of about 243 g/mile in MY 2016 phasing down to 163 g/mile in MY 2025.[460] Across the MY 2016–2025 program, therefore, EPA projected menu credits would be about 4 percent to 6 percent of the standard. Now, EPA is proposing standards that would reduce fleet average emissions to about 82 g/mile and therefore off-cycle credits would become an outsized portion (*e.g.,* up to 12 percent) of the program if they were retained in their current form. One concern is that there is not currently a mechanism to check that off-cycle technologies provide emissions reductions in use commensurate with the level of the credits the menu provides. This is becoming more of a concern as vehicles become less polluting overall. The menu credits are based on MY 2008 vintage engine and vehicle baseline technologies (assessed during the 2012 rule) and therefore the credit levels are potentially becoming less representative of the emissions reductions provided by the off-cycle technologies as vehicle emissions are reduced. Some stakeholders have also become increasingly concerned that the emissions reductions reflected in the off-cycle credits may not be being achieved.[461] Also, details such as the synergistic effects and overlap among off-cycle technologies take on more importance as the credits represent a larger portion of the emissions reductions. During the rulemaking to revise the MY 2023–2026 standards, EPA received comments that due to the potential for loss of GHG emissions reductions, the off-cycle program should be further constrained, or discontinued, or that a significantly more robust mechanism be implemented for verifying purported emissions reductions of off-cycle technologies. The potential for a loss of GHG emissions reductions could become further exacerbated as the standards become more stringent.[462]

Initially, EPA addressed the uncertainty surrounding the precise emissions reductions from equipping vehicle models with off-cycle technologies by making the initial credit values conservative, but the values may no longer be conservative, and may even provide more credits than appropriate for later MY vehicles. Because off-cycle credits effectively displace two-cycle emissions reductions, EPA has long strived to ensure that off-cycle credits are based on real-world reductions and do not result in a loss of emissions reductions overall. EPA received comments in past rules that it should revise the program to better ensure real-world emissions reductions.[463] However, EPA has learned through its experience with the program to date that such demonstrations can be exceedingly challenging. At this time, EPA has not identified a single robust methodology that can provide sufficient assurance across potential off-cycle technologies due to the wide variety of off-cycle real world conditions over which a potential technology may reduce emissions. EPA does not have a proposed methodology that would provide such assurance across a range of technologies. Finally, while the off-cycle program provides an incentive for off-cycle emissions reduction technologies, it does not include full accounting of off-cycle emissions. Vehicle equipment such as remote start and even roof racks added at the dealership may well increase off-cycle emissions. For all of these reasons, EPA believes the role of off-cycle credits should be de-emphasized in the future and in the longer term the credits should be phased out.

EPA is proposing to phase out menu credits over the MY 2028–2031 timeframe as a reasonable way to bring the program to an end. The cap would be reduced as shown in Table 36. EPA is proposing to end the program through a phase-out rather than simply ending the program entirely in MY 2027 to provide a transition period to help manufacturers who have made substantial use of the program in their product planning. Currently, the cap is applied to individual manufacturers by dividing the credits generated by a manufacturer's entire vehicle production to determine an average credit level for the model year. EPA proposes that starting in MY 2027, the denominator would include only eligible vehicles (*i.e.,* vehicles equipped with an IC engine) rather than all vehicles produced by the manufacturer. EPA requests comment on its approach for phasing out the off-cycle program, including the number of years over which the menu phase out would occur as well as the proposed menu credit caps in those years.

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[456] Reuters, ''A Reuters analysis of 37 global automakers found that they plan to invest nearly $1.2 trillion in electric vehicles and batteries through 2030,'' October 21, 2022. Accessed on November 4, 2022 at *https://graphics.reuters.com/AUTOS-INVESTMENT/ELECTRIC/akpeqgzqypr/*.

[457] Reuters, ''Exclusive: Automakers to double spending on EVs, batteries to $1.2 trillion by 2030,'' October 25, 2022. Accessed on November 4, 2022 at *https://www.reuters.com/technology/exclusive-automakers-double-spending-evs-batteries-12-trillion-by-2030-2022-10-21/*.

[458] Center for Automotive Research, ''Automakers Invest Billions in North American EV and Battery Manufacturing Facilities,'' July 21, 2022. Retrieved on November 10, 2022 at *https://www.cargroup.org/automakers-invest-billions-in-north-american-ev-and-battery-manufacturing-facilities/*.

[459] ''The 2022 EPA Automotive Trends Report, Greenhouse Gas Emissions, Fuel Economy, and Technology since 1975,'' EPA–420–R–22–029, December 2022.

[460] 77 FR 62641.

[461] ''Revised 2023 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emission Standards: Response to Comments,'' Chapter 8, EPA–420–R–21–027, December 2021.

[462] *Ibid.*

[463] *Ibid.* See also 85 FR 25232–25242.

TABLE 36—PROPOSED OFF-CYCLE MENU CREDIT CAP PHASE DOWN

| Model year | Off-cycle menu credit cap (g/mile) |
|---|---|
| MY 2027 (current program) | 10 |
| MY 2028 | 8.0 |
| MY 2029 | 6.0 |
| MY 2030 | 3.0 |
| MY 2031 and later | 0.0 |

Also, as discussed in detail in Section III.B.8, EPA is proposing to revise the utility factor for PHEVs. While PHEVs would remain eligible for off-cycle credits under EPA's proposed eligibility criteria, EPA proposes, as a reasonable approach for addressing off-cycle credits for PHEVs, to scale the menu credit cap for PHEVs by the vehicle's assigned utility factor. For example, if a PHEV has a utility factor of 0.3, meaning the vehicle is estimated to operate as an ICE vehicle 70 percent of the vehicle's VMT, the PHEV would be eligible for 70 percent of the cap value. For example, if the cap is 10.0 g/mile in MY 2027, PHEVs would be eligible for off-cycle credits up to 7.0 g/mile. Therefore, manufacturers producing PHEVs would not be eligible for the full menu credit cap value shown in Table 36. EPA proposes that the menu credit cap for each manufacturer's eligible vehicles would be the production-weighted average of ICE vehicles counting at the full cap amount and PHEVs at their maximum credit allowance. EPA proposes that manufacturers would apply the utility factor to the total off-cycle credits generated by the PHEVs to properly account for the value of the off-cycle credit corresponding to expected engine operation. As is the case in the current program, individual vehicles could generate more credits than the fleetwide cap value but the fleet average credits per vehicle must remain at or below the applicable menu cap. EPA requests comments on this as well as other potential ways of addressing off-cycle credits for PHEVs.

There are two pathways for generating credits in addition to the menu. In cases where additional laboratory testing can demonstrate emission benefits, the ''5-cycle'' pathway allows manufacturers to use a broader array of emission tests (known as 5-cycle testing because the methodology uses five different testing procedures) to demonstrate and justify off-cycle $CO_2$ credits. The additional emission tests allow emission benefits to be demonstrated over elements of real-world driving not captured by the GHG compliance tests, including high speeds, rapid accelerations, interior air conditioning and heater usage and cold temperature operation. The third pathway for off-cycle technology performance credits allows manufacturers to seek EPA approval to use an alternative methodology for determining off-cycle technology $CO_2$ credits. This option is only available if the benefit of the technology cannot be adequately demonstrated using the 5-cycle methodology. The regulations require that EPA seek public comment on and publish each manufacturer's application for credits sought using this pathway. After reviewing the petitions submitted by manufacturers and the comments, EPA drafts and publishes decision documents that explain the impacts and applicability of the unique alternative method technologies via the **Federal Register**. The public process pathway is also available for MD vehicles.

Regarding the 5-cycle pathway, these credits have a more rigorous basis compared to credits generated under the other pathways because they are based on vehicle testing. However, the 5-cycle pathway has been used infrequently. In MY 2021, there were no credits generated using the 5-cycle pathway and historically only one manufacturer has used the pathway since MY 2012.[464] MDV manufacturers also are not using the 5-cycle pathway. Given that the 5-cycle pathway is not being actively used and we are not aware of any OEM plans to make significant use of the 5-cycle pathway in the future, EPA believes phasing it out for both light-duty and medium-duty vehicles in MY 2027 is reasonable. EPA requests comment on this approach for 5-cycle based credits.

Since MY 2012, manufacturers have used the public process pathway more extensively than the 5-cycle pathway. In fact, several manufacturers successfully applied for high efficiency alternator credits through the public process which led EPA to add the technology to the menu as part of the 2020 rule.[465] However, as of MY 2021, the public process pathway is resulting in relatively few credits. While there were nine manufacturers generating credits, the average per vehicle credit across all manufacturers was 0.2 g/mile. Manufacturers claiming credits averaged between 0.0–0.7 g/mile per vehicle.[466] Thus, more than 95 percent of off-cycle credits in MY 2021 were based on the menu. For MDVs, manufacturers are not generating any credits under the public process pathway. In addition, there are significant resources involved both for the manufacturer in developing a methodology and submitting it to EPA and for EPA in evaluating the applications, including soliciting public comments. Given that the pathway is little used, is resulting in few credits, and can be resource-intensive for both manufacturers and EPA, EPA is proposing to eliminate this pathway in MY 2027 as well. EPA would eliminate the pathway for both LD and MDVs. EPA requests comment on its proposal to end the public process pathway in MY 2027.

Regarding EPA's proposal to limit off-cycle credit eligibility to vehicles equipped with ICE engine, the menu credits levels were based on potential emissions reductions from ICE vehicles and are not representative of emissions reductions for BEVs, especially in a program based solely on tailpipe emissions. Especially now that EPA is proposing to make the 0 g/mile treatment of BEV operation a permanent part of the program (see Section III.B.7), with no accounting for upstream emissions, EPA believes it is most appropriate to limit eligibility for off-cycle credits to vehicle with tailpipe emissions, discontinuing off-cycle credits for BEVs. While off-cycle technologies may provide some overall efficiency improvement for BEVs (with some potential upstream emissions benefit), off-cycle technologies do not impact BEV tailpipe emissions, since BEVs have no tailpipe emissions and therefore are not relevant for this program. This issue will only become more pronounced as the

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[464] ''The 2022 EPA Automotive Trends Report, Greenhouse Gas Emissions, Fuel Economy, and Technology since 1975,'' EPA–420–R–22–029, December 2022.

[465] 85 FR 25236.

[466] ''The 2022 EPA Automotive Trends Report, Greenhouse Gas Emissions, Fuel Economy, and Technology since 1975,'' EPA–420–R–22–029, December 2022.

implementation of BEV technologies in the fleet increases. Therefore, EPA is proposing to end off-cycle credits for vehicles with no IC engine beginning in MY 2027.[467]

EPA is proposing substantial revisions to the off-cycle credits program, including restricting eligibility and eliminating credit pathways starting in MY 2027 and phasing out the program entirely starting with MY 2031. EPA requests comment on these proposals. Commenters advocating for continuing the off-cycle program in some form are encouraged to consider EPA's concerns as described in this section and to provide data to the extent possible to support their comments. For example, to the extent commenters support keeping the off-cycle menu in some form, EPA would be especially interested in comments supported with data on how the level of the credits should be adjusted to better reflect emission reductions for future ICE vehicles.

### 7. Treatment of PEVs and FCEVs in the Fleet Average

In the 2012 rule, for MYs 2022–2025, EPA allowed manufacturers to use a 0 g/mi compliance value (*i.e.,* a value reflecting tailpipe emissions only) for the electric-only portion of operation of BEVs/PHEVs/FCEVs up to a per-company cumulative production cap.[468] As originally envisioned in the 2012 rule, starting with MY 2022, the compliance value for BEVs, FCEVs, and the electric portion of PHEVs in excess of individual automaker cumulative production caps would be based on net upstream emissions accounting (*i.e.,* EPA would attribute a pro rata share of national $CO_2$ emissions from electricity generation to each mile driven under electric power minus a pro rata share of upstream emissions associated with from gasoline production). The 2012 rule would have required net upstream emissions accounting for all MY 2022 and later electrified vehicles. However, in the 2020 rule, prior to upstream accounting taking effect, EPA revised its regulations to extend the use of 0 g/mile compliance value through MY 2026 with no production cap, effectively continuing the practice of basing compliance only on tailpipe emissions for all vehicle and fuel types.

EPA is proposing to make the current treatment of PEVs and FCEVs through MY 2026 permanent. EPA proposes to include only emissions measured directly from the vehicle in the vehicle GHG program for MYs 2027 and later (or until EPA changes the regulations through future rulemaking) consistent with the treatment of all other vehicles. Electric vehicle operation would therefore continue to be counted as 0 g/mile, based on tailpipe emissions only. Vehicles with no IC engine (*i.e.,* BEVs and FCEVs) would be counted as 0 g/mile in compliance calculations, while PHEVs would apply the 0 g/mile factor to electric-only vehicle operation (see also Section III.B.8 for EPA's proposed treatment of PHEVs). The program has now been in place for a decade, since MY 2012, with no upstream accounting and has functioned as intended, encouraging the continued development and introduction of electric vehicle technology. These emissions reduction technologies are now coming into the mainstream and can serve as the primary technologies upon which EPA can base more stringent standards. As a separate and independent reason for making the current treatment permanent, EPA originally proposed using upstream emissions in PEV compliance calculations at a time when there was little if any regulation of stationary sources for GHGs, and noted at the time this was a departure from its usual practice of relying on stationary source programs to address pollution risks from stationary sources.[469] In the 2020 rule, EPA extended 0 g/mi in part because power sector emissions were declining and the trend was projected to continue and stated ''EPA agrees that, at this time, manufacturers should not account for upstream utility emissions.'' [470] As noted elsewhere, power sector emissions are expected to decline further in the future. EPA continues to believe that it is appropriate for any vehicle which has zero tailpipe emissions to use 0 g/mi as its compliance value.[471] This approach of looking only at tailpipe emissions and letting stationary source GHG emissions be addressed by separate stationary source programs is consistent with how every other light duty vehicle calculates its compliance value. If EPA deviated from this tailpipe emissions approach by including upstream accounting, it would appear appropriate to do so for all vehicles, including gasoline-fueled vehicles. EPA notes that while upstream emissions are not included in vehicle compliance determinations, which are based on direct vehicle emissions, upstream emissions impacts from fuel production at refineries and electricity generating units are considered in EPA's analysis of overall estimated emissions impacts and projected benefits.

EPA requests comments on its proposed treatment of electrified vehicles in manufacturer compliance calculations.

### 8. Proposed Approach for the PHEV Utility Factor

EPA is proposing to revise the light-duty vehicle PHEV Fleet Utility Factor curve used in $CO_2$ compliance calculation for PHEVs, beginning in MY 2027. The agency believes the current light-duty vehicle PHEV compliance methodology significantly underestimates PHEV $CO_2$ emissions. The mechanism that is used to apportion the benefit of a PHEV's electric operation for purposes of determining the PHEV's contribution towards the fleet average GHG requirements is the fleet utility factor (FUF). We have analyzed available data and compiled literature [472] [473] [474] [475] showing that the current utility factors are overestimating the operation of PHEVs on electricity, and therefore would underestimate the $CO_2$ g/mi compliance result. The current and proposed FUFs are shown in Figure 12.

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[467] EPA is not proposing to reopen previously established standards for earlier MYs, for example MYs 2025–2026, to eliminate off-cycle credits for BEVs prior to MY 2027 because off-cycle credits were integral to EPA's cost analysis for the prior standards and such an action would need to be accompanied by a new analysis of the footprint standards for those model years to account for the elimination of off-cycle credits for BEVs.

[468] See 77 FR 62816.

[469] 75 FR 25434.

[470] 85 FR 25208.

[471] See Section IV.C.3 for a full discussion of power sector emissions projections.

[472] Krajinska, Poliscanova, Mathieu, & Ambel, Transport & Environment. 2020. ''A new Dieselgate in the making.'' November: *https://www.transportenvironment.org/discover/plug-hybrids-europe-heading-new-dieselgate/.*

[473] Plötz, P., Moll, C., Bieker, G., Mock, P., Li, Y. 2020. Real-world usage of plug-in hybrid electric vehicles: fuel consumption, electric driving, and $CO_2$ emissions. ICCT, September 2020. Retrieved from *https://theicct.org/publication/real-world-usage-of-plug-in-hybrid-electric-vehicles-fuel-consumption-electric-driving-and-co2-emissions/.*

[474] Plötz, P., Link, S., Ringelschwendner, H., Keller, M., Moll, C., Bieker, G., Dornoff, J., Mock, P. 2022. Real-world usage of plug-in hybrid electric vehicles in Europe: A 2022 update on fuel consumption, electric driving, and $CO_2$ emissions. ICCT, June 2022. Retrieved from *https://theicct.org/publication/real-world-phev-use-jun22/.*

[475] Patrick Plötz *et al* 2021 *Environ. Res. Lett.* 16 054078. From lab-to-road: real-world fuel consumption and $CO_2$ emissions of plug-in hybrid electric vehicles. *https://iopscience.iop.org/article/10.1088/1748-9326/abef8c.*

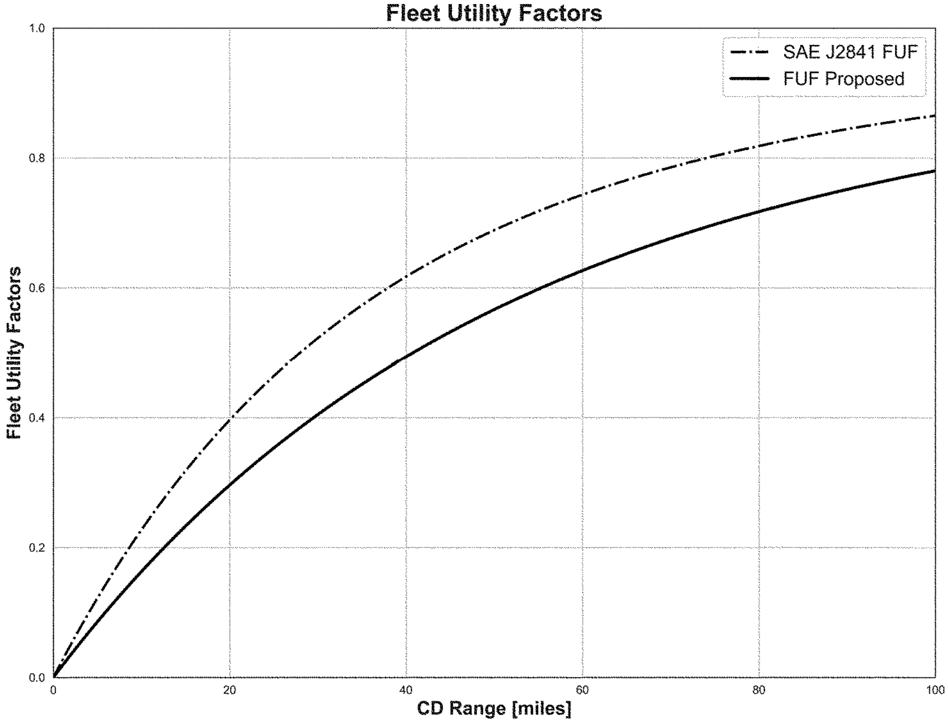

**Figure 12. Current and proposed fleet utility factor for PHEV compliance.**

The current FUFs were developed in SAE 2841[476] and are used to estimate the percentage of operation that is expected to be in charge depleting mode (vehicle operation that occurs while the battery charge is being depleted, sometimes referred to as electric range). The measurement of the charge depleting (CD) range is performed over the EPA city and highway test cycles, also called the 2-cycle tests. The tested cycle-specific charge depleting range is used as an input to the FUF curves (or lookup tables, as shown in Tables 1 and 2 in 40 CFR 600.116–12) to determine the specific city and highway FUFs. The resulting FUFs are used to calculate a composite $CO_2$ value for the city and highway $CO_2$ results, by weighting the charge depleting $CO_2$ by the FUF and weighting the charge sustaining (CS) $CO_2$ by one minus the FUF.

The FUFs developed in SAE J2841 rely on a few important assumptions and underlying data: (1) Trip data from the 2001 National Household Travel Survey,[477] used to establish daily driving distance assumptions, and (2) the assumption that the vehicle is fully charged before each day's operation. These assumptions are important because they affect the shape of the utility factor curves, and therefore affect the weighting of CD (primarily electric operation)[478] $CO_2$ and CS (primarily internal combustion engine operation)[479] $CO_2$ in the compliance value calculation. SAE J2841 was developed more than ten years ago during the early introduction of light-duty PHEVs and at the time was a reasonable approach for weighting the CD and CS vehicle performance for a vehicle manufacturer's compliance calculation given the available information. The PHEV market has since grown and there is significantly more real-world data available to EPA on which to design an appropriate compliance program for PHEVs. The agency believes that the use of an FUF is still an appropriate and reasonable means of calculating the contribution of PHEVs to GHG emissions and compliance, but the real-world data available today clearly no longer supports the FUF established in SAE J2841 more than a decade ago.

Because the tailpipe $CO_2$ produced from PHEVs varies significantly between CD and CS operation, both the charge depleting range and the utility factor curves play an important role in determining the magnitude of $CO_2$ that is calculated for compliance. In charge depleting mode, EPA is proposing to maintain a zero gram per mile contribution when the internal combustion engine is not running. The significant difference is between, potentially, zero grams per mile in CD mode versus $CO_2$ grams per mile that are likely to be similar to a hybrid (non-plug-in) vehicle in CS mode. Charge depleting range for a PHEV is determined by performing single cycle city and highway charge depleting tests according to SAE Standard J1711,[480] Recommended Practice for Measuring the Exhaust Emissions and Fuel Economy of Hybrid-Electric Vehicles,

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[476] SAE J2841. "Utility Factor Definitions for Plug-In Hybrid Electric Vehicles Using Travel Survey Data," Issued March 2009, Revised September 2010.

[477] We used the latest NHTS data (2017) and executed the utility factor code that is in SAE J2841, Appendix C, and found that the latest NHTS data did not significantly change the utility factor curves. NHTS data can be found at U.S. Department of Transportation, Federal Highway Administration, 2017 National Household Travel Survey. URL: *https://nhts.ornl.gov/.*

[478] The complexity of PHEV designs is such that not all PHEVs operate solely on the electric portion of the propulsion system even when the battery has energy available. Engine operation during these scenarios may be required because of such design aspects as blended operation when both the electric power and the engine are being utilized, or during conditions such as when heat or air conditioning is needed for the cabin and can only be obtained with engine operation.

[479] Because most CD operation occurs without engine operation, the $CO_2$ value for CD operation is often 0 or near 0 g/mi. This means that a high utility factor results in a $CO_2$ compliance value that is heavily-weighted with 0 or near 0 g/mi.

[480] SAE J1711. 2023. "Recommended Practice for Measuring the Exhaust Emissions and Fuel Economy of Hybrid-Electric Vehicles, Including Plug-in Hybrid Vehicles." Issued 1999–03, Revised 2010–06, Revised 2023–02, February.

Including Plug-In Hybrid Vehicles. The charge depleting range is determined by arithmetically averaging the city and highway range values weighted 55 percent/45 percent, respectively as noted in 40 CFR 600.311–12(j)(4)(i).

### i. FUF Comparisons With Real World Data

Recent literature and data have identified that the current utility factor curves may overestimate the fraction of driving that occurs in charge depleting operation.[481] [482] This literature also concludes that vehicles with lower charge depleting ranges have even greater discrepancy in $CO_2$ emissions.

EPA and ICCT [483] have also evaluated recently available OBD data [484] that has been collected through the California Bureau of Automotive Repair (BAR) and found that the data shows that, on average, there is more charge sustaining operation and more gasoline operation than is predicted by the current fleet utility factor curves. The BAR OBD data enable the evaluation of real-world PHEV distances travelled in various operational modes; these include charge-depleting engine-off distance, charge-sustaining engine-on distance, total distance traveled, odometer readings, total fuel consumed, and total grid energy inputs and outputs of the battery pack. These fields of data allow us to use the BAR OBD data to filter the data and calculate 5-cycle comparable real-world driving ratios of charge depleting distance to total distance and to then compare to the existing FUFs, using the 5-cycle range from the fuel economy and environment label.[485]

In addition to the BAR OBD data, ICCT also evaluated a dataset from *Fuelly.com. Fuelly.com* is a website and smartphone application that allows users to self-report fuel consumption data. The curve that is fitted from the *Fuelly.com* data also yields lower utility factors than the SAE J2841 FUF curve, for the same charge depleting distance; however, the Fuelly curve is not as low as the BAR OBD curve.

A comparison of the results of EPA's data analysis as well as the ICCT analyses is shown in Figure 13. The FUF applied in the current regulations is labeled as ''SAE J2841 FUF''. EPA's data analysis of the BAR OBD data is labeled as ''Linear Regression Fit'' and the two ICCT curves are labeled as ''ICCT–BAR'' and ''ICCT–FUELLY''. ICCT created the ICCT–BAR and ICCT–Fuelly curves by adjusting the normalized distances in the UF equation for both the BAR OBD data and the Fuelly user-reported data, using sample-size weighted nonlinear least squares regression.[486] As shown in Figure 13, the EPA ''Linear Regression Fit'', where about 78 percent of the total data points are between 12- to 32-miles for the CD range, lies on top of the ''ICCT–BAR'' curve.

The BAR OBD data is a recent and relatively large dataset that includes the charge depleting distance (or electric operating distance) and total distance, which makes it a reasonable source for evaluating the real-world utility factors for recent PHEV usage. However, we recognize that the curve developed from this data is a departure from the SAE J2841 FUF curves, that the BAR OBD data has some limitations (see DRIA Chapter 3), and that the original SAE J2841 FUF methodology was also a reasonable approach at the time it was adopted. Therefore, we created the proposed curve by averaging the SAE J2841 FUF curve and the ICCT–BAR curve. The resulting proposed FUF curve lies almost on top of the ICCT–FUELLY curve. Some of the data suggest that a lower curve might more appropriately reflect current real-world usage, however, EPA recognizes that PHEV technology has the potential to provide significant GHG reductions and an overly low FUF curve could disincentivize manufacturers to apply this technology. In addition, anticipated longer all-electric range and greater all-electric performance, partially driven by CARB's ACC II program, as well as increased consumer technology familiarity and available infrastructure should result in performance more closely matching our proposed curve. EPA will continue to monitor real-world data as it becomes available.

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[481] Plötz, P. and Jöhrens, J. (2021): Realistic Test Cycle Utility Factors for Plug-in Hybrid Electric Vehicles in Europe. Karlsruhe: Fraunhofer Institute for Systems and Innovation Research ISI. Retrieved from. *https://www.isi.fraunhofer.de/content/dam/isi/dokumente/cce/2021/BMU_Kurzpapier_UF_final.pdf.*

[482] *https://www.transportenvironment.org/wp-content/uploads/2022/06/TE-Anlaysis_-Update-of-PHEV-utility-factors-1.pdf.*

[483] ''Real world usage of plug-in hybrid vehicles in the United States.'' Aaron Isenstadt, Zifei Yang, Stephanie Searle, John German, ICCT Report, December 2022.

[484] California Air Resource Board [OBD data records dated October 2022], *https://www.bar.ca.gov/records-requests.*

[485] Because the data collected is real-world data, we used the combined city and highway 5-cycle label range as an input to the FUF curve described in SAE J2841, to create an apples-to-apples comparison. The existing regulatory FUFs are separate city and highway curves, and the charge depleting ranges that are used with the city and highway FUF curves are 2-cycle range.

[486] Supra footnote 483.

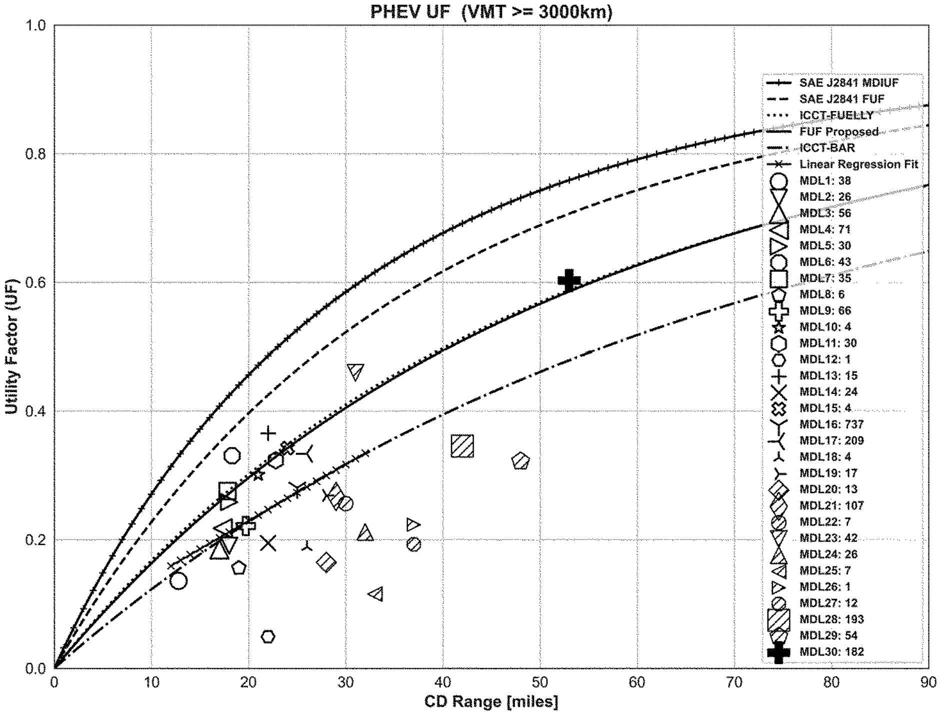

**Figure 13. FUF proposed, SAE J2841 FUF and ICCT-BAR/FUELLY curves.**

We believe that it is important for PHEV compliance utility factors to accurately reflect the apportionment of charge depleting operation, for weighting the 2-cycle $CO_2$ test results; therefore, we are proposing to update the city and highway fleet utility factor curves with a new, single curve that is shown in Figure 12. We are proposing a single curve to better reflect real world performance where the underlying real-world data is not parsed into city and highway data. Since the fleet average calculations are based on a combined city and highway $CO_2$ value, a single FUF curve can be used for these calculations. EPA is requesting comment on whether the ICCT–BAR curve shown in Figure 13 is a more appropriate fleet utility factor curve instead of the FUF proposed curve, as shown in the same figure.

EPA has chosen the proposed FUF curve based on the best data available. Commentors may have other data sets from PHEV vehicles; EPA would welcome additional data on real-world PHEV operation, which we would consider and may use to update the utility factor in a future rulemaking. The type of data that would be most useful would have measured mileage in charge depleting range and measured total mileage for a large number of PHEV vehicles that are nationally representative and cover a broad range of PHEV models.

### ii. Impact on Compliance

The proposed revisions to the PHEV FUF curve will increase $CO_2$ compliance values for PHEVs because the charge depleting test values will be weighted less heavily than they are currently in compliance calculations. Based on EPA's review of real-world utility factor data it appears the assumptions in SAE J2841 tend to overestimate the charge depleting operation of PHEVs. As such, the Agency is proposing to use the FUF determined from real world data. This change will result in a reduction to the FUF used to determine PHEV $CO_2$ compliance values. PHEVs that are designed with a large charge depleting range would still have a significantly lower compliance value than their hybrid counterparts would have.

### iii. Consideration of CARB ACC II PHEV Provisions

CARB recently set minimum performance requirements for PHEVs in their ACC II program. These requirements include performance over the US06 test cycle and a minimum range and are meant to set qualifications for PHEV's to be included in a manufacturer's ZEV compliance. EPA is not proposing to adopt the range and US06 performance requirements or fleet penetration limits that are included in the CARB ACC II ZEV provisions. EPA agrees that the performance provisions required by CARB in ACC II are important real-world performance attributes and have the ability to provide greater environmental benefits as compared to PHEVs that are less capable. However, unlike the ACC II program, the GHG program in this proposal is performance-based and not a ZEV mandate. In that regard, EPA believes that it is appropriate to have a robust GHG compliance program for PHEVs that properly accounts for their GHG emissions independent of a PHEV's range or capability over the US06 test cycle.

## 9. Small Volume Manufacturer GHG Standards

### i. Background

EPA's light-duty vehicle greenhouse gas (GHG) program for model years (MYs) 2012–2016 provided a conditional exemption for small volume manufacturers (SVMs) with annual U.S. sales of less than 5,000 vehicles due to unique feasibility issues faced by these SVMs.[487] The exemption was conditioned on the manufacturer making a good faith effort to obtain credits from larger volume manufacturers. For the MY 2017–2025 light-duty vehicle GHG program (*i.e.,* the 2012 rule), EPA adopted specific

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[487] 75 FR 25419–25421, May 7, 2010. Note that SVMs are generally not small businesses that qualify for EPA's small business provisions discussed in Section III.B.10.

regulations allowing SVMs to petition EPA for alternative standards, again recognizing that the primary program standards may not be feasible for SVMs and could drive these manufacturers from the U.S. market.[488]

EPA acknowledged in the 2012 final rule that SVMs may face a greater challenge in meeting $CO_2$ standards compared to large manufacturers because they only produce a few vehicle models, mostly focused on high performance sports cars and luxury vehicles. SVMs have limited product lines across which to average emissions, and the few vehicles they produce often have very high vehicle $CO_2$ g/mile levels. EPA also noted that the total U.S. annual vehicle sales of SVMs are much less than 1 percent of total sales of all manufacturers and contribute minimally to total vehicular GHG emissions, and foregone GHG reductions from SVMs likewise are a small percentage of total industry-wide reductions. EPA adopted a regulatory pathway for SVMs to apply for alternative GHG emissions standards for MYs 2017 and later, based on information provided by each SVM on factors such as technical feasibility, cost, and lead time.[489]

The regulations established in the 2012 rule outline eligibility criteria and a framework for establishing SVM alternative standards. Manufacturer average annual U.S. sales must remain below 5,000 vehicles to be eligible for SVM alternative standards.[490] The regulations specify the requirements for supporting technical data and information that a manufacturer must submit to EPA as part of its application.[491] SVMs may apply for alternative standards for up to five model years at a time. SVMs may use the averaging, banking, and trading provisions to meet the alternative standards, but may not trade credits to another manufacturer.[492]

EPA received applications for SVM alternative standards for MYs 2017–2021 from four manufacturers: Aston Martin, Ferrari, Lotus and McLaren.[493] The regulations require SVMs to submit information, including cost information, to EPA as part of their applications. Each SVM provided its technical basis for the requested standards including a discussion of technologies that could and could not be feasibly applied to their vehicles in the time frame of the standards. In 2019, EPA issued proposed determinations of SVM alternative standards, including background information and EPA's assessment of the proposed standards, and requested public comment.[494] In 2020, EPA finalized the SVM alternative standard determinations as proposed, shown in Table 37.[495]

TABLE 37—SUMMARY OF CURRENT SVM ALTERNATIVE STANDARDS

[g/mile]

| | Aston Martin | Ferrari | Lotus | McLaren |
|---|---|---|---|---|
| MY 2017 | 431 | 421 | 361 | 372 |
| MY 2018 | 396 | 408 | 361 | 372 |
| MY 2019 | 380 | 395 | 344 | 368 |
| MY 2020 | 374 | 386 | 341 | 360 |
| MY 2021 | 376 | 373 | 308 | 329 |

ii. Proposed SVM Standards for MY 2022 and Later

EPA established the SVM alternative standards option in the 2012 rule when ICE technologies were the primary $CO_2$ control technologies and vehicle electrification technologies were in their relative infancy. The landscape has fundamentally changed with electrification technologies maturing to become significant control technologies in this proposal. Vehicle electrification technologies are currently being implemented across many vehicle types including both luxury and high-performance vehicles by larger manufacturers and EPA expects this trend to continue. EPA believes that meeting the $CO_2$ standards is becoming less a feasibility issue and more a lead time issue for SVMs. Also, the credit trading market has become more robust since we initially established the SVM unique standards provisions. Now that it has, we would expect SVMs to be able to seek credit purchases as a compliance strategy.[496] As electrification technologies become more widespread and commonly used, EPA believes there is no reason SVMs cannot adopt similar technological approaches with enough lead time (or purchase credits from other OEMs).

Given this changed landscape for SVMs, EPA believes it is appropriate to transition away from unique SVM standards and bring SVMs into the primary program. As a reasonable way to transition SVMs into the primary program, EPA is proposing to phase in primary standards gradually over MYs 2025–2032 resulting in SVMs being "caught up" to the proposed primary program standards by MY 2032.[497] Specifically, EPA proposes that SVM alternative standards established for MY 2021 would apply through MY 2024 to provide stability for SVMs so that SVMs have an opportunity to reduce their GHG emissions in future years. EPA proposes that starting in MY 2025, SVMs would meet primary program standards albeit with additional lead-time. As shown in Table 38, EPA proposes that SVMs would meet the primary program standards for MY 2023 in MY 2025, providing two years of additional lead time. EPA is also proposing a period of stability rather than year-over-year incremental reductions in the standards levels for SVMs. SVMs have fewer vehicle models over which to average, and EPA believes a staggered phase down in standards with a period of stability between the steps is reasonable. As shown in Table 38, EPA proposes that the two-year offset would then continue with a period of stability between step changes

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[488] 77 FR 62789–62795, October 15, 2012.

[489] 40 CFR 86.1818–12(g).

[490] 40 CFR 86.1818–12(g)(1).

[491] 40 CFR 86.1818–12(g)(4).

[492] 40 CFR 86.1818–12(g)(6).

[493] Ferrari was previously owned by Fiat Chrysler Automobiles (FCA) and petitioned EPA for operationally independent status under 40 CFR 86.1838–01(d). In a separate decision EPA granted this status to Ferrari starting with the 2012 model year, allowing Ferrari to be treated as an SVM under EPA's GHG program. Ferrari has since become an independent company and is no longer owned by FCA.

[494] 84 FR 37277.

[495] 85 FR 39561 (July 1, 2020). See also docket EPA–HQ–OAR–2019–0210 for additional information on the SVM alternative standards setting proceedings.

[496] "The 2022 EPA Automotive Trends Report, Greenhouse Gas Emissions, Fuel Economy, and Technology since 1975," EPA–420–R–22–029, December 2022.

[497] See 40 CFR 86.1818–12(c) for the primary program standards through MY 2026.

in the standards until SVMs are required to meet the proposed MY 2032 standards in MY 2032. EPA is not reopening the eligibility requirements for the proposed SVM standards currently in the regulations for SVM alternative standards and SVMs would need to remain eligible to use these proposed provisions.[498]

TABLE 38—PROPOSED ADDITIONAL LEAD TIME FOR SVM STANDARDS UNDER THE PRIMARY PROGRAM

| Model year | Primary program standards that apply | Years of additional lead time |
|---|---|---|
| 2025 | 2023 | 2 |
| 2026 | 2023 | 3 |
| 2027 | 2025 | 2 |
| 2028 | 2025 | 3 |
| 2029 | 2027 | 2 |
| 2030 | 2028 | 2 |
| 2031 | 2030 | 1 |
| 2032 and later | 2032 | 0 |

This additional lead time approach is similar to the approach EPA used in the 2012 rule to provide additional lead time to intermediate volume manufacturers.[499] As with the intermediate volume manufacturer temporary lead time flexibility, EPA believes that the proposed additional lead time for SVMs will be sufficient to ease the transition to more stringent standards in the early years of the proposed program that could otherwise present a difficult hurdle for them to overcome. The proposed alternative phase-in would provide necessary lead time for SVMs to better plan and implement the incorporation of $CO_2$ reducing technologies and/or provide time needed to seek and secure credits from other manufacturers to bring them into compliance with the primary standards.

Importantly, SVMs would continue to remain eligible to use the ABT 5-year credit carry-forward provisions, allowing SVMs to bank credits in these intermediate years to further help smooth the transition from one step change in the standards to the next. EPA is, however, proposing to prohibit any SVM opting to use the additional lead time allowance from trading credits generated under the additional lead time standards to another manufacturer. These proposed credit provisions are also currently in place as part of the current SVM alternative standards. EPA believes that credit banking along with the staggered phase down of the standards would help SVMs meet the standards, recognizing that they have limited product lines. As with the SVM alternative standards, SVMs would have the option of following the additional lead time pathway with credit trading restrictions or opt into the primary program with no such restrictions. Once opted into the primary program, however, manufacturers would no longer be eligible for the alternative standards.

EPA requests comment on the proposal to apply the primary program standards, including the proposed standards, to SVMs with the specified additional lead time through MY 2032 EPA requests comment on whether the phase-in appropriately provides additional lead time for SVMs, including whether SVMs should be brought into the primary program sooner than proposed.

### *C. Proposed Criteria and Toxic Pollutant Emissions Standards for Model Years 2027–2032*

EPA is proposing changes to criteria pollutant emissions standards for both light-duty vehicles and medium duty vehicles (MDV). Light-duty vehicles include LDV, LDT, and MDPV. $NMOG+NO_X$ changes for light-duty vehicles include a fleet average that declines from 2027–2032 in the early compliance program (or steps down in 2030 for GVWR >6,000 pounds in the default program), the elimination of higher certification bins, a requirement for the same fleet average emissions standard to be met across four test cycles (25 °C FTP, HFET, US06, SC03), a change from fleet average NMHC standards to one fleet average $NMOG+NO_X$ standard in the −7 °C FTP test, and three $NMOG+NO_X$ provisions similar to requirements defined by the CARB Advanced Clean Cars II program. $NMOG+NO_X$ changes for MDV include a fleet average that declines from 2027–2032 in the early compliance program (or steps down in 2030 in the default program), the elimination of higher certification bins, a requirement for the same fleet average emissions standard to be met across four test cycles (25 °C FTP, HFET, US06, SC03), and a new fleet average $NMOG+NO_X$ standard in the −7 °C FTP. EPA is proposing a requirement for spark ignition and compression ignition MDV with GCWR above 22,000 pounds to comply with engine-dynamometer-based criteria pollutant emissions standards under the heavy-duty engine program[500] instead of the chassis-dynamometer-based criteria pollutant emissions standards.

EPA is proposing to continue light-duty vehicle and MDV fleet average FTP $NMOG+NO_X$ standards that include both ICE-based and zero emission vehicles in a manufacturer's compliance calculation. Performance-based standards that include both ICE and zero emission vehicles are consistent with the existing $NMOG+NO_X$ program as well as the GHG program. EPA has considered the availability of battery electric vehicles as a compliance strategy in determining the appropriate fleet average standards. Given the cost-effectiveness of BEVs for compliance with both criteria pollutant and GHG standards, EPA anticipates that most (if not all) automakers will include BEVs in their compliance strategies. However, the standards continue to be a performance-based fleet average standard with multiple paths to compliance, depending on choices manufacturers make about deployment of a variety of emissions control technologies for ICE as well as electrification and credit trading.

EPA is proposing a PM standard of 0.5 mg/mi for light-duty vehicles and MDV

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[498] See 40 CFR 86.1818–12(g).

[499] 77 FR 62623 (October 15, 2023) at 62795.

[500] *https://www.epa.gov/regulations-emissions-vehicles-and-engines/final-rule-and-related-materials-control-air-pollution.*

that must be met across three test cycles (−7 °C FTP, 25 °C FTP, US06), a requirement for PM certification tests at the test group level, and a requirement that every in-use vehicle program (IUVP) test vehicle is tested for PM. The 0.5 mg/mi standard is a per-vehicle cap, not a fleet average.

EPA is proposing CO and formaldehyde (HCHO) emissions requirement changes for light-duty vehicles and MDVs including transitioning to emissions caps (as opposed to bin-specific standards) for all emissions standards, a requirement that CO emissions caps be met across four test cycles (25 °C FTP, HFET, US06, SC03), and a CO emissions cap for the −7 °C FTP that is the same for all light-duty vehicles and MDVs.

EPA is proposing a refueling standards change to require incomplete MDVs to have the same on-board refueling vapor recovery standards as complete MDVs. EPA is also proposing eliminating commanded enrichment as an AECD for power and component protection.

The proposal allows light-duty vehicle 25 °C FTP NMOG+$NO_X$ credits and −7 °C FTP NMHC credits (converting to NMOG+$NO_X$ credits) to be carried into the new program. It only allows MDV 25 °C FTP NMOG+$NO_X$ credits to be carried into the new program if a manufacturer selects the early compliance pathway. New credits may be generated, banked and traded within the new program to provide manufacturers with flexibilities in developing compliance strategies.

### 1. Phase-in of Criteria Pollutant Standards

The proposed phase-in for criteria pollutant standards, including NMOG+$NO_X$, PM, CO, HCHO, CARB ACC II NMOG+$NO_X$ provisions, and elimination of enrichment, is described in this section. Proposed refueling standards for incomplete vehicles begin with model year 2030 and are not part of the early phase-in scenario for the other pollutant standards. Table 39 shows eight phase-in scenarios that manufacturers may choose from. Manufacturers may comply with phase-in scenarios based on model year (MY) sales or MY U.S. directed production volume.

Under the default compliance scenario shown in the bottom matrix in Table 39, 40 percent of vehicles with gross vehicle weight rating (GVWR) at or below 6,000 pounds must comply in MY 2027, 80 percent in MY 2028, and 100 percent in MY 2029 and after. For the heavier vehicle classes, 100 percent of vehicles must comply starting in MY 2030 in a single step under the default compliance pathway, which provides a full four years of lead time as required by CAA section 202(a)(3)(C). Under this default compliance scenario, chassis cert vehicles between 8501 and 14,000 pounds GVWR may not carry forward Tier 3 NMOG+$NO_X$ credits (as allowed by the early phase-in schedule), and engine cert vehicles between 8501 and 14,000 pounds GVWR may not use HD phase 2 work factor based GHG standards after 2027 (as allowed by the early phase-in schedule). Details are provided in Sections III.B.3, III.C.5, and III.C.9.

The top matrix in Table 39 describes the phase-in scenario where a manufacturer chooses an early phase-in schedule for all vehicle classes. In this scenario 40 percent of the vehicles of each class (each column) comply in MY 2027, 80 percent comply in MY 2028, and 100 percent comply starting in MY 2029 and after. If a manufacturer chooses this phase-in scenario, phase-in percentages for vehicles at or below 8500 pounds GVWR are calculated as one group. Chassis cert vehicles between 8501 and 14,000 pounds GVWR may carry forward Tier 3 NMOG+$NO_X$ credits, and engine cert vehicles between 8501 and 14,000 pounds GVWR may use the HD phase 2 work factor based GHG standards from MY 2026 without a capped GCWR input from MY 2027 to MY 2029. Then in MY 2030 chassis cert vehicles between 8501 and 14,000 pounds GVWR must switch to new work factor based GHG standards with the capped work factor equation.

The six phase-in scenarios between default and early show other options that manufacturers may select from. Any scenario that follows an early phase-in schedule for vehicles at or below 8500 pounds GVWR, results in phase-in percentages being calculated as one group. Any scenario that follows an early phase-in schedule for chassis cert vehicles between 8501 and 14,000 pounds GVWR may carry forward Tier 3 NMOG+$NO_X$ credits. And any scenario that follows an early phase-in schedule for engine cert vehicles between 8501 and 14,000 pounds GVWR may use the HD phase 2 work factor based GHG standards from MY 2026 without a capped GCWR input from MY 2027 to MY 2029.

Vehicles that are not part of the phase-in percentages are considered interim vehicles, which must continue to demonstrate compliance with all Tier 3 regulations with the exception that all vehicles (interim and those that are part of the phase-in percentages) contribute to the NMOG+$NO_X$ fleet average standards shown in Table 40 and Table 41.

EPA requests comment on increasing or decreasing the proposed phase-in percentages shown in Table 39.

TABLE 39—PROPOSED CRITERIA POLLUTANT PHASE-IN SCENARIOS AVAILABLE TO MANUFACTURERS

| Model year | ≤8,500 lb. GVWR (%) | 8,501–14,000 lb. GVWR Chassis cert (%) | 8,501–14,000 lb. GVWR Engine cert (%) |
|---|---|---|---|
| **Early phase-in schedule for all vehicle classes (Scenario A)** | | | |
| 2027 | 40 | 40 | 40 |
| 2028 | 80 | 80 | 80 |
| 2029 | 100 | 100 | 100 |
| 2030+ | 100 | 100 | 100 |
| **Intermediate scenario (Scenario B)** | | | |
| 2027 | 40 | 0 | 40 |
| 2028 | 80 | 0 | 80 |
| 2029 | 100 | 0 | 100 |
| 2030+ | 100 | 100 | 100 |

Table 39—Proposed Criteria Pollutant Phase-In Scenarios Available to Manufacturers—Continued

| Model year | ≤8,500 lb. GVWR (%) | 8,501–14,000 lb. GVWR Chassis cert (%) | 8,501–14,000 lb. GVWR Engine cert (%) |
|---|---|---|---|
| **Intermediate scenario (Scenario C)** | | | |
| 2027 | 40 | 40 | 0 |
| 2028 | 80 | 80 | 0 |
| 2029 | 100 | 100 | 0 |
| 2030+ | 100 | 100 | 100 |
| **Intermediate scenario (Scenario D)** | | | |
| 2027 | 40 | 0 | 0 |
| 2028 | 80 | 0 | 0 |
| 2029 | 100 | 0 | 0 |
| 2030+ | 100 | 100 | 100 |

| Model year | ≤6,000 lb. GVWR | 6,001–8500 lb. GVWR (%) | 8,501–14,000 lb. GVWR Chassis cert (%) | 8,501–14,000 lb. GVWR Engine cert (%) |
|---|---|---|---|---|
| **Intermediate scenario (Scenario E)** | | | | |
| 2027 | 40 | 0 | 40 | 40 |
| 2028 | 80 | 0 | 80 | 80 |
| 2029 | 100 | 0 | 100 | 100 |
| 2030+ | 100 | 100 | 100 | 100 |
| **Intermediate scenario (Scenario F)** | | | | |
| 2027 | 40 | 0 | 0 | 40 |
| 2028 | 80 | 0 | 0 | 80 |
| 2029 | 100 | 0 | 0 | 100 |
| 2030+ | 100 | 100 | 100 | 100 |
| **Intermediate scenario (Scenario G)** | | | | |
| 2027 | 40 | 0 | 40 | 0 |
| 2028 | 80 | 0 | 80 | 0 |
| 2029 | 100 | 0 | 100 | 0 |
| 2030+ | 100 | 100 | 100 | 100 |
| **Default compliance scenario (Scenario H)** | | | | |
| 2027 | 40 | 0 | 0 | 0 |
| 2028 | 80 | 0 | 0 | 0 |
| 2029 | 100 | 0 | 0 | 0 |
| 2030+ | 100 | 100 | 100 | 100 |

### 2. Proposed NMOG+NO$_X$ Standards

EPA is proposing new NMOG+NO$_X$ standards for MY 2027 and later. The standards are structured to take into account the increased electrification of new light-duty vehicles and MDVs that is projected to occur over the next decade.

The current Tier 3 fleet average NMOG+NO$_X$ emissions standards were fully phased-in for Class 2b and Class 3 (MDV within this proposal) in MY 2022 at 178 and 247 mg/mi, respectively. Tier 3 standards for light-duty vehicles, including LDT3 and LDT4 above 6,000 pounds GVWR and medium-duty passenger vehicles (MDPVs), will be fully phased into the Tier 3 30 mg/mi fleet average NMOG+NO$_X$ standard in MY 2025. Tier 3 standards include a Bin 0 which allows PEV's to be averaged with conventional ICE-based vehicles. In the absence of our proposed NMOG+NO$_X$ standards, as sales of PEVs continue to increase, there would be an opportunity for the ICE portion of light-duty vehicles and MDVs to reduce emission control system content (*i.e.,* system costs) and comply with less stringent NMOG+NO$_X$ standard bins under Tier 3. If this were to occur, it would have the effect of increasing NMOG+NO$_X$ emissions from the ICE portion of the light-duty vehicle and MDV fleet and delay the overall fleet emission reductions of NMOG+NO$_X$ that would have occurred from increased penetration of PEVs into the light-duty vehicle and MDV fleets.

The structure of the proposed NMOG+NO$_X$ standards has been designed to cap the NMOG+NO$_X$ contribution of ICE vehicles at approximately Tier 3 levels for light-duty vehicles and at approximately 100 mg/mi NMOG+NO$_X$ for MDV. The feasibility of ICE MDV meeting 100 mg/mi NMOG+NO$_X$ by 2027 is discussed in further detail within Chapter 3.2.1.3 of the DRIA. EPA projects the year-over-year reductions in MY 2027 and later light-duty vehicle and MDV NMOG+NO$_X$ standards from an average of 30 mg/mi and 100 mg/mi, respectively, thus would occur primarily from increased year-over-year electrification of new vehicle sales and the resulting averaging of zero emission vehicles with ICE vehicles within the fleet average light-duty vehicle and MDV NMOG+NO$_X$ standards.

The CAA requires 4 years of lead time and 3 years of standards stability for heavy-duty vehicles. There are three categories of vehicles that are currently regulated as light-duty vehicles but are defined within the CAA as heavy-duty vehicles for purposes of lead time and standards stability: The heavy-light-duty truck categories (LDT3 and LDT4) and MDPV.[501] Furthermore, MDVs are also defined as heavy-duty vehicles under the CAA. EPA is proposing several alternative pathways for these three categories of vehicles for compliance with the proposed NMOG+NO$_X$ standards. The Agency's early compliance NMOG+NO$_X$ program would apply to all LDV, LDT, MDPV, and MDV vehicles beginning in 2027 in order to coincide with the timing of increased electrification of these vehicles. However, mandatory regulations beginning in 2027 would not provide 4 years of lead time as required for vehicles defined as heavy-duty under the CAA. To address this issue, we are proposing two schedules for compliance with NMOG+NO$_X$ standards for LDT3, LDT4, MDPV, and MDV. The eight alternatives describe the breadth of compliance scenarios. The two schedules referenced here include one for early compliance and one for later compliance for each reg class.

The early compliance pathway shown in Table 40 has LDT3, LDT4 and MDPV meeting identical and gradually declining fleet average NMOG+NO$_X$ emissions standards to those for LDV, LDT1 and LDT2 as described in Section III.C.2.iii; and includes separate gradually declining fleet average NMOG+NO$_X$ emissions standards for MDV at or below 22,000 pounds GCWR as described in Section III.C.2.iv. This pathway for earlier compliance with NMOG+NO$_X$ emissions standards for LDT3, LDT4, MDPV, and MDV includes additional flexibilities. We request comment on the addition of a temporary ''bin 200'' (200 mg/mi NMOG+ NO$_X$) that would apply solely to MY 2027 and MY 2028 Class 3 MDV for manufacturers opting into early compliance for MDV.

The second, and default, schedule to NMOG+NO$_X$ compliance shown in Table 41 has LDV, LDT1, and LDT2 meeting a gradually declining fleet average NMOG+NO$_X$ standards from 2027 through 2032. Vehicles in the LDT3, LDT4, and MDPV categories would continue to meet Tier 3 standards through the end of MY 2029 and then would proceed to meeting a 12 mg/mi NMOG+NO$_X$ standard in a single step in MY 2030 in order to comply with CAA provisions for 4 years of lead time and 3 years of standards stability. Similarly, MDVs would continue to meet Tier 3 standards through the end of MY 2029 and then MDVs at or below 22,000 pounds GCWR would proceed to meeting a 60 mg/mi NMOG+NO$_X$ standard in a single step in 2030 in order to comply with CAA provisions for 4 years of lead time and 3 years of standards stability.

We are also proposing a similar choice between early compliance and default compliance pathways for MDVs with high GCWR, which are defined as being above 22,000 pounds. Under the early compliance pathway, high GCWR MDVs would comply with MY 2027 and later heavy-duty engine criteria pollutant emissions standards beginning with MY 2027 (Section III.C.5). Manufacturers with high GCWR MDVs choosing the early compliance pathway would have additional flexibilities with respect to GHG compliance. They could delay entry into the MDV GHG work factor-based fleet average standards until the beginning of MY 2030 (see Section III.B.3).

Under the default compliance path, high GCWR MDVs would continue to comply with Tier 3 standards until the end of MY 2029 and then would comply with MY 2027 and later heavy-duty engine criteria pollutant emissions standards beginning with MY 2030 in order to comply with CAA provisions for 4 years of lead time. Under this default compliance path, high GCWR MDVs would comply with fleet average MDV GHG emissions beginning with MY 2027 (see Section III.B.3).

TABLE 40—LDV, LDT, MDPV, AND MDV FLEET AVERAGE NMOG+NO$_X$ STANDARDS UNDER THE EARLY COMPLIANCE PATHWAY

| Model year | LDV, LDT1, LDT2, LDT3$^{\dagger}$, LDT4$^{\dagger}$ & MDPV$^{\dagger}$ NMOG+NO$_X$ (mg/mi) | MDV$^{\dagger}$ NMOG+NO$_X$ (mg/mi) | |
|---|---|---|---|
| | | Class 2b | Class 3 |
| 2026 | *30 | *178 | *247 |
| 2027 | 22 | 160 | |
| 2028 | 20 | 140 | |
| 2029 | 18 | 120 | |
| 2030 | 16 | 100 | |
| 2031 | 14 | 80 | |
| 2032 and later | 12 | 60 | |

* Tier 3 standards provided for reference.

† NMOG+NO$_X$ credit generated under Tier 3 can be carried forward for 5 years after it is generated. MDV standards only apply for vehicles at or below 22,000 lb. GCWR.

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[501] Light-duty truck 3 (LDT3) is defined as any truck with more than 6,000 pounds GVWR and with an ALVW of 5,750 pounds or less. Light-duty truck 4 (LDT4) is defined as any truck is defined as any truck with more than 6,000 pounds GVWR and with an ALVW of more than 5,750 pounds. See 40 CFR 86.1803–01—Definitions. For current and proposed MDPV definitions, see Section III.D.

TABLE 41—LDV, LDT, MDPV AND MDV FLEET AVERAGE NMOG+$NO_X$ STANDARDS UNDER THE DEFAULT COMPLIANCE PATHWAY

| Model year | LDV, LDT1 & LDT2 NMOG+$NO_X$ (mg/mi) | LDT3, LDT4 & MDPV NMOG+$NO_X$ (mg/mi) | MDV† NMOG+$NO_X$ (mg/mi) | |
|---|---|---|---|---|
| | | | Class 2b | Class 3 |
| 2026 | *30 | *30 | *178 | *247 |
| 2027 | 22 | *30 | *178 | *247 |
| 2028 | 20 | *30 | *178 | *247 |
| 2029 | 18 | *30 | *178 | *247 |
| 2030 | 16 | 12 | 60 | |
| 2031 | 14 | 12 | 60 | |
| 2032 and later | 12 | 12 | 60 | |

*Tier 3 standards provided for reference.

†MDV standards only apply for vehicles at or below 22,000 lb GCWR.

i. NMOG+$NO_X$ Bin Structure for Light-Duty Vehicles and MDVs

The bin structure being proposed for light-duty vehicles and MDVs is shown in Table 42. The upper two bins (Bin 160 and Bin 125) are only available to MDV at or below 22,000 pounds GCWR.[502]

For light-duty vehicles, the proposed bin structure removes the two highest Tier 3 bins (Bin 160 and Bin 125) and adds several new bins (Bin 60, Bin 40, Bin 10). For MDV, the proposed bin structure moves away from separate bins for Class 2b and Class 3 vehicles, adopting light-duty vehicle bins with higher bins only available to MDV.

TABLE 42—LIGHT-DUTY VEHICLE AND MDV NMOG+$NO_X$ BIN STRUCTURE

| LDV bin | NMOG+$NO_X$ (mg/mi) |
|---|---|
| Bin 160* | 160 |
| Bin 125* | 125 |
| Bin 70 | 70 |
| Bin 60 | 60 |
| Bin 50 | 50 |
| Bin 40 | 40 |
| Bin 30 | 30 |
| Bin 20 | 20 |
| Bin 10 | 10 |
| Bin 0 | 0 |

*MDV only.

ii. Smog Scores for the Fuel Economy and Environment Label

This proposed rule includes new Tier 4 bins that do not directly align with the existing smog scores used on the Fuel Economy and Environment Label (see 40 CFR 600.311–12(g)). We are therefore seeking comment on fitting the new Tier 4 bins into the existing MY 2025 Tier 3 smog score structure for the Tier 4 phase-in period (MY 2027–2029), and we are also seeking comment on a new Tier 4 smog score structure for MY 2030 and later. For both ratings structures, it is important to avoid having any bin assigned to a higher score in a newer model year than it was assigned in an older model year (no ''backsliding'' for smog score ratings).

For MY 2027–2029, EPA is seeking comment on how the new Tier 4 bins and California LEV IV categories should fit into the existing Tier 3 bin structure for smog scores. For example, EPA seeks comment on what smog score should apply to the new Tier 4, bin 10 and new California LEV IV category of SULEV 15. The current MY 2025 Tier 3 rating system in Table 1 of 40 CFR 600.311–12(g) has a smog score of 10 for bin 0 and a score of 7 for bin 20, suggesting that a smog score of 8 might be appropriate for SULEV 15 and a smog score of 9 might be appropriate for bin 10; however we may also consider assigning bin 10 and SULEV 15 to the same rating, either 8 or 9. In addition, EPA is seeking comment on the smog scores that should apply to Tier 4 bin 60/LEV IV ULEV 60, Tier 4 bin 40/LEV 40, and SULEV 25. We seek comment on assigning bin 60/ULEV 60 a score of 4, sharing a rating with bin 70 ULEV 70; assigning bin 40/ULEV 40 a rating of 5, sharing a rating with bin 50; and assigning SULEV 25 a rating of 6, sharing a rating with bin 30. These assignments would allow the MY 2025 Tier 3 ratings to remain in place, while placing the new Tier 4 bins and LEV IV categories in logical locations.

For MY 2030 and later, we seek comment on maintaining the smog rating bin assignments from MY 2027–2029 for bin 40/ULEV 40 and lower bins. Since there is no longer a need for Tier 3 bin 160 or bin 125 after MY 2029, we seek comment on assigning a smog score of 2 to bin 70/ULEV 70, a score of 3 to bin 60/ULEV 60, and a score of 4 to bin 50/ULEV 50. This approach allows bin 40 through bin 70 to each correspond to a single smog score.

We welcome comment on this approach and after consideration of comment may adopt final smog scores that are higher or lower.

iii. NMOG+$NO_X$ Standards and Test Cycles for Light-Duty Vehicles

EPA is proposing increasingly stringent light-duty vehicle NMOG+$NO_X$ standards (Table 43) for the sales weighted average inclusive of all LDV, LDT and MDPV (e.g. ICE vehicles, BEVs, PHEVs, fuel cell, vehicles, etc.). The proposed phase-in of the standards by vehicle category is described in Section III.C.1.

EPA recognizes that vehicles will differ with respect to their levels of NMOG+$NO_X$ emissions control depending on degree of electrification, choice of fuel, ICE technology, and other differences. The proposed fleet average standards are feasible in light of anticipated technology penetration rates commensurate with the GHG technology implementation during this same time period and increasing electrification of light-duty vehicles.

TABLE 43—NMOG+$NO_X$ FLEET AVERAGE STANDARDS OVER THE FTP† FOR LIGHT-DUTY VEHICLES*

| Model year | NMOG+$NO_X$ (mg/mi) |
|---|---|
| 2027 | 22 |
| 2028 | 20 |
| 2029 | 18 |
| 2030 | 16 |
| 2031 | 14 |
| 2032 and later | 12 |

†As defined in 40 CFR 1066.801(c)(1)(i) and 1066.815.

*For a complete description of fleet average NMOG+$NO_X$ standards for LDT3, LDT4, and MDPV under both the early compliance and default programs, see Section III.C.1.

The declining fleet average standards over the FTP cycle ensure that NMOG+$NO_X$ continues to decrease over time for the light-duty fleet. The

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[502] MDV at or above 22,000 pounds GCWR must comply with 2027 and later heavy-duty engine emissions standards.

elimination of the two highest bins (Table 42) caps the maximum NMOG+NO$_X$ emissions from an individual new vehicle model. EPA anticipates that electrified technology, including BEVs, will play a significant role within the compliance strategies for meeting the fleet average NMOG+NO$_X$ standards for each manufacturer. However, EPA anticipates that manufacturers may use multiple technology solutions to comply with fleet average NMOG+NO$_X$ standards. For example, a manufacturer may choose to offset any ICE increases with increased BEV sales, or could alternatively improve engine and exhaust aftertreatment designs to reduce emissions for ICE vehicles while planning for a more conservative percentage of BEV sales as part of their compliance with the declining fleet average NMOG+NO$_X$ standards reflected in Table 43.

Since technologies are available to further reduce NMOG+NO$_X$ emissions relative to the current fleet, and since more than 20 percent of MY 2021 Bin 30 vehicle certifications already show an FTP certification value under 15 mg/mi NMOG+NO$_X$, achieving reduced NMOG+NO$_X$ emissions through improved ICE technologies is feasible and reasonable. Regardless of the compliance strategy chosen, overall, the fleet will become significantly cleaner.

EPA is proposing that the same bin-specific numerical standards be applied across four test cycles: 25 °C FTP,[503] HFET,[504] US06[505] and SC03.[506] This means that a manufacturer certifying a vehicle to comply with Bin 30 NMOG+NO$_X$ standards would be required to meet the Bin 30 emissions standards for all four test cycles. Meeting the same NMOG+NO$_X$ standards across four cycles is an increase in stringency from Tier 3, which had one standard for the higher of FTP and HFET, and a less stringent composite based standard for the SFTP (weighted average of 0.35*FTP + 0.28*US06 + 0.37*SC03).

Present-day engine, transmission, and exhaust aftertreatment control technologies allow closed-loop air-to-fuel (A/F) ratio control and good exhaust catalyst performance throughout the US06 and SC03 cycles. As a result, higher emissions standards over these cycles are no longer necessary. Approximately 60 percent of the test group/vehicle model certifications from MY 2021 have higher NMOG+NO$_X$ emissions over the FTP cycle as compared to the US06 cycle, supporting the conclusion that a single standard is feasible and appropriate.

EPA is proposing to replace the existing −7 °C FTP NMHC fleet average standard of 300 mg/mi for passenger cars and LDT1, and 500 mg/mi fleet average standard for LDT2 through LDT4 and MDPV, with a single NMOG+NO$_X$ fleet average standard of 300 mg/mi for LDV, LDT1 through 4 and MDPVs to harmonize with the combined NMOG+NO$_X$ approach adopted in Tier 3 for all other cycles (*i.e.,* 25 °C FTP, HFET, US06, and SC03 cycles). EPA emissions testing at −7 °C FTP showed that a 300 mg/mi standard is feasible with a large compliance margin for NMOG+NO$_X$. See DRIA for additional certification data to support the proposed fleet average NMOG+NO$_X$ standard of 300 mg/mi. EPA did not include EVs in the assessment of the proposed fleet average standard and therefore EVs and other zero emission vehicles are not included and not averaged into the fleet average −7 °C FTP NMOG+NO$_X$ standards.

Since −7 °C FTP and 25 °C FTP are both cold soak tests that include TWC operation during light-off and at operating temperature, it is appropriate to apply the same Tier 3 useful life to both standards.

EPA requests comment on whether a 400 mg/mi cap should replace the proposed 300 mg/mi fleet average for the −7 °C FTP NMOG+NO$_X$ standard. Additional discussion on the feasibility of the proposed standards can be found in DRIA Chapter 3.2.

The proposed standards apply equally at high altitude, rather than including compliance relief provisions from Tier 3 for certification at high altitude. Modern engine management systems can use idle speed, engine spark timing, valve timing, and other controls to offset the effect of lower air density on exhaust catalyst performance at high altitudes.

#### iv. NMOG+NO$_X$ Standards and Test Cycles for MDV at or Below 22,000 lb GCWR

The proposed MDV (medium duty vehicles, 8,501 to 14,000 pounds GVWR) NMOG+NO$_X$ standards for vehicles at or below 22,000 pounds GCWR are shown in Table 44. Certification data show that for MY 2022–2023, 75 percent of sales-weighted Class 2b/3 gasoline vehicle certifications were below 120 mg/mi in FTP and US06 tests. Diesel-powered MDVs designed for high towing capability (*i.e.,* GCWR above 22,000 pounds) were higher (75 percent were below 180 mg/mi) but they are not being used to inform the proposed MDV standard because the Agency is proposing the requirement that MDVs (diesel and gasoline) with GCWR (gross combined weight rating) above 22,000 pounds comply with criteria pollutant emissions standards under the HD engine program, as described in Section I.A.1, MDVs at or below 22,000 pounds GCWR have comparable emissions performance to LDVs and LDTs. The year-over-year fleet average FTP standards for MDV at or below 22,000 pounds GCWR and the rationale for the manufacturer's choice of early compliance and default compliance pathways is described in Section III.C.1. For further discussion of MDV NMOG+NO$_X$ feasibility, please refer to Chapter 3.2 of the DRIA.

The proposed MDV NMOG+NO$_X$ standards are based on applying existing light-duty vehicle technologies, including electrification, to MDV. As with the light-duty vehicle categories, EPA anticipates that there will be multiple compliance pathways, such as increased electrification of vans together with achieving 100 mg/mile NMOG+NO$_X$ for ICE-power MDV. Present-day MDV engine and aftertreatment technology allows fast catalyst light-off after cold-start followed by closed-loop A/F control and excellent exhaust catalyst emission control on MDV, even at the adjusted loaded vehicle weight, ALVW [(curb + GVWR)/2] test weight, which is higher than loaded vehicle weight, LVW (curb + 300 pounds) used for testing light-duty vehicles. The proposed MDV standards begin to take effect in 2030, consistent with the CAA section 202(a)(3)(C) lead time requirement for these vehicles.

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[503] 40 CFR 1066.801(c)(1)(i) and 1066.815.

[504] 40 CFR 1066.840.

[505] 40 CFR 1066.831.

[506] 40 CFR 1066.835.

TABLE 44—MDV FLEET AVERAGE NMOG+NO$_X$ STANDARDS UNDER THE EARLY COMPLIANCE PATHWAY †

| Model year | NMOG+NO$_X$ (mg/mi) | |
|---|---|---|
| | Class 2b | Class 3 |
| 2026 | * 178 | * 247 |
| 2027 | 160 | |
| 2028 | 140 | |
| 2029 | 120 | |
| 2030 | 100 | |
| 2031 | 80 | |
| 2032 and later | 60 | |

† Please refer to Section III.C.1 for further discussion of the early compliance and default compliance pathways.
* Tier 3 standards provided for reference.

TABLE 45—MDV FLEET AVERAGE CHASSIS DYNAMOMETER FTP NMOG+NO$_X$ STANDARDS UNDER THE DEFAULT COMPLIANCE PATHWAY

| Model year | MDV † NMOG+NO$_X$ (mg/mi) | |
|---|---|---|
| | Class 2b | Class 3 |
| 2026 | * 178 | * 247 |
| 2027 | * 178 | * 247; |
| 2028 | * 178 | * 247 |
| 2029 | * 178 | * 247 |
| 2030 | 60 | |
| 2031 | 60 | |
| 2032 and later | 60 | |

* Tier 3 standards provided for reference.
† MDV chassis dynamometer NMOG+NO$_X$ standards only apply for vehicles at or below 22,000 lb GCWR.

If a manufacturer has a fleet mix with relatively high sales of MDV BEV, that would ease compliance with MDV NMOG+NO$_X$ fleet average standards for MDV ICE-powered vehicles. If the manufacturer has a fleet mix with relatively low BEV sales, then improvements in NMOG+NO$_X$ emissions control for ICE-powered vehicles would be required to meet the fleet average standards. Improvements to NMOG+NO$_X$ emissions from ICE-powered vehicles are feasible with available engine, aftertreatment, and sensor technology, and has been shown within an analysis of MY 2022–2023 MDV certification data (see DRIA Chapter 3.2). Fleet average NMOG+NO$_X$ will continue to decline to well below the final Tier 3 NMOG+NO$_X$ standards of 178 mg/mi and 247 mg/mi for Class 2b and 3 vehicles, respectively.

The proposed standards require the same MDV numerical standards be met across all four test cycles, the 25 °C FTP, HFET, US06 and SC03, consistent with the proposed approach for light-duty vehicles described in Section III.C.1.ii. This would mean that a manufacturer certifying a vehicle to bin 60 would be required to meet the bin 60 emissions standards for all four cycles.

Meeting the same NMOG+NO$_X$ standard across four cycles is an increase in stringency from Tier 3, which had one standard over the FTP and less stringent bin standards for the HD–SFTP (weighted average of 0.35×FTP + 0.28×HDSIM + 0.37×SC03, where HDSIM is the driving schedule specified in 40 CFR 86.1816–18(b)(1)(ii)). Current MDV control technologies allow closed-loop A/F control and high exhaust catalyst emissions conversion throughout the US06 and SC03 cycles, so compliance with higher numerical emissions standards over these cycles is no longer needed. Manufacturer submitted certification data and EPA testing show that Tier 3 MDV typically have similar NMOG+NO$_X$ emissions in US06 and 25 °C FTP cycles, and NMOG+NO$_X$ from the SC03 is typically much lower. Testing of a 2022 F250 7.3L at EPA showed average NMOG+NO$_X$ emissions of 56 mg/mi in the 25 °C FTP and 48 mg/mi in the US06. Manufacturer-submitted certifications show that MY 2021+2022 gasoline 2b/3 trucks achieved, on average, 69/87 mg/mi in the FTP, and 75/NA [507] mg/mi in the US06, and 18/25 mg/mi in the SC03.

Several Tier 3 provisions would end with the elimination of the HD–SFTP and the combining of bins for Class 2b and class 3 vehicles. First, Class 2b vehicles with power-to-weight ratios at or below 0.024 hp/pound could no longer replace the full US06 component of the SFTP with the second of three sampling bags from the US06. Second, class 3 vehicles would no longer use the LA–92 cycle in the HD–SFTP calculation but would rather have to meet the NMOG+NO$_X$ standard in each of four test cycles (25 °C FTP, HFET, US06 and SC03). Third, the SC03 could no longer be replaced with the FTP in the SFTP calculation.

The proposed standards do not include relief provisions for MDV certification at high altitude. Modern engine systems can use idle speed, engine spark timing, valve timing, and other controls to offset the effect of lower air density on catalyst light-off at high altitudes.

EPA is also proposing a new −7 °C FTP NMOG+NO$_X$ fleet average standard of 300 mg/mi for gasoline and diesel MDV. EPA testing has demonstrated the feasibility of a single fleet average −7 °C FTP NMOG+NO$_X$ standard of 300 mg/mi across light-duty vehicles and MDV. EPA did not include EV's in the assessment of the proposed fleet average standard and therefore EVs and other zero emission vehicles are not included and not averaged into the fleet average −7 °C FTP NMOG+NO$_X$ standards.

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[507] Tier 3 US06 certification data are not available for class 3 trucks because Tier 3 requires them to certify using the LA92 instead of the US06.

Since −7 °C FTP and 25 °C FTP are both cold soak tests that include TWC operation during light-off and at operating temperature, it is appropriate to apply the same Tier 3 useful life to both standards.

EPA requests comment on whether a 400 mg/mi cap should replace the proposed 300 mg/mi fleet average for the −7 °C FTP NMOG+$NO_X$ standard. Additional discussion on the feasibility of the proposed standards can be found in DRIA 3.2.

### 3. Revised PM Standard

#### i. PM Standard and Test Cycles for Light-Duty Vehicles and MDV

EPA is proposing several changes to the current Tier 3 p.m. requirements. These changes include a more stringent standard for the 25 °C FTP and US06 test cycles, and addition of a cold PM standard for the existing Cold Test (−7 °C FTP). The same numerical standard of 0.5 mg/mi and the same certification test cycles are being proposed for both light-duty vehicles (LDV, LDT, and MDPV) and MDV (Class 2b and 3 vehicles) at or below 22,000 pounds GCWR, as shown in Table 46 for light-duty vehicles and Table 47 for MDV. Comparisons to current Tier 3 p.m. standards are provided for reference. The same Tier 3 defined useful life standard applies to all three test cycles.

TABLE 46—PROPOSED LIGHT-DUTY VEHICLE PM STANDARDS

| Test cycle | Tier 3 standards (mg/mi) | Proposed PM standard (mg/mi) |
|---|---|---|
| 25 °C FTP | 3 | 0.5 |
| US06 | 6 | 0.5 |
| −7 °C FTP | Not applicable | 0.5 |

TABLE 47—PROPOSED MDV (CLASS 2B AND 3) AT OR BELOW 22,000 LB GCWR PM STANDARDS

| Test cycle | Tier 3 standards (mg/mi) | Proposed PM standard (mg/mi) |
|---|---|---|
| 25 °C FTP | 8/10 for 2b/3 vehicles | 0.5 |
| US06 | 10/7 for 2b/3 vehicle on SFTP | 0.5 |
| −7 °C FTP | Not applicable | 0.5 |

EPA believes that these standards are appropriate and feasible to reduce PM emissions over the broadest range of vehicle operating and environmental conditions. The current Tier 3 p.m. standards capture only a portion of vehicle operation. EPA has observed that PM emissions increase dramatically during cold cold-starts and during high engine power driving not captured by on-cycle tests. While several vehicles in the current fleet demonstrate emissions performance that could comply with the proposed standards at 25 °C, the −7 °C PM standard will most likely lead to the adoption of Gasoline Particulate Filters (GPF) as the most practical and cost-effective means to control PM emissions. GPF is a mature and cost-effective technology that operates under all vehicle operating conditions. Current GPF technology (*e.g.,* MY 2022 GPFs) has high filtration efficiency, even during and immediately after GPF regenerations, when the GPF cannot rely on soot loading to improve filtration. GPFs are being widely used in Europe and China and vehicle manufacturers are already building GPF-equipped vehicles in the United States for sale in other countries.

In support of the proposed PM standards, EPA has conducted robust and detailed GPF testing to characterize GPF performance. During this testing EPA not only measured the change in PM and polyaromatic hydrocarbon (PAH) emissions, with and without the GPF installed, but also assessed impacts on GHG emissions and vehicle performance. In summary, EPA noted that with a properly sized GPF, no measurable impact on GHG emissions and only slight impact on vehicle performance should occur, while PM emissions are typically reduced by over 95 percent and filter-collected PAH emissions are typically reduced by over 99 percent. A review of GPF technology, analyses of its benefits, challenges and costs, and demonstration of the feasibility of the proposed PM standard are discussed in Chapter 3.2 of the DRIA.

#### ii. Phase-In for Light-Duty Vehicles and MDV at or Below 22,000 lb GCWR

The proposed phase-in for the PM standard is the same as for other criteria emissions, as described in Section III.C.1. EPA requests comment on accelerating the phase-in for PM relative to other criteria emissions requirements of this rule (NMOG+$NO_X$, CO, HCHO, NMOG+$NO_X$ previsions aligned with the CARB ACC II program, certifying high GCWR MDV under the HD engine program for criteria pollutants, evaporative emissions, and elimination of enrichment) because GPFs are a mature technology that has been in mass production since 2017 in Europe, since 2020 in China, and since 2023 in India, and because several manufacturers assemble vehicles equipped with GPF in the U.S. for export to other markets. An accelerated phase-in could also be supported by increased availability of BEVs. EPA requests comment on accelerating PM phase-in to 50% or 80% in MY 2027 and 100% in MY 2028 for vehicles with GVWR≤14,000 pounds under the early compliance pathway, and for vehicles with GVWR≤6000 pounds under the default compliance pathway.

#### iii. Feasibility of the PM Standard and Selection of Test Cycles

The PM standards that EPA is proposing would require vehicle manufacturers to produce vehicles that emit PM at GPF-equipped levels (GPF-level PM). The proposed rule does not require that GPF hardware be used on vehicles, but rather reflects EPA's judgement that it is feasible and appropriate to achieve the proposed PM standards considering the availability of this technology. It is expected that GPF technology will be the most practical and cost-effective pathway for meeting the standard, especially in −7 °C FTP and US06 test cycles.

To establish what level of PM standards are appropriate for this proposal, EPA conducted a test program that considered multiple vehicle types and powertrain technologies as well as GPF technology. Much like many other aspects of aftertreatment technology and emissions controls, GPFs have gone through considerable development since their initial introduction and as a result have provided significantly improved effectiveness with each successive iteration. EPA evaluated available technology with respect to the emissions benefits observed over the regulated cycles, including two generations of GPF technology.

The PM test program included five chassis dynamometer test cells at EPA, Environment and Climate Change Canada (ECCC), and FEV North America Inc., and five test vehicles (2011 F150, 2019 F150, 2021 F150 HEV, 2021 Corolla, 2022 F250) tested in stock and GPF configurations. These test vehicles include a passenger car, three Class 2a trucks, and one Class 2b truck. The two generations of GPFs include series production MY 2019 and series production MY 2022 models, catalyzed and bare substrates, and close-coupled and underfloor GPF installations. Results from the test program are summarized in Figure 14. The study demonstrates that Tier 3 light-duty vehicles and MDV equipped with GPFs that are currently in series production in Europe and China (*i.e.,* MY 2022 GPF) can easily meet the proposed standard of 0.5 mg/mi in all three test cycles with a large compliance margin.

In Figure 14, tests without GPFs are shown in black, tests with MY 2019 GPFs are shown in gray, and tests performed with MY 2022 GPFs are shown in stripes. The top of each bar represents the highest measurement set mean of one vehicle in one laboratory and the bottom of each bar represents the lowest measurement set mean. The tops of the black bars are off scale in this figure, but their values are indicated with numbers above the bars.

The striped bars include PM measurements from two vehicles: A 2021 F150 HEV (Class 2a vehicle) retrofit with a MY 2022 bare GPF in the underfloor location, and a 2022 F250 7.3L (Class 2b vehicle) retrofit with two MY 2022 bare GPFs, one for each engine bank, in the underfloor location.

Results show that only the GPF-equipped vehicles could meet the 0.5 mg/mi proposed standard in the −7 °C FTP test. The MY 2019 GPFs failed to meet the proposed standard in the US06 because passive GPF regeneration occurred as a result of high exhaust gas temperatures (GPF inlet gas temperature greater than 600 °C). GPF regeneration oxidizes stored soot and reduces GPF filtration efficiency during and immediately after the regeneration. Vehicles equipped with MY 2022 GPFs met the 0.5 mg/mi standard in all three test cycles with a compliance margin of 100 percent or more. The MY 2022 GPFs showed high filtration efficiencies generally over 95 percent, even in the US06 cycle because they did not rely on stored soot for high filtration efficiency. The mean of test sets with MY 2022 GPF are over 95 percent lower than the mean of non-GPF test sets in each of the three test cycles.

The data show that MY 2022 GPFs are capable of emissions performance commensurate with EPA's goal of requiring GPF-level emissions over the broadest range of vehicle operating and environmental conditions. The results support the conclusion that a 0.5 mg/mi PM standard over the −7 °C FTP, 25 °C FTP, and US06 test cycles is feasible and appropriate.

The −7 °C FTP test cycle is crucial to the proposed PM standard because it differentiates vehicles with GPF-level PM from vehicles with Tier 3 levels of PM, and because −7 °C is an important real-world temperature that addresses uncontrolled cold PM emissions in Tier 3.

The US06 cycle is similarly crucial to the proposed PM standard because it induces passive GPF regeneration across vehicle-GPF combinations (*i.e.,* light-duty vehicles and MDV, naturally aspirated and turbocharged engines, close-coupled and underfloor GPF installations, bare and catalyzed GPFs), and GPF regeneration is an important mode of operation with respect to emissions. GPF regeneration does not occur in the −7 °C FTP, 25 °C FTP, and LA–92 across vehicle and exhaust system combinations. Including a certification test in which passive GPF regeneration occurs is important because it ensures low tailpipe PM during and immediately after GPF regenerations, which occur during high load operation, including road grades, towing, and driving at higher speeds.

Older GPF technology does not exhibit high PM filtration during and immediately after GPF regeneration. Older GPF technology can have filtration efficiency as low as 50 percent, as opposed to generally more than 95 percent demonstrated by the MY 2022 GPFs shown in Figure 14. Without the US06 test cycle, manufacturers could employ old GPF technology that has poor PM control during high load operation. Average US06 p.m. from the MY 2019 GPFs is 15 times higher than average US06 p.m. from the MY 2022 GPFs from the data shown in Figure 14.

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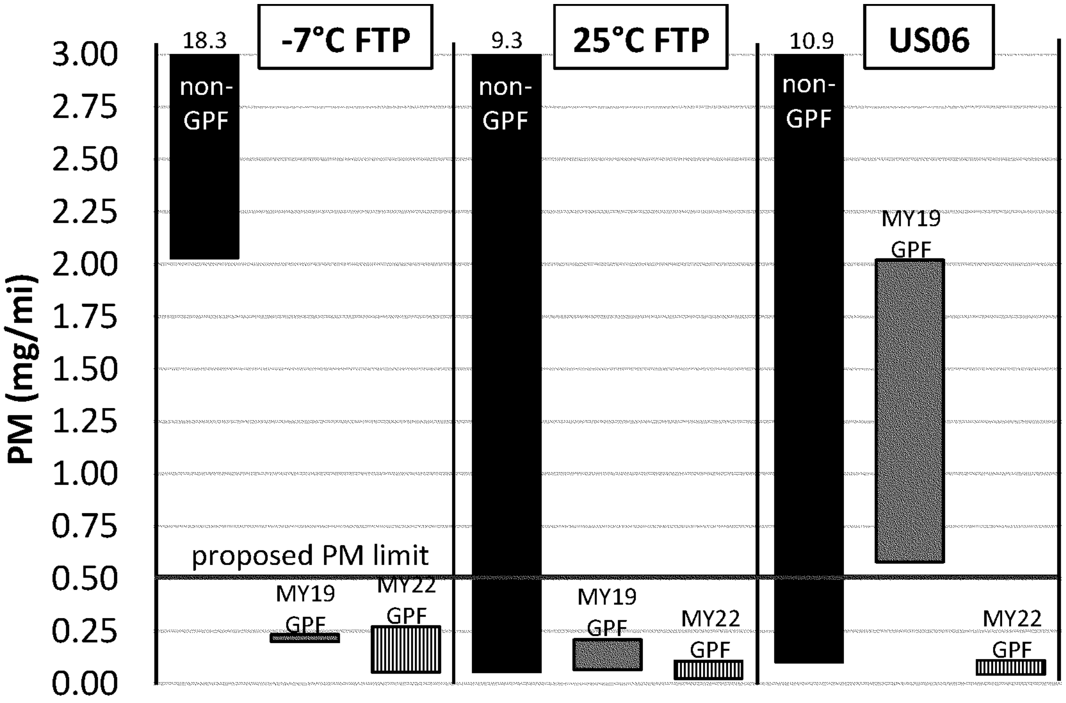

**Figure 14. Results from a five-lab five-vehicle test program illustrating the effectiveness of series production MY 2019 GPFs and series production MY 2022 GPFs in meeting the proposed 0.5 mg/mi PM standard in -7°C FTP, 25°C FTP, and US06 test cycles.**

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MDVs are certified at higher test weights and road load coefficients than light-duty vehicles, but measurements show that series production MY 2022 GPF technology enables meeting the proposed 0.5 mg/mi standard equally well on MDV as light-duty vehicles, with compliance margins of over 100 percent. Measurements comparing PM from a Class 2b vehicle with a current technology GPF (MDV MY 2022 F250 with a MY 2022 GPF), to a Class 2a vehicle with a current technology GPF (LDV MY 2021 F150 HEV with a MY 2022 GPF) are shown in Figure 15. Additional testing supports the same conclusion for Class 3 vehicles.

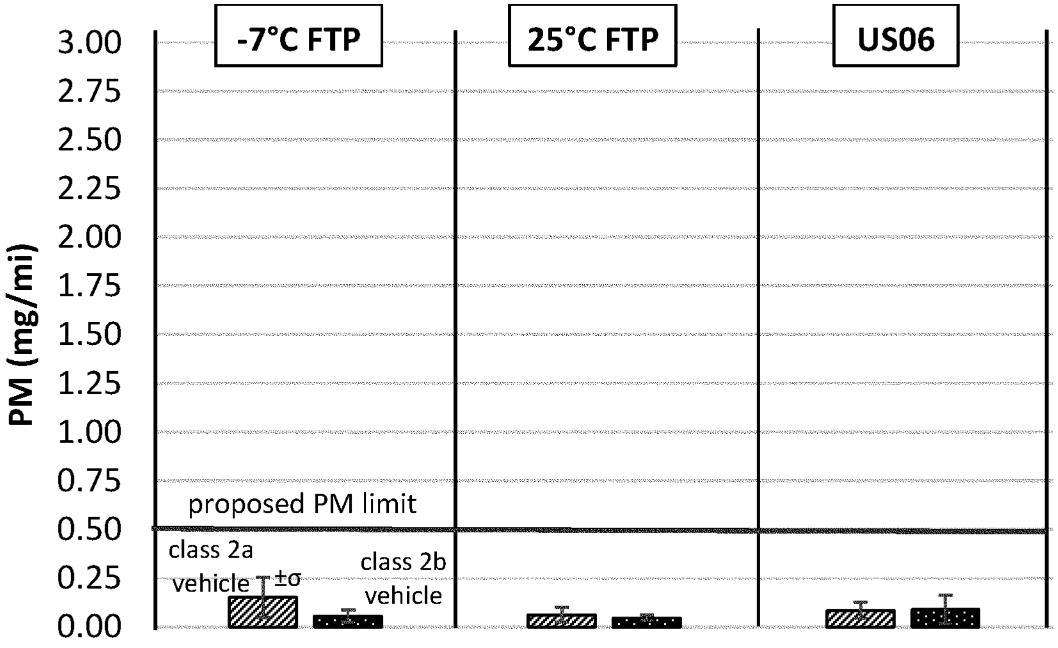

**Figure 15. PM measurements comparing PM from a Class 2a vehicle to a Class 2b vehicle, both with MY 2022 GPFs, in -7°C FTP, 25°C FTP, and US06 test cycles.**

As was the case for light-duty vehicles, the −7 °C FTP cycle is crucial because it differentiates Tier 3 levels of PM from GPF-level PM and because −7 °C is an important real-world temperature that addresses uncontrolled cold PM emissions in Tier 3. Furthermore, as was the case for light-duty vehicles, the US06 cycle is crucial to the proposed PM standard for MDV because the US06 induces passive GPF regeneration across different vehicle-GPF combinations and GPF regeneration is an important mode of operation with respect to emissions. The LA–92, which was used instead of the US06 cycle on Class 3 vehicles in Tier 3, does not induce GPF regeneration, and for this reason the US06 cycle is required for all light-duty vehicles and MDV in the proposed standard.

GPF inlet gas temperatures measured on the MY 2022 F250 7.3L during sampled US06, sampled hot LA–92, and −7 °C FTP operation, are shown in Figure 16. Fast soot oxidation begins in a GPF around 600 °C.[508] The US06 is the only cycle where GPF inlet gas temperature of the MY 2022 F250 exceeded 600 °C and it exceeded it for a significant amount of time (265 seconds), resulting in passive GPF regeneration. Peak inlet gas temperature was 674 °C in the US06. In contrast, GPF inlet gas temperature never exceeded 600 °C in the LA–92 and only exceeded 500 °C for a limited period of time. Peak GPF inlet gas temperature in the LA–92 (566 °C) was closer to the −7 °C FTP (493 °C) than the US06 (674 °C).

In this vehicle configuration, GPF regeneration does not occur in LA–92, 25 °C FTP, or −7 °C FTP cycles to a significant degree, which makes those cycles unable to force PM emissions control commensurate with MY 2022 GPF technology. Additional tests performed with the MY 2022 F250 with MY 2022 GPFs using test weight and road load coefficients from a MY 2022 F350 Class 3 vehicle show that even with the higher test weight and road load, the GPFs did not undergo substantial regeneration in the LA–92 cycle. Without requiring the US06 as a certification cycle for MDV, the GPF may not undergo GPF regeneration and high PM filtration, which new GPF technology offers, would not be ensured during high load operation, including trailer towing, road grades, or high speeds, for which these vehicles are designed.

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[508] Achleitner, E., Frenzel, H., Grimm, J., Maiwald, O., Rösel, G., Senft, P., Zhang, H., ‘‘System approach for a vehicle with gasoline direct injection and particulate filter for RDE,’’ 39th International Vienna Motor Symposium, Vienna, April 26–27, 2018.

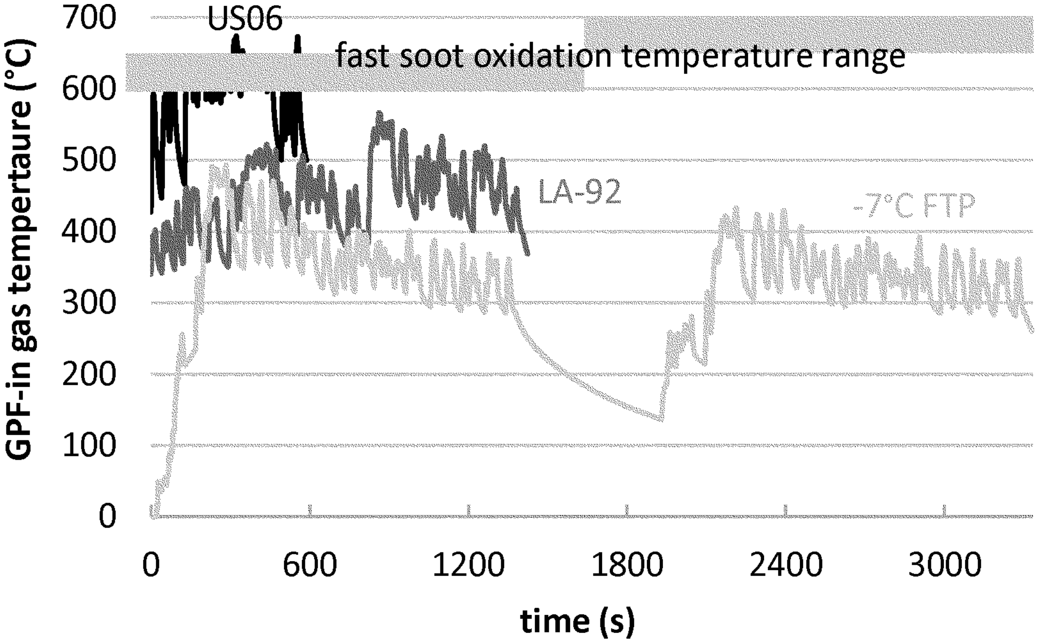

**Figure 16. GPF inlet gas temperatures measured on MY 2022 F250 7.3L left engine bank GPF during sampled US06, sampled hot LA-92, and -7°C FTP test cycles.**

Under the proposed standards, Class 2b vehicles with power-to-weight ratios at or below 0.024 hp/pound could no longer replace the full US06 component of the SFTP with the second of three phases of the US06 for their PM certification. If a test vehicle is unable to follow the trace, it must perform maximum effort to follow the trace, and that would not result in a voided test. This procedure mimics how vehicles with low power-to-weight tend to be driven in the real world.

Also, Class 3 vehicles would not use the LA–92 for PM certification, as they did in Tier 3. Instead, Class 3 vehicles would have to meet the 0.5 mg/mi PM standard across the same three test cycles as light-duty vehicles and other MDV: −7 °C FTP, 25 °C FTP, and US06.

GPF technology is both mature and cost effective. It has been used in series production on all new pure gasoline direct injection (GDI) vehicle models in Europe since 2017 (WLTC and RDE test cycles) and on all pure GDI vehicles in Europe since first registration of 2019 (WLTC and RDE test cycles) to meet Europe's emissions standards. All gasoline vehicles in China have had to meet similar standards in the WLTC since 2020, and in the WLTC and RDE starting in 2023. All pure GDI vehicles in India also have to meet similar GPF-forcing standards starting in 2023. GPFs like the MY 2022 GPFs described by Figure 14 and Figure 15 are being used in series production by U.S., European, and Asian manufacturers, and several manufacturers currently assemble vehicles equipped with GPF in the U.S. for export to other markets.

Further details and discussion of test vehicles, GPFs, test procedures, and results are provided in the DRIA 3.2.

### iv. PM Measurement Considerations

Current test procedures, as outlined in 40 CFR part 1066, allow robust gravimetric PM measurements well below the proposed PM standard of 0.5 mg/mi. Repeat measurements in EPA laboratories, at different levels of PM below 0.5 mg/mi, are shown in Figure 17. The size of the error bars relative to the measurement averages at and below 0.5 mg/mi demonstrates that the measurement methodology is sufficiently precise to support a 0.5 mg/mi standard. Other than selecting test settings appropriate for quantifying low PM, no test procedure changes are needed. Good engineering judgment should be used with respect to dilution factor, filter media selection, filter flow rate, using a single filter for all phases of a test cycle, filter static charge removal, robotic weighing, and minimizing contamination during filter handling. EPA is not reopening the test procedures, nor does the agency believe that test procedure changes are required, to measure PM for the proposed PM standards. Further discussion of selecting test settings is discussed in the DRIA.

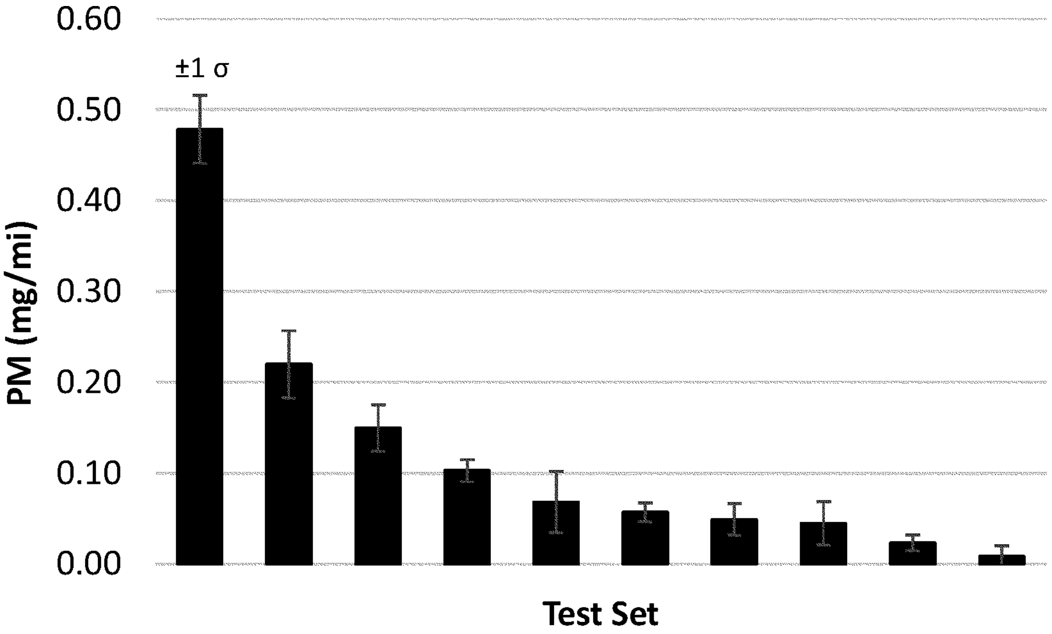

**Figure 17. Example of test-to-test repeatability of PM measurements from vehicles without and with GPF, an aerosol generator, and tunnel blanks from three EPA test cells.**

v. Pre-Production Certification

EPA is proposing that PM emissions be certified over −7 °C FTP, 25 °C FTP, and US06 cycles with at least one Emissions Data Vehicle (EDV) per test group in model years 2027, 2028, and 2029+ for light-duty vehicles and MDV compliant with the new 0.5 mg/mi standard in the early compliance program. In the default program, PM emissions would be certified with at least one EDV per test group in model years 2027, 2028, and 2029+ for light-duty vehicles compliant with the new standard, and with at least one EDV per test group in 2030+ for MDV compliant with the new standard. See 40 CFR 86.1829–15. This level of certification testing matches the requirement to certify gaseous criteria emissions at the test group level and ensures that the significantly lower PM emissions standard of 0.5 mg/mi is being met across a wide range of ICE technologies. The requirement to certify PM emissions at the test group level is an increase in testing requirements relative to Tier 3, where PM emissions could be certified at the durability group level. The increase in testing requirement is tempered by the phase-in of the PM standard described in Table 39, and since BEVs do not require testing.

EPA solicits comment on whether pre-production PM certification should go back to testing at the durability group level in 2030 for light-duty vehicles and in 2031 for MDV after PM control technologies have been demonstrated across a range of ICE technologies. If PM certification were to go back to testing at the durability level in 2030/2031, manufacturers would still have to attest that the 0.5 mg/mi standard is being met by all test groups.

EPA is proposing to update the instructions to select a worst-case test vehicle from each test group by considering −7 °C FTP testing with all the other criteria standards. This contrasts with the current approach, in which manufacturers select worst-case test vehicles separate from −7 °C FTP testing and then select a test vehicle for −7 °C FTP testing from those test vehicles included in the same durability group. The current approach is appropriate for measuring CO and NMHC for −7 °C FTP testing. However, the concern for PM emissions with −7 °C FTP testing are on par with concern for the other standards already considered for selecting a worst-case test vehicle to represent the test group. EPA requests comments on different approaches for selecting test vehicles to most effectively apply test resources to ensure compliance with the range of emission standards.

vi. In-Use Compliance Testing

In addition to pre-production certification, the proposed PM standard requires in-use compliance testing as part of the in-use vehicle program (IUVP). The proposed PM standard requires that PM from each in-use test vehicle be tested using 25 °C FTP and US06 cycles and meet the 0.5 mg/mi PM standard. In-use vehicles are also required to comply with the −7 °C FTP standard, but manufacturers are not required to test using this cycle to reduce testing burden. EPA may test in-use vehicles using −7 °C FTP, 25 °C FTP, and US06 cycles to ensure compliance. Given the certification test demonstration for meeting the −7 °C FTP PM standard, along with expected IUVP testing over 25 °C FTP and US06 cycles and the potential for EPA testing, we find that there is not enough justification to require the additional test burden associated with IUVP testing for PM emissions over the −7 °C FTP cycle.

vii. OBD Monitoring

Since GPF technology is expected to be an important enabler for meeting the proposed PM standard, OBD monitoring of the GPF system is necessary. If a vehicle uses a GPF, the OBD system must detect GPF-related malfunctions, store trouble codes related to detected malfunctions, and alert operators appropriately.

It is expected that the OBD system detect system tampering and major malfunctions using, for example, using a pressure sensor. The same pressure sensor that senses GPF soot overloading may be used to detect system tampering and major malfunctions. It is expected that if a pressure sensor is used for OBD functions, it should detect a GPF pressure drop greater than zero and less than an expected maximum as a function of engine operating point. Further OBD discussion is provided in Section III.G.

### viii. GPF Cost

A GPF cost model is described in DRIA Chapter 3.2 and GPF cost is included in the OMEGA model. The model anticipates the direct manufacturing cost (DMC) for a bare downstream GPF ranges from $51 dollars for a 1.0-liter engine using a relatively low GPF volume to engine displacement ratio, up to $166 dollars for a 7.0 liter engine using a relatively high GPF volume to engine displacement ratio.

## 4. Revised CO and Formaldehyde (HCHO) Standards

### i. CO and HCHO Standards for Light-Duty Vehicles

EPA is proposing CO and formaldehyde (HCHO) emissions caps for light-duty vehicles shown in Table 48. The proposed value of the CO emissions cap for the 25 °C FTP, HFET, US06, SC03 test cycles, 1.7 g/mi, is the same as the Tier 3 bin-specific standards for Bin 50 and Bin 70, but it must be met across four cycles instead of the Tier 3 cycles of 25 °C FTP and a separate standard for the SFTP.

The proposed value of the HCHO emissions cap, 4 mg/mi, is the same as the Tier 3 bin-specific standards for Bin 20 through Bin 160. The HCHO cap only applies to the 25 °C FTP, as in Tier 3.

The proposed CO emissions cap for the −7 °C FTP is 10.0 g/mi. This differs from the current standards in that the same cap applies to all light-duty vehicles. The current CO cap is 10.0 g/mi for LDV and LDT1, and 12.5 g/mi for LDT2, LDT3, LDT4, and MDPV.

TABLE 48—LIGHT-DUTY VEHICLE CO AND HCHO EMISSIONS CAPS

| | |
|---|---|
| CO cap for 25 °C FTP, HFET, US06, SC03 (g/mi) | 1.7 |
| HCHO cap for 25 °C FTP (mg/mi) | 4 |
| CO cap for −7 °C FTP (g/mi) | 10.0 |

### ii. CO and HCHO Standards for MDV at or Below 22,000 lb GCWR

EPA is proposing CO and formaldehyde (HCHO) emissions caps for MDV at or below 22,000 pounds GCWR shown in Table 49. The proposed value of the CO emissions cap for the 25 °C FTP, HFET, US06, SC03 test cycles, 3.2 g/mi, is the same as the Tier 3 bin-specific standard for Bin 20 through Bin 160, but it must be met across four cycles instead of the Tier 3 cycles of 25 °C FTP and a separate standard for the SFTP.

The proposed value of the HCHO emissions cap, 6 mg/mi, is the same as the Tier 3 bin-specific standards for Bin 20 through Bin 160. The HCHO cap only applies to the 25 °C FTP, as in Tier 3.

The proposed CO emissions cap for the −7 °C FTP is 10.0 g/mi.

TABLE 49—MDV AT OR BELOW 22,000 LB GCWR CO AND HCHO EMISSIONS CAPS

| | |
|---|---|
| CO cap for 25 °C FTP, HFET, US06, SC03 (g/mi) | 3.2 |
| HCHO cap for 25 °C FTP (mg/mi) | 6 |
| CO cap for −7 °C FTP (g/mi) | 10.0 |

Present-day MDV gasoline engine aftertreatment technology allows fast catalyst light-off followed by closed-loop A/F control and excellent emissions conversion on Class 2b and 3 vehicles, even at the ALVW [(curb + GVW)/2] test weight, which is higher than light-duty vehicle test weight of LVW (curb + 300 pounds). Testing of a 2022 F250 7.3L in the −7 °C FTP at EPA showed average CO emissions of 2.7 g/mi CO, demonstrating that a 10.0 g/mi standard is feasible for MDV.

## 5. Requirements To Certify MDV With High GCWR Under the HD Engine Program for Criteria Emissions

The Agency is proposing mandatory engine certification for compliance with criteria pollutant emissions standards for MDVs above 22,000 pounds GCWR. The proposed standards would include both spark ignition and compression ignition (diesel) engines, complete and incomplete vehicles, and require compliance with all of the same engine certification criteria pollutant requirements and standards as for 2027 and later engines installed in Class 4 and higher HD vehicles, including NMHC, CO, $NO_X$ and PM standards, useful life, warranty and in-use requirements that were finalized in December 2022.[509] Complete MDVs would still require chassis dynamometer testing for demonstrating compliance with GHG standards as described in Section III.B.3 and would be included within the fleet average MDV GHG emissions standards along with the other MDVs at or below 22,000 GCWR. Manufacturers could certify incomplete MDVs to GHG standards under 40 CFR 86.1819 or 40 CFR part 1037. Note that existing regulations (40 CFR 1037.150(l)) allow a comparable dual testing methodology, which utilizes engine dynamometer certification for demonstration of compliance with criteria pollutant emissions standards while maintaining chassis dynamometer certification for demonstration of compliance with GHG emissions standards under 40 CFR 86.1819. One manufacturer has been using this provision to certify all gasoline vehicles over 14,000-pound GVWR and the corresponding engines since MY 2016. Proposed requirements are summarized in Table 50.

The purpose of this proposed change is to ensure that criteria pollutant emissions are controlled under the sustained high load conditions that many of these vehicles encounter, particularly during heavy towing operation. Some Class 2b and Class 3 trucks have towing capability exceeding that of Class 4 and Class 5 trucks. Some diesel Class 3 emissions families have GCWR in excess of 40,000 pounds. The agency considers trucks above 22,000 pounds GCWR to be predominantly work vehicles that will reasonably encounter significant towing and/or other highly loaded use during normal operation. Many of these vehicles currently do not have exhaust aftertreatment sized for effective emissions control under sustained high loads. Current chassis dynamometer test cycles used for demonstrating compliance do not include such sustained high load operation. Manufacturers have also indicated to the agency that there is a trade-off between sustained high load exhaust aftertreatment performance and cold-start light off performance over the FTP cycle. It is more appropriate that trucks above 22,000 pounds GCWR be tested as heavy-duty engines due capabilities and predominant use that are much more closely aligned with Class 4 and above heavy-duty applications than with light-duty vehicles and light-duty trucks.

Based on an analysis of the MY 2022 and MY 2023 emissions certification data, most MDV complete and incomplete diesel pickup trucks would be required to switch to engine dynamometer certification; MY 2022 vans would not be required to use engine dynamometer certification; and only a small number of gasoline pickup trucks would be required to switch to engine certification.

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[509] See *https://www.epa.gov/regulations-emissions-vehicles-and-engines/final-rule-and-related-materials-control-air-pollution.*

As described in Section III.C.1, under the CAA trucks over 6,000 pounds GVWR are allowed 4 years of lead time before they are required to begin implementation of new criteria pollutant emission standards. The agency is providing an earlier implementation pathway beginning in 2027 in order for manufacturers to better plan for program changes over a larger time window and to encourage earlier emissions reductions. Because of this earlier opportunity for manufacturers and the potential for the agency to realize earlier emission reductions, we are providing additional flexibilities.

Manufacturers who choose to optionally implement this engine certification requirement for all their trucks above 22,000 pounds GCWR beginning in 2027 model year will be allowed an additional GHG compliance flexibility. If manufacturers choose to certify their vehicles to these proposed standards in 2027 MY, they will be allowed to continue to use the HD GHG Phase 2 based final 2026 work factor-based target GHG standards, without a capped GCWR input for the work factor-based target standard. This allowance would continue through 2029 MY, after which vehicle manufacturers would be required to switch to the new work factor standards and the capped GCWR work factor equation input proposed in Section III.B.3 in 2030. This will provide an opportunity for manufacturers to balance the implementation of new GHG program plans for these much higher GCWR vehicles while also achieving important criteria pollutant emission reductions earlier in the program. The agency seeks comments on additional flexibilities that achieve the same or similar emission reductions.

The default compliance pathway for MDV would be compliance with 2027 and later HD engine emissions standards beginning in 2030. Under the default compliance pathway, GHG compliance flexibilities to extend compliance with the heavy-duty Phase 2 GHG standards beyond the 2026 model year do not apply and manufacturers would need to meet the proposed MDV GHG standards described in Section III.B.3 beginning with the 2027 model year.

The Agency seeks comment on several alternatives for high GCWR MDV criteria pollutant emissions standards: (1) MDV above 22,000 pounds GCWR would comply with the MDV chassis dynamometer standards proposed in Section III.C with the introduction of additional engine-dynamometer-based standards over the Supplemental Emissions Test as finalized within the Heavy-duty 2027 and later standards; (2) MDV above 22,000 pounds GCWR would comply with the MDV chassis dynamometer standards proposed in Section III.C with additional in-use testing and standards comparable to those used within the California ACC II; (3) Introduction of other test procedures for demonstration of effective criteria pollutant emissions control under the sustained high-load conditions encountered during operation above 22,000 pounds GCWR.

TABLE 50—CERTIFICATION REQUIREMENTS OF HIGH GCWR VEHICLES

| Vehicle | GVWR (lb) | GCWR (lb) | Criteria pollutant standards | GHG standards | Compared to tier 3 |
|---|---|---|---|---|---|
| Complete | 8500–14,000 | ≤22,000 | Part 86 | Part 86 | Same. |
| Incomplete | 8500–14,000 | ≤22,000 | Part 86<br>-OR-<br>Part 1036 | Part 1036 & 1037 | Same. |
| Complete | 8500–14,000 | >22,000 | Part 1036 | Part 86 | New for criteria. |
| Incomplete | 8500–14,000 | >22,000 | Part 1036 | Part 86 or 1037 | New for criteria. |

6. Refueling Standards for Incomplete Spark-Ignition Vehicles

The agency is proposing to require that incomplete medium duty vehicles meet the same on-board refueling vapor recovery (ORVR) standards as complete vehicles. Incomplete vehicles have not been required to comply with the ORVR requirements to date because of the potential complexity of their fuel systems, primarily the filler neck and fuel tank. Unlike complete vehicles, which have permanent fuel system designs that are fully integrated into the vehicle structure at time of original construction by manufacturers, it was previously believed that incomplete vehicles may need to change or modify some of fuel system components during their finishing assembly. For this reason, it was previously determined that ORVR might introduce complexity for the upfitters that is unnecessarily burdensome.

Since then, the agency has newly assessed both current ORVR equipped vehicles and their incomplete versions. Based on our updated assessment, the agency believes that the fuel system designs are almost identical with only the ORVR components removed for the incomplete version. The complete and incomplete vehicles appear to share the same fuel tanks, lines, and filler tubes. The original thought that extensive differences between the original manufacturer's designs and the upfitter modifications to the fuel system would be required have not been observed. Therefore, the agency believes that all incomplete vehicles can comply with the same ORVR standards as complete vehicles with the addition of the same ORVR components on the incomplete vehicles as the complete version of the vehicle possesses.

The current practice of manufacturers of the original incomplete vehicles is to specify to the upfitter that modifications of the fuel system are not allowed by the upfitter. This is because the incomplete vehicle manufacturers are responsible for all current evaporative requirements (2-day, 3-day, running loss, spitback, etc.) and almost any modification could compromise compliance with those program standards. There is also an aspect of compliance with crash and safety requirements that prevent upfitters from making changes to the fuel system components. For these reasons, with rare exception, the fuel system design and installation is completed by the original vehicle manufacturer. The exception that the agency observed is that some incomplete vehicles do not have the filler tube permanently mounted to a body structure until the upfitter adds the finishing body hardware (*i.e.,* flatbed, box). In these cases, the upfitter is limited to only attaching the filler tube to their added structure but must maintain the original manufacturer designs that are certified to meet existing EPA evaporative emission standards.

Net emission impacts are expected to be small in the context of the entire inventory and were not estimated for the NPRM, but the VOC and air toxics reductions will be important in locations where these vehicles are commonly refueled.

### i. Summary of Medium Duty Vehicle Refueling Emission Standards and Test Procedures

Compliance with evaporative and refueling emission standards is demonstrated at the vehicle level. The vehicle manufacturers produce MD spark-ignition (SI) complete vehicles and, in some instances, sell incomplete vehicles to secondary manufacturers. As noted in the following sections, we are proposing refueling emission standards for incomplete vehicles 8501 to 14,000 pounds GVWR. These proposed standards would apply over a useful life of 15 years or 150,000 miles, whichever occurs first, consistent with existing evaporative emission standards for these vehicles and for complete versions. No changes to evaporative and refueling emission standards for complete vehicles are being proposed by this rulemaking.

### ii. Current Refueling Emission Standard and Test Procedures

Spark-ignition medium duty vehicles generally operate with volatile liquid fuel (such as gasoline or ethanol) or gaseous fuel (such as natural gas or LPG) that have the potential to release high levels of evaporative and refueling HC emissions. As a result, EPA has issued evaporative emission standards that apply to vehicles operated on these fuels.[510] Refueling emissions are evaporative emissions that result when the pumped liquid fuel displaces the vapor in the vehicle tank. Without refueling emission controls, most of those vapors are released into the ambient air. The HC emissions emitted are a function of temperature and the Reid Vapor Pressure (RVP).[511] The emissions control technology which collects and stores the vapor generated during refueling events is the Onboard Refueling Vapor Recovery (ORVR) system.

Light-duty vehicles and chassis-certified complete medium-duty vehicles that are 14,000 pounds GVWR and under have been meeting evaporative and refueling requirements for many years. ORVR requirements for light-duty vehicles started phasing in as part of EPA's National Low Emission Vehicle (NLEV) and Clean Fuel Vehicle (CFV) programs in 1998.[512] In EPA's Tier 2 vehicle program, all complete vehicles with a GVWR of 8,501 to 14,000 pounds were required to phase-in ORVR requirements between 2004 and 2006 model years.[513] In the Tier 3 rulemaking, all complete vehicles were required to meet a more-stringent standard of 0.20 grams of HC per gallon of gasoline dispensed by MY 2022 (see 40 CFR 86.1813–17(b)).[514] The recent 2027 heavy duty final rule added refueling standards for incomplete heavy-duty vehicles over 14,000 pounds GVWR. This left incomplete medium duty SI engine powered vehicles 8,501 to 14,000 pounds GVWR as the only SI vehicles not required to meet refueling standards.

While the agency does not believe manufacturers of the very limited volumes of incomplete LD vehicles (*i.e.,* mainly some LD pick-ups for commercial customers who upfit application specific boxes and flatbeds) are currently ''removing'' any ORVR related hardware already required for the complete vehicle version like what has been observed in the MDV applications, and this proposal focuses on the known incomplete vehicles without ORVR in MDVs, the agency seeks comment on whether to extend this ORVR requirement to all incomplete LDVs and MDVs to prevent any future removal of ORVR from LDVs.

### iii. Proposed ORVR HC Standard

We are proposing a refueling emission standard of 0.20 grams HC per gallon of dispensed fuel for incomplete vehicles 8,501 to 14,000 pounds GVWR (0.15 grams for gaseous-fueled vehicles), which is the same as the existing refueling standards for complete vehicles.[515] We note that these proposed refueling emission standards would apply to all liquid-fueled and gaseous-fueled spark-ignition medium-duty vehicles, including gasoline and ethanol blends.[516] We believe it is feasible for manufacturers to achieve these standards by adopting the technology in use on complete vehicles.

We are proposing to apply the refueling standards for new incomplete vehicles starting with model year 2030. This meets the statutory obligation to allow four years of lead time for new emissions standards for criteria pollutants for heavy-duty vehicles. This schedule also complements the alternative phase-in provisions adopted in our final rule setting these same standards for vehicles above 14,000 pounds GVWR (88 FR 4296, January 24, 2023). Those alternative phase-in provisions allowed for manufacturers to phase in certification of all their incomplete medium-duty and heavy-duty vehicles to the new standards from 2027 through 2030. This proposed rule provides a complete set of options for manufacturers. Specifically, manufacturers may certify incomplete heavy-duty vehicles above 14,000 pounds GVWR to the refueling standards in 2027 and incomplete medium-duty vehicles to the refueling standards in 2030. The second option is to meet the phase-in for the combined set of vehicles for 2027 through 2030.

We request comment on our proposed standards.

### iv. Impact on Secondary Manufacturers

For incomplete vehicles 8,501 to 14,000 pounds GVWR, the chassis manufacturer performs the evaporative emissions testing and obtains the vehicle certificate from EPA. When the chassis manufacturer sells the incomplete vehicle to a secondary vehicle manufacturer, the chassis manufacturer provides specific instructions to the secondary manufacturer indicating what they must do to maintain the certified configuration, how to properly install components, and what, if any, modifications may be performed. For the evaporative emission system, a chassis manufacturer may require specific tube lengths and locations of certain hardware, and modifications to the fuel tank, fuel lines, evaporative canister, filler tube, gas cap and any other certified hardware would likely be limited.

We anticipate that the addition of any ORVR hardware and all ORVR-related aspects of the certified configuration would continue to be managed and controlled by the chassis manufacturer that holds the vehicle certificate. The engineering associated with all aspects of the fuel system design, which would include the ORVR system, is closely tied to the engine design, and the chassis manufacturer is the most qualified party to ensure its performance and

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[510] 40 CFR 86.1813–17.

[511] E.M. Liston, American Petroleum Institute, and Stanford Research Institute. A Study of Variables that Effect the Amount of Vapor Emitted During the Refueling of Automobiles. Available online: *http://books.google.com/books?id=KW2IGwAACAAJ*, 1975.

[512] 62 FR 31192 (June 6, 1997) and 63 FR 926 (January 7, 1998).

[513] 65 FR 6698 (February 10, 2000).

[514] 79 FR 23414 (April 28, 2014) and 80 FR 0978 (February 19, 2015).

[515] 40 CFR 86.1813–17.

[516] Refueling requirements for incomplete medium duty vehicles that are fueled by CNG or LNG would be the same as the current complete gaseous-fueled Spark-ignition medium-duty vehicle requirements.

compliance with applicable standards. Example fuel system changes the OEM may implement include larger canisters bracketed to the chassis frame close to the fuel tanks. Additional valves may be necessary to route the vapors to the canister(s) during refueling. Most other evaporative and fuel lines would remain in the same locations to meet existing evaporative requirements. There may be slightly different filler neck tube designs (smaller fuel transfer tube) as well as some additional tubes and valves to allow proper fuel nozzle turn-off (click off) at the pump, but this is not expected to include relocating the filler neck. Based on the comments received during the 2027 HD rule making that established refueling requirements for incomplete vehicles over 14,000 GVWR, we believe these changes would not adversely impact the secondary manufacturers finishing the vehicles.[517]

The instructions provided by the chassis manufacturer to the secondary manufacturer to meet our proposed refueling standards should include new guidelines to maintain the certified ORVR configuration. We do not expect the new ORVR system to require significant changes to the vehicle build process, since chassis manufacturers would have a business incentive to ensure that the ORVR system integrates smoothly in a wide range of commercial vehicle bodies. Accordingly, we do not expect that addition of the ORVR hardware would result in any appreciable change in the secondary manufacturer's obligations or require secondary builders to perform significant modifications to their products.

### v. Feasibility Analysis for the Proposed Refueling Emission Standards

This section describes the effectiveness and projected costs of the emissions technologies that we analyzed for our proposed refueling standards. Feasibility of the proposed refueling standard of 0.20 grams of HC per gallon is based on the widespread adoption of ORVR systems used in the light-duty and complete medium-duty vehicle sectors. As described in this section, we believe manufacturers can effectively use the same technologies already implemented in the complete medium-duty versions of the same vehicles to meet the proposed standard.

### vi. Summary of Refueling Emission Technologies Considered

This section summarizes the specific technologies we considered as the basis for our analysis of the proposed refueling emission standards. The technologies presented in this section are described in greater detail in the DRIA.

Instead of releasing HC vapors into the ambient air, ORVR systems capture HC emissions during refueling events when liquid fuel displaces HC vapors present in the vehicle fuel tank as the tank is filled. These systems recover the HC vapors and store them for later purging from the system and use as fuel to operate the engine. An ORVR system consists of four main components that are incorporated into the existing fuel system: Filler pipe and seal, flow control valve, carbon canister, and purge system.

The filler pipe is the section of line from the fuel tank to where fuel enters the fuel system from the fuel nozzle. The filler pipe is typically sized to handle the maximum fill rate of liquid fuel allowed by law and integrates either a mechanical or liquid seal to prevent fuel vapors from exiting through the filler pipe to the atmosphere. The flow control valve senses that the fuel tank is getting filled and triggers a unique low-restriction flow path to the canister. The carbon canister is a container of activated charcoal designed to effectively capture and store fuel vapors. Carbon canisters are already a part of MD SI fuel systems to control evaporative emissions. Fuel systems with ORVR would require additional capacity, by increasing either the canister volume or the effectiveness of the carbon material. The purge system is an electro-mechanical valve used to redirect fuel vapors from the fuel tank and canister to the running engine where they are burned in the combustion chamber.[518]

The fuel systems on 8,501 to 14,000 pounds GVWR incomplete heavy-duty vehicles are similar, if not identical to those on complete medium-duty vehicles that are currently subject to refueling standards. These incomplete vehicles may have slightly larger fuel tanks than most certified (complete) medium-duty vehicles and in some applications may have dual fuel tanks. These differences may necessitate greater ORVR system storage capacity and possibly some unique accommodations for dual tanks (*e.g.,* separate fuel filler locations), as commented by ORVR suppliers in response to the similar program in the HD 2027 ANPR.[519]

### vii. Projected Refueling Emission Technology Packages

The ORVR emission controls we projected in our feasibility analysis build upon four components currently installed on complete medium-duty vehicles 8,501 to 14,000 pounds GVWR to meet the Tier 3 evaporative emission standards: The carbon canister, flow control valves, filler pipe and seal, and the purge system. For our feasibility analysis, we assumed a 35-gallon fuel tank to represent an average tank size[520] of medium-duty gasoline fueled vehicles 8,501 to 14,000 pounds GVWR. A summary of the projected technology updates and costs are presented in this section. See the DRIA for additional details.

In order to capture the vapor volume of fuel tanks during refueling, we project manufacturers would increase canister vapor or ''working'' capacity of their liquid-sealed canisters by 15 to 40 percent depending on the individual vehicle systems. If a manufacturer chooses to increase the canister volume using conventional carbon, we project a canister meeting Tier 3 evaporative emission requirements with approximately 2.5 liters of conventional carbon would need up to an additional 1 liters of carbon to capture refueling emissions from a 35-gallon fuel tank. A change in canister volume to accommodate additional carbon would result in increased costs for retooling and additional canister plastic, as well as design considerations to fit the larger canister on the vehicle. Alternatively, a manufacturer could choose to use the same size fuel tank and canister currently used to meet refueling requirements for complete medium duty vehicles to avoid the re-tooling costs. Another approach, based on discussions with canister and carbon manufacturers, could be for manufacturers to use a higher adsorption carbon and modify compartmentalization within the existing shell to increase the canister working capacity. We do not have data to estimate the performance or cost of higher adsorption carbon and so did not include this additional approach in our analysis.

The projected increase in canister volumes assumes manufacturers would use a liquid seal in the filler pipe, which

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[517] See comments from the Manufacturers of Emission Controls Association (EPA–HQ–OAR–2019–0055–0365) and Ingevity Corporation (EPA–HQ–OAR–2019–0055–0271).

[518] This process displaces some amount of the liquid fuel that would otherwise be used from the fuel tank and results in a small fuel savings.

[519] See comments from the Manufacturers of Emission Controls Association (EPA–HQ–OAR–2019–0055–0365) and Ingevity Corporation (EPA–HQ–OAR–2019–0055–0271).

[520] Advertised MY 2022 fuel tank sizes ranged from 31 to 43 gallons.

is less effective than a mechanical seal. For a manufacturer that replaces their liquid seal with a mechanical seal, we assumed an approximate 20 percent reduction in the necessary canister volume. Despite the greater effectiveness of a mechanical seal, manufacturers in the past have not preferred this approach because it introduces another wearable part that can deteriorate, introduces safety concerns, and may require replacement during the useful life of the vehicle. To meet the proposed ORVR standards, manufacturers may choose the mechanical seal design to avoid retooling charges. We included this potential compliance approach in our cost analysis. We assumed a cost of $10.00 per seal for a manufacturer to convert from a liquid seal to a mechanical seal. We also analyzed costs based on the use of liquid seals, and we assumed zero cost in our analysis for manufacturers to maintain their current liquid seal approach for filler pipes already used in the complete medium-duty applications.

In order to manage the large volume of vapors during refueling, manufacturers' ORVR updates would include flow control valves integrated into the roll-over/vapor lines. We assumed manufacturers would, on average, install one flow control valve per vehicle that would cost $6.50 per valve. And lastly, we project manufacturers may need to update their purge strategy to account for the additional fuel vapors from refueling. Manufacturers may add hardware and optimize calibrations to ensure adequate purge in the time allotted over the preconditioning drive cycle of the demonstration test.

Table 51 presents the ORVR system specifications and assumptions used in our cost analysis, including key characteristics of the baseline incomplete vehicle's evaporative emission control system. Currently manufacturers may size the canisters of their Tier 3 evaporative emission control systems based on the diurnal 3-day test and the Bleed Emission Test Procedure (BETP).[521] During the diurnal test, the canister is loaded with hydrocarbons over two or three days, allowing the hydrocarbons to load a conventional carbon canister (1,500 GWC, gasoline working capacity) at a 70 g/L effectiveness. In contrast, a refueling event takes place over a few minutes, and the ORVR directs the vapor from the gas tank onto the carbon in the canister at a canister loading effectiveness of 50 g/L. For our analysis, we added a design safety margin of 10 percent extra carbon to our ORVR systems. While less overall vapor mass may be vented into the canister from the fuel tank during a refueling event compared to the three-day diurnal test period, a higher amount of carbon is needed to contain the faster rate of vapor loaded at a lower efficiency during a refueling event. These factors were used to calculate the canister volumes for the two filler neck options in our cost analysis.

TABLE 51—ORVR SPECIFICATIONS AND ASSUMPTIONS USED IN THE COST ANALYSIS FOR HD SI INCOMPLETE VEHICLES ABOVE 14,000 LBS GVWR

| | Tier 3 baseline | ORVR filler neck options | |
|---|---|---|---|
| | | Mechanical seal | Liquid seal |
| | Diurnal | ORVR | |
| Diurnal Heat Build | 72–96 °F | 80 °F | |
| RVP | 9 psi | | |
| Nominal Tank Volume | 35 gallons | | |
| Fill Volume | 40% | 10% to 100% | |
| Air Ingestion Rate | | 0% | 13.50% |
| Mass Vented per heat build, g/d | 60 | | |
| Mass Vented per refueling event | | 128 | 158 |
| Hot Soak Vapor Load | 2.5 | | |
| Mass vented over 48-hour test | 114 | | |
| Mass vented over 72-hour test | 162 | | |
| 1,500 GWC, g/L[a] | 70 | 50 | 50 |
| Excess Capacity | 10% | 10% | 10% |
| Estimated Canister Volume Requirement, liters[b] | | | |
| 48-hour Evaporative only | 1.8 | | |
| 72-hour Evaporative only | 2.5 | | |
| Total of 72-hour + ORVR[c] | | 2.8 | 3.5 |

[a] Efficiency of conventional carbon.

[b] Canister Volume = 1.1 (mass vented)/1,500 GWC (Efficiency).

[c] ORVR adds .3 liters and 1 liter for Mechanical Seal and Liquid Seal, respectively.

The ORVR components described in this section represent technologies that we think most manufacturers would choose to adopt to meet our proposed refueling requirements. It is possible that manufacturers may choose a different approach, or that unique fuel system characteristics may require additional hardware modifications not described here, but we do not have reason to believe costs would be significantly higher than presented in the following section. We request comment, including data, on our assumptions related to the increased canister working capacity demands, the appropriateness of our average fuel tank size, the technology costs for the

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[521] 40 CFR 86.1813–17(a).

specific ORVR components considered and any additional information that can improve our cost projections in the final rule analysis.

### viii. Summary of Costs To Meet Proposed Refueling Emission Standards

Table 52 shows cost estimations for the different approaches evaluated. In calculating the overall cost of our proposed program, we used $19, the average of both approaches, to represent the cost for manufacturers to adopt the additional canister capacity and hardware to meet our proposed refueling emission standards for incomplete medium duty vehicles. See Section V of this preamble for a summary of our overall program cost and Chapter 3 of the DRIA for more details.

TABLE 52—ESTIMATED DIRECT MANUFACTURING COSTS FOR ORVR OVER TIER 3 AS BASELINE

| | Liquid seal | Mechanical seal |
|---|---|---|
| | New canister | New canister |
| Additional Canister Costs | $10 | $4 |
| Additional Tooling [a] | 0.50 | 0.50 |
| Flow Control Valves | 6.50 | 6.50 |
| Seal | 0 | 10 |
| Total [b] | 17 | 21 |

[a] Assumes the retooling costs will be spread over a five-year period.
[b] Possible additional hardware for spitback requirements.

Incomplete vehicles may include dual fuel tanks, which may require some unique accommodations to adopt ORVR systems. A dual fuel tank chassis configuration would need separate canisters and separate filler pipes and seals for each fuel tank. Depending on the design, a dual fuel tank chassis configuration may require a separate purge valve for each fuel tank. We assume manufacturers would install one additional purge valve for dual fuel tank applications that also incorporate independent canisters for the second fuel tank/canister configuration and manufacturers adopting a mechanical seal in their filler pipe would install an anti-spitback valve for each filler pipe. See the DRIA for a summary of the design considerations for these fuel tank configurations. We did not include an estimate of the population or impact of dual fuel tank vehicles in our cost analysis of our proposed refueling emission standards because we believe that is a very rare option found on only one manufacturer's MY 2022 incomplete pickup model.

### ix. Summary of Additional Program Considerations

We are requesting comment regarding the cost, feasibility, and appropriateness of our proposed refueling emission standard for incomplete light-duty trucks. While we do not believe that any significant volume of incomplete LD vehicles is produced, we request comment on extending this proposal to all incomplete vehicles. The proposed standard is based on the current refueling standard that applies to complete light-duty and medium-duty gasoline-fueled vehicles. We are proposing that compliance with these standards may be demonstrated under an existing regulatory provision allowing them to group incomplete vehicles with completes if they share identical evaporative emission hardware and meet other engineering and temperature profile requirements impacting evaporative emissions and durability.

EPA has identified a potential issue with Non-Integrated Refueling Canister Only Systems (NIRCOS) designed fuel vapor handling designs. During refueling events, because the sealed system may be under pressure and the pressure must be released before the fuel cap is removed, these NIRCOS systems initially release any tank vapors into the canister prior to the cap removal and the refueling event. These initial pressurized fuel vapors are not allowed to be simply vented through the gas cap and are therefore appropriately released into and absorbed by the carbon canister. However, the identified issue relates to the ORVR test procedure which does not account for this extra fuel vapor loading prior to the refueling event. The testing procedure for ORVR certification starts with a fully purged canister with no vapor loading from the release of the pressurized vapors prior to the cap removal that would likely occur in actual operation in the real world.

To address this limited issue, instead of a challenging change to the established ORVR test procedure, the agency is seeking comment for the need for an engineering requirement related to the canister working capacity that would provide an increase in the capacity in order to properly capture this initial pressurized vapor load and still have the needed capacity to handle the vapors generated during the refueling event. The agency requests comment on the need to address this limited issue.

EPA requests comment on the proposed evaporative emissions standards.

## 7. NMOG+NO$_X$ Provisions Aligned With CARB ACC II Program

EPA proposes the adoption of three NMOG+NO$_X$ provisions for light-duty vehicles (LDV, LDT, MDPV) aligned with the CARB ACC II program. Each provision addresses frequently encountered vehicle operating conditions that are not currently captured in EPA test procedures and produce significant criteria pollutant emissions. The operating conditions include high power cold starts in plug-in hybrid vehicles, early drive-away (*i.e.,* drive-away times shorter than in the FTP), and mid-temperature engine starts. EPA believes that the rationale and technical assessment performed by CARB applies not only for vehicles sold in California but for products sold across the country. EPA would require vehicle manufacturers to attest to meeting the three specific CARB ACC II program standards using CARB-defined test procedures.[522] The proposed phase-in for the three CARB ACC II program provisions is the same as for other criteria emissions standards and is described in Section III.C.1.

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[522] CARB Title 16, Section 1961.4. Final Regulation Order. Exhaust Emission Standards and Test Procedures—2026 and Subsequent Model Year Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles.

i. PHEV High Power Cold Starts

The first provision addresses NMOG+NO$_X$ emissions from PHEV high power cold starts (HPCS), which is when a driver demands more torque than the battery and electric motor can supply, and the ICE is started and immediately produces high torque while also working to light off the catalyst. NMOG+NO$_X$ exhaust emissions for this provision are measured over the Cold Start US06 Charge-Depleting Emission Test, as described in, ''California Test Procedures for 2026 and Subsequent Model Year Zero-Emission Vehicles and Plug-in Hybrid Electric Vehicles, in the Passenger Car, Light-Duty Truck and Medium-Duty Vehicle Classes.'' [523]

EPA's proposed bin-specific standards are shown in Table 53. The bins are slightly different than the ACC II bins. Specifically, EPA is not proposing Bin 125, Bin 25 or Bin 15, as found in CARB ACC II, and is instead proposing Bin 10. EPA is proposing Step 1 of this provision to start with MY 2027, one year later than CARB, and for Step 2 of the provision to start in MY 2029, which is the same as CARB.

TABLE 53—HIGH POWER COLD START STANDARDS

Cold start US06 PHEV standards (150,000-mile durability vehicle basis)

| Vehicle emission category | NMOG+NO$_X$ (g/mi) | |
|---|---|---|
| | Step 1: 2027 to 2028 MY | Step 2: 2029+ MY |
| Bin 70 | 0.320 | 0.200 |
| Bin 60 | 0.280 | 0.175 |
| Bin 50 | 0.240 | 0.150 |
| Bin 40 | 0.200 | 0.125 |
| Bin 30 | 0.150 | 0.100 |
| Bin 20 | 0.100 | 0.067 |
| Bin 10 | 0.050 | 0.034 |

For Step 1, PHEVs with Cold Start US06 all-electric range of at least 10 miles are exempt from the standard. For Step 2, PHEVs with Cold Start US06 all-electric range of at least 40 miles are exempt from the standard. CARB testing identified several existing PHEVs that started on the US06 and met the standard by a small margin.

EPA requests comment on Step 2 of the PHEV HPCS standard, specifically whether the Step 2 standard should (1) be finalized as proposed, (2) have a start date later than MY 2029, (3) have an alternative stringency, either for all light-duty vehicles or just for LDT3 and LDT4, or (4) should be removed, leaving Step 1 to apply indefinitely. EPA encourages commenters to provide underlying data to support their comments, particularly addressing any technical challenges regarding the lead time or feasibility of the Step 2 standard. EPA will consider the comments along with any additional available data in assessing the Step 2 standards for the final rule.

ii. Early Driveaway

EPA is proposing NMOG+NO$_X$ emissions standards that address emissions from earlier gear engagement and drive-away described by the CARB ACC II program.[524] In a regular 25 °C FTP, gear engagement happens at 15 seconds and driveaway happens at 20 seconds, but studies have shown many drivers begin driving earlier than this. Vehicle manufacturers have historically designed their aftertreatment systems and controls to meet emissions standards based on the timing of the FTP drive away. However, given the existing field data regarding the propensity of drivers to drive off sooner than the delay represented in the FTP and that vehicle manufacturers have demonstrated that they are able to address and reduce the emissions associated with this event, EPA feels it is appropriate to require vehicle manufacturers to meet this ACC II requirement.

EPA believes that CARB has properly captured early driveaway vehicle operation in the test procedures developed for ACC II. The bin-specific standards are shown in Table 54, which are congruent with those of the ACC II program. The bins are slightly different than the ACC II bins. Specifically, EPA is not proposing Bin 125, Bin 25 or Bin 15, as found in ACC II, and is instead proposing Bin 10.

TABLE 54—EARLY DRIVEAWAY STANDARDS

| Vehicle emissions category | NMOG+NO$_X$ (g/mi) |
|---|---|
| Bin 70 | 0.082 |
| Bin 60 | 0.072 |
| Bin 50 | 0.062 |
| Bin 40 | 0.052 |
| Bin 30 | 0.042 |
| Bin 20 | 0.032 |
| Bin 10 | 0.022 |

Vehicles are exempt from the ACC II early driveaway bin standards if the vehicle prevents engine starting during the first 20 seconds of a cold-start FTP test interval and the vehicle does not use technology (*e.g.,* electrically heated catalyst) that would cause the engine or emission controls to be preconditioned such that NMOG+NO$_X$ emissions would be higher during the first 505 seconds of the early driveaway emission test compared to the NMOG+NO$_X$ emissions during the first 505 seconds of the standard FTP emission test.

iii. Intermediate Soak Mid-Temperature Starts

EPA also proposes to adopt a third provision defined by the CARB ACC II program that addresses NMOG+NO$_X$ emissions from intermediate soak mid-temperature starts.[525] Current EPA test

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[523] CARB Title 16, Section 1961.4. Final Regulation Order. Exhaust Emission Standards and Test Procedures—2026 and Subsequent Model Year Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles.

[524] CARB Title 16, Section 1961.4. Final Regulation Order. Exhaust Emission Standards and Test Procedures—2026 and Subsequent Model Year Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles.

[525] CARB Title 16, Section 1961.4. Final Regulation Order. Exhaust Emission Standards and

procedures capture emissions from vehicle cold start and vehicle hot start. However, many vehicles in actual operation experience starts after an intermediate time (*i.e.,* soak times between 10 minutes and 12 hours). Vehicle manufacturers are not currently required to control the emissions associated with these mid-temperature starts to the same degree that they manage cold and hot starts.

Tier 3 vehicles achieve low start emissions when soak times are short because the engine and aftertreatment are still hot from prior operation. Start emissions after long soak periods are addressed by the 12+ hour soak of the 25 °C FTP, which requires vehicle calibrations to quickly heat the catalyst and sensors from an engine at ambient temperature. The mid-temperature intermediate soak provision addresses emissions from intermediate soak times where the engine and aftertreatment have cooled but may still be warmer than ambient temperature.

Vehicle manufacturers have demonstrated that they are able to address and reduce the emissions associated with this type of event, and EPA feels it is appropriate to require vehicle manufacturers to meet this requirement. EPA believes that CARB has properly captured the vehicle operation in the test procedures they developed for ACC II.

The bin-specific proposed standards shown in Table 55, are congruent with those of the ACC II program. The bins are slightly different than the ACC II bins. Specifically, EPA is not proposing Bin 125, Bin 25, or Bin 15, as found in ACC II, and is instead proposing Bin 10.

Manufacturers would need to submit data at each of the three standards: 9–11 minutes for the 10-minute requirement, 39–41 minutes for the 40-minute requirement, and 5–7 hours for the 3–12 hour requirement, and attest to meeting the standards at other soak times by linearly interpolating between 10 minutes and 40 minutes, and between 40 minutes and 12 hours. The proposed intermediate soak mid-temperature standards are shown in Table 55.

TABLE 55—INTERMEDIATE SOAK MID-TEMPERATURE START STANDARDS

| Vehicle emissions category | 10-Minute soak NMOG+NO$_X$ (g/mi) | 40-Minute soak NMOG+NO$_X$ (g/mi) | 3–12 hour soak NMOG+NO$_X$ (g/mi) |
|---|---|---|---|
| Bin 70 | 0.035 | 0.054 | 0.070 |
| Bin 60 | 0.030 | 0.046 | 0.060 |
| Bin 50 | 0.025 | 0.038 | 0.050 |
| Bin 40 | 0.020 | 0.031 | 0.040 |
| Bin 30 | 0.015 | 0.023 | 0.030 |
| Bin 20 | 0.010 | 0.015 | 0.020 |
| Bin 10 | 0.005 | 0.008 | 0.010 |

EPA recognized that requiring compliance to an emissions standard represented by a curve requires more testing effort than requiring compliance to a point standard and thus requests comment on whether to simplify the compliance requirements of this provision, in light of benefits and costs.

### 8. Elimination of Commanded Enrichment for Power or Component Protection

EPA is proposing to eliminate the allowance of the use of commanded enrichment as an AECD on SI engines used in light-duty vehicles and MDV for either power or component protection during normal operation and use. Normal operation is defined at 40 CFR 86.1803–01 to include vehicle speeds and grades of public roads, and vehicle loading and towing within manufacturer recommendations, even if the operation occurs infrequently. Commanded enrichment includes lean best torque enrichment.

Brief rich excursions are allowed during (1) engine start, (2) lambda dithering[526] or slight lambda biasing to achieve optimal three-way catalyst (TWC) conversion efficiency of criteria emissions, (3) catalyst re-wetting after deceleration fuel cut off (DFCO), (4) brief lambda excursions during engine transients, (5) intrusive OBD monitoring of aftertreatment, evaporative canister purge valve, etc., and (6) in vehicle ‘‘limp-home’’ operation where the malfunction indicator light (MIL, commonly known as the ‘‘check engine light’’) or other warning systems are triggered.

Most current vehicles incorporate AECDs that utilize enrichment (*i.e.,* commanding air/fuel ratio less than the stoichiometric air/fuel ratio) for the purpose of protecting components in the exhaust system from thermal damage during normal operation and use. Some vehicles incorporate similar strategies for the purpose of increasing the power output of the engine. Such strategies significantly reduce the effectiveness of the aftertreatment system.

Technologies exist that can prevent thermal damage of engine and/or exhaust system components without the use of enrichment during normal operation and use (see DRIA Chapter 3 for technology discussion). Modern vehicles have sufficient power without the use of enrichment. The use of enrichment only has the potential to incrementally increase power but significantly reduces the effectiveness of the catalytic aftertreatment system, resulting in a ten-fold or greater increase of CO and HC emissions.

EPA requests comment on the proposed prohibition of commanded enrichment as an AECD, including analyses of benefits and costs, and additional exceptions where brief rich operation should be allowed.

### 9. Averaging, Banking, and Trading Provisions

Section III.B.4 describes averaging, banking, and trading (ABT) credit provisions included in the proposed GHG program and the basis for providing them. ABT provisions are also included in the proposed criteria pollutant program for NMOG+NO$_X$ standards. ABT has a long history for both light duty and heavy duty vehicles and EPA is not reopening or soliciting comment on the basic structure of the ABT program for criteria pollutants or GHG.

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Test Procedures—2026 and Subsequent Model Year Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles.

[526] Lambda dithering is an engine-TWC control strategy that commands or allows small fluctuations in exhaust lambda that can expand the lambda range over which a TWC exhibits good conversion of hydrocarbons, carbon monoxide and oxides of nitrogen. Lambda is actual air fuel ratio divided by stoichiometric air fuel ratio.

As introduced in Sections III.C.1 and III.C.2, EPA is proposing to allow light-duty vehicle (LDV, LDT, MDPV) 25 °C FTP NMOG+$NO_X$ credits to be transferred into the proposed program up to the end of the Tier 3 five-year credit life. Light-duty vehicle −7 °C FTP NMHC credits may also be transferred into the proposed program on a 1:1 basis for −7 °C FTP NMOG+$NO_X$ credits up to the end of the five-year credit life. EPA is proposing to consider −7 °C FTP NMHC credits to be equal in value and freely exchangeable with the credits corresponding to the proposed −7 °C FTP NMOG+$NO_X$ standards.

EPA proposes that MDV (Class 2b and 3 vehicles) 25 °C FTP NMOG+$NO_X$ credits may only be transferred into the proposed program if a manufacturer selects the early compliance schedule for MDV. If so, these MDV credits may be transferred into the program up to the end of the Tier 3 five-year credit life. There were no −7 °C FTP NMHC or NMOG+$NO_X$ standards for MDV in Tier 3 so there are no MDV −7 °C FTP credits to transfer.

New credits may be generated, banked, and traded within the new program to provide manufacturers with flexibilities in developing compliance strategies.

### *D. Proposed Modifications to the Medium-Duty Passenger Vehicle Definition*

In EPA's 2000 Tier 2 criteria pollutant rule, EPA established a new medium-duty passenger vehicle (MDPV) regulatory classification [527] to bring passenger vehicles over 8,500 pounds GVWR into the Tier 2 program.[528] EPA created the MDPV classification under the Tier 2 program because the agency determined that a portion of the MDV fleet was predominantly being utilized as passenger vehicles instead of being used for ''work,'' for example, to transport goods or pull trailers. These larger vehicles were driven in the same way as passenger vehicles, despite the fact their weight threshold put them in the HD category, and from an emissions control standpoint we found it was feasible for these vehicles to meet the same set of emissions standards as other passenger vehicles. The MDPV definition was focused primarily on the largest SUVs and passenger vans above 8,500 pounds GVWR. These vehicles would have otherwise remained subject to less stringent heavy-duty vehicle standards. When EPA established its GHG standards in 2010, EPA included MDPVs in the light-duty vehicle GHG program as well. Essentially, MDPVs are heavy-duty vehicles that are included in light-duty vehicle programs.

As we did in the Tier 2 rule, we are once again cognizant of potential market changes that could move passenger vehicles out of the LD regulatory class, and we have examined changes to the MDPV definition to avoid this situation. For example, the new GM Hummer pickup and SUVs are over 10,000 pounds GVWR due to battery weight but do not have significant work capabilities (*e.g.,* towing and hauling), as measured by the work factor, relative to other vehicles in the MDV category. EPA is proposing two modifications to the MDPV definition starting in MY 2027 to address passenger vehicles that could potentially fall outside the current definition. First, EPA is proposing to include in the MDPV definition any passenger vehicles at or below 14,000 pounds GVWR with a work factor at or below 5,000 pounds except for pickups with an open bed interior length of eight feet or larger which would continue to be excluded from the MDPV category.[529] This modification would address new BEVs that are primarily passenger vehicles but fall above the current 10,000 pound MDPV threshold primarily due to battery pack weight increasing the vehicle's GVWR. EPA believes these vehicles should be in the light-duty vehicle program because they are passenger vehicles and would likely displace the purchase of other passenger vehicles rather than a heavy-duty vehicle due to their relatively low utility. In selecting the proposed 5,000-pound work factor cut point, EPA reviewed current vehicle offerings and does not believe this threshold would pull into the MDPV category a significant number of work vans or trucks. EPA requests comment on this approach for addressing heavy passenger vehicles as well as other approaches that might more effectively capture these types of new vehicles.

Currently, the MDPV category generally includes pickups below 10,000 pounds GVWR with an open cargo bed length of less than six feet (72.0 inches). The second proposed MDPV definition modification is to include in the MDPV category any pickups with a GVWR below 9,900 pounds and an interior bed length less than eight feet regardless of whether the vehicle work factor is above 5,000 pounds. Pickups at or above 9,900 pounds up to 14,000 pounds GVWR with a work factor above 5,000 pounds would be included as MDPVs only if their interior bed length is less than six feet.

Currently, there is a clear distinction between pickups in the light-duty vehicle category and those in the medium-duty category. Light-duty pickups are those pickups with a GVWR at or below 8,500 pounds and they currently generally have a GVWR below 8,000 pounds. MD pickups are those pickups that are at or above 8,501 pounds and all such vehicles currently have a GVWR above 9,900 pounds.[530] The proposed changes to the MDPV definition are intended to account for any new pickup offerings that would fall into the GVWR ''space'' at or above 8,501 pounds but below 9,900 pounds. EPA is not aware of any current or planned products that would be covered by this proposed modification. However, EPA is concerned that differences between the light-duty and medium-duty pickups could become blurred if manufacturers were to offer somewhat more capable pickups with GVWR just above 8,500 pounds. Manufacturers could in essence move their light-duty pickups up into the medium-duty category through relatively minor vehicle modifications. EPA believes it is appropriate to address this possibility given that the light-duty vehicle footprint standards, as proposed, would be more stringent compared to the proposed work factor-based standards for MDVs and could provide an unintended incentive for manufacturers to take such an approach. EPA requests comment on this proposed change in the MDPV category.

Table 56 summarizes the MDPV proposal in terms of what vehicles would not be covered as MDPVs under EPA's proposed changes to the qualifying criteria.

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[527] 65 FR 6697 (February 10, 2000) at 6749.

[528] EPA defined medium-duty passenger vehicles as any complete heavy-duty vehicle less than 10,000 pounds GVWR designed primarily for the transportation of persons including conversion vans (*i.e.,* vans which are intended to be converted to vans primarily intended for the transportation of persons). The definition does not include any vehicle that (1) has a capacity of more than 12 persons total or, (2) that is designed to accommodate more than 9 persons in seating rearward of the driver's seat or, (3) has a cargo box (*e.g.,* a pickup box or bed) of six feet or more in interior length.

[529] In the proposed regulatory text, EPA is proposing that pickups with an interior bed length of 94 inches or greater would be excluded, which would exclude pickups with eight-foot beds (96 inches) with a 2-inch allowance for vehicle design variability. This also applies for the second change to the MDPV definition.

[530] Currently, these pickups are covered by HDV standards in 40 CFR 86.1816–18.

TABLE 56—SUMMARY OF EXCLUSIONS FOR THE PROPOSED REVISED MDPV DEFINITION

A vehicle would not be an MDPV if:

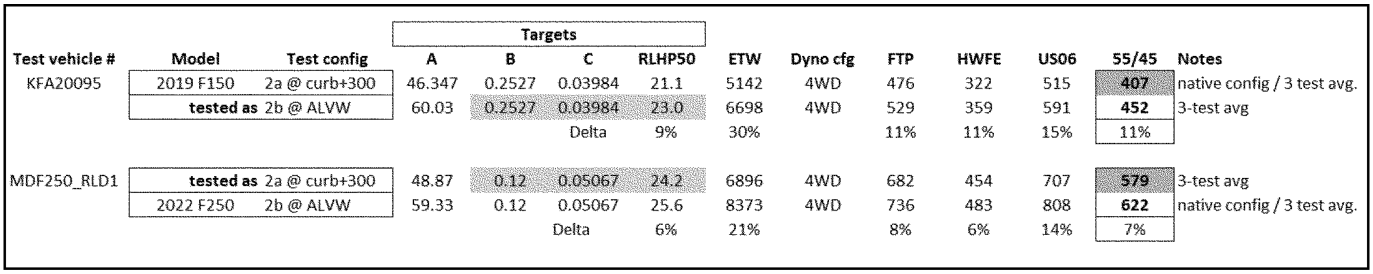
| | Work factor (WF) | |
|---|---|---|
| | WF <5,000 lbs. | WF >5,000 lbs. |
| GVWR <9,900 lbs | bed length >94.0 inches | bed length >94.0 inches. |
| 9,900 lb ≤GVWR ≤14,000 lbs | bed length >94.0 inches | bed length >72.0 inches. |

Finally, EPA is also clarifying that MDPVs will include only vehicles with seating behind the driver's seat such that vehicles like cargo vans and regular cab pickups with no rear seating would remain in the MDV category and subject to work factor-based standards regardless of the proposed changes to the MDPV definition. Also, pickups with 8-foot beds would continue to be excluded from the MDPV category under all circumstances. Prior to MY 2027, EPA proposes that a manufacturer may optionally place vehicles that are brought into the MDPV category by the proposed MDPV definition revisions into the light-duty vehicles program rather than the MDV program. Due to lead time concerns, EPA is proposing that the changes would be mandatory starting in MY 2027. In addition, for the proposed Tier 4 criteria pollutant standards discussed in Section III.C, manufacturers opting for the Tier 4 full lead time optional standards would not be required to include vehicles meeting the revised MDPV definition in their Tier 4 fleet calculations until their fleet is fully covered by the Tier 4 standards to ensure the program would be compliant with applicable CAA lead time requirements. In the meantime, manufacturers would continue to certify those vehicles to the Tier 3 standards for heavy-duty vehicles in 40 CFR 86.1816–18. EPA requests comment on its proposed revisions to the MDPV category including timing of implementation.

Historically, consumers without the need for the additional utility offered by medium-duty pickups have sound reasons for buying the light-duty versions. Medium-duty versions compared to their light-duty counterparts tend to be higher priced, less fuel efficient, less maneuverable, and may also have a harsher ride when unloaded due to heavier suspensions. However, EPA recognizes that there is the possibility that the pickup market could shift from light-duty versions to medium-duty versions of pickups due to consumer preference changes, but also due to manufacturer changes to vehicle designs and pricing and marketing strategies. At this time, EPA is not proposing to fundamentally change its program to pull a large portion of medium-duty pickups into the light-duty program to address this possibility due to the potential disruption such an approach would have both for the vehicle industry and for consumers needing highly capable work vehicles. EPA plans to monitor vehicle market trends over the next several years to identify any new trends that could potentially lead to the loss of emissions reductions, and if so, to explore appropriate ways to address such a situation. EPA is requesting comment on the potential likelihood of this type of market shift from the light- to the medium-duty sector, and potential ways to address the issue if needed in a future rulemaking.

EPA performed a study to assess the GHG increases of a medium duty pickup compared to a similar sized light-duty pickup when they are operated similarly as primarily unloaded vehicles transporting just the operator and also if they are lightly loaded with ½ the payload capacity. This comparison reflects the issue that medium-duty pickups have certain heavier duty design aspects (frames, axles, brakes, transmissions, etc.) intended for trailer towing work that negatively impact GHG emissions when they are only operated with lighter loads similar to the expected operation from a light-duty pickup.

Figure 18 summarizes the chassis test data for the F150 and the F250, each tested in its original configuration and alternative configuration (as a 2b for the F150, and as a 2a for the F250). The F250 with the 7.3L engine, tested at curb+300 pounds. ETW, emitted 172 g/mi more than the F150. Similarly, the F250 emitted 170 g/mi more than the F150 with both tested at ALVW.



| | | | Targets | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Test vehicle # | Model | Test config | A | B | C | RLHP50 | ETW | Dyno cfg | FTP | HWFE | US06 | 55/45 | Notes |
| KFA20095 | 2019 F150 | 2a @ curb+300 | 46.347 | 0.2527 | 0.03984 | 21.1 | 5142 | 4WD | 476 | 322 | 515 | **407** | native config / 3 test avg. |
| | **tested as** | 2b @ ALVW | 60.03 | 0.2527 | 0.03984 | 23.0 | 6698 | 4WD | 529 | 359 | 591 | **452** | 3-test avg |
| | | | | | Delta | 9% | 30% | | 11% | 11% | 15% | 11% | |
| MDF250_RLD1 | **tested as** | 2a @ curb+300 | 48.87 | 0.12 | 0.05067 | 24.2 | 6896 | 4WD | 682 | 454 | 707 | **579** | 3-test avg |
| | 2022 F250 | 2b @ ALVW | 59.33 | 0.12 | 0.05067 | 25.6 | 8373 | 4WD | 736 | 483 | 808 | **622** | native config / 3 test avg. |
| | | | | | Delta | 6% | 21% | | 8% | 6% | 14% | 7% | |

**Figure 18. Test data summary for F150 and F250.**

The GHG emission difference observed in the data indicates that light to medium load operation results in much higher $CO_2$ emissions in the medium-duty pickup under similar passenger or payload conditions. The medium-duty pickup is designed primarily for regular towing and therefore may have higher emissions under other operating conditions compared to light-duty pickups designed more for transportation of passengers or cargo in the bed.

*E. What alternatives did EPA consider?*

EPA is seeking comment on three alternatives to its proposed light-duty

GHG standards. Alternative 1 is more stringent than the proposal across the MY 2027–2032 time period, and Alternative 2 is less stringent. The proposal as well as Alternatives 1 and 2 all have a similar proportional ramp rates of year over year stringency, which includes a higher rate of stringency increase in the earlier years (MYs 2027–2029) than in the later years. Alternative 3 achieves the same stringency as the proposed standards in MY 2032 but provides for a more consistent rate of stringency increase for MY 2027–2031.

In selecting the stringencies for the alternatives, EPA assessed a range available technologies (including the costs and pace of deployment) along with the resulting emissions reductions associated with each alternative. Each of the stringency alternatives are supported by a set of feasible technologies. The Alternative 1 projected fleet-wide $CO_2$ targets are 10 g/mi lower on average than the proposed targets; Alternative 2 projected fleet-wide $CO_2$ targets averaged 10 g/mi higher than the proposed targets.[531] While the 20 g/mi range of stringency options may appear fairly narrow, for the MY 2032 standards the alternatives capture a range of 12 percent higher and lower than the proposed standards in the final year. Our goal in selecting the alternatives was to identify a range of stringencies that we believe are appropriate to consider for the final standards because they represent a range of standards that are anticipated to be feasible and are highly protective of human health and the environment.

While the proposed standards, Alternative 1 and Alternative 2 are all characterized by larger increases in stringency between in the earlier years than in the later years, Alternative 3 was constructed with the goal of evaluating roughly equal reductions in absolute g/mi targets over the duration of the program while achieving the same overall targets as the proposed standards by MY 2032. This has the effect of less stringent year-over-year increases in the early years of the program.

As noted elsewhere in this preamble, EPA may choose to update its modeling for the final rulemaking, *e.g.,* by updating inputs for costs to reflect newly available information or to incorporate PHEV technology as outlined in the DRIA while considering information and views provided by stakeholders in public comments. Thus, we recognize that our cost estimates and assessments of feasibility may change, and EPA is soliciting comment on all of the model year standards of Alternatives 1, 2, and 3, and standards generally represented by the range across those alternatives. EPA anticipates that the appropriate choice of final standards within this range will reflect the Administrator's judgments about the uncertainties in EPA's analyses as well as consideration of public comment and updated information where available. However, EPA proposes to find that standards substantially more stringent than Alternative 1 would not be appropriate because of uncertainties concerning the cost and feasibility of such standards. EPA proposes to find that standards substantially less stringent than Alternative 2 would not be appropriate because they would forgo feasible emissions reductions that would improve the protection of public health and welfare.

Table 57 and Table 58 give the details for the car and truck curves for Alternative 1, and Table 59 and Table 60 give details for Alternative 2. Table 61 and Table 62 provide details for Alternative 3 for cars and trucks.

TABLE 57—FOOTPRINT-BASED STANDARD CURVE COEFFICIENTS FOR CARS—ALTERNATIVE 1

| | 2027 | 2028 | 2028 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| MIN $CO_2$ (g/mi) | 121.3 | 104.4 | 87.2 | 79.7 | 71.5 | 62.0 |
| MAX $CO_2$ (g/mi) | 129.6 | 111.0 | 92.3 | 83.9 | 75.3 | 65.3 |
| Slope (g/mi/ft2) | 0.59 | 0.51 | 0.42 | 0.38 | 0.34 | 0.30 |
| Intercept (g/mi) | 96.4 | 82.6 | 68.6 | 62.4 | 56.0 | 48.6 |
| MIN footprint (ft2) | 42 | 43 | 44 | 45 | 45 | 45 |
| MAX footprint (ft2) | 56 | 56 | 56 | 56 | 56 | 56 |

TABLE 58—FOOTPRINT-BASED STANDARD CURVE COEFFICIENTS FOR TRUCKS—ALTERNATIVE 1

| | 2027 | 2028 | 2028 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| MIN $CO_2$ (g/mi) | 124.3 | 108.6 | 92.0 | 85.3 | 76.5 | 66.5 |
| MAX $CO_2$ (g/mi) | 198.4 | 168.1 | 138.0 | 124.0 | 111.2 | 96.7 |
| Slope (g/mi/ft2) | 2.39 | 2.05 | 1.70 | 1.55 | 1.39 | 1.21 |
| Intercept (g/mi) | 23.9 | 20.5 | 17.0 | 15.5 | 13.9 | 12.1 |
| MIN footprint (ft2) | 42 | 43 | 44 | 45 | 45 | 45 |
| MAX footprint (ft2) | 73 | 72 | 71 | 70 | 70 | 70 |

TABLE 59—FOOTPRINT-BASED STANDARD CURVE COEFFICIENTS FOR CARS—ALTERNATIVE 2

| | 2027 | 2028 | 2028 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| MIN $CO_2$ (g/mi) | 140.5 | 123.8 | 106.6 | 99.2 | 91.0 | 81.5 |
| MAX $CO_2$ (g/mi) | 150.1 | 131.6 | 112.8 | 104.5 | 95.8 | 85.9 |
| Slope (g/mi/ft2) | 0.69 | 0.60 | 0.52 | 0.48 | 0.44 | 0.39 |
| Intercept (g/mi) | 111.6 | 97.9 | 83.9 | 77.7 | 71.3 | 63.9 |
| MIN footprint (ft2) | 42 | 43 | 44 | 45 | 45 | 45 |
| MAX footprint (ft2) | 56 | 56 | 56 | 56 | 56 | 56 |

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[531] For reference, the targets at a footprint of 50 square feet were exactly 10 g/mi lower and greater for the alternatives.

TABLE 60—FOOTPRINT-BASED STANDARD CURVE COEFFICIENTS FOR TRUCKS—ALTERNATIVE 2

| | 2027 | 2028 | 2028 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| MIN $CO_2$ (g/mi) | 141.7 | 126.3 | 110.0 | 103.6 | 94.8 | 84.8 |
| MAX $CO_2$ (g/mi) | 226.1 | 195.4 | 165.0 | 150.7 | 137.9 | 123.4 |
| Slope (g/mi/ft2) | 2.72 | 2.38 | 2.04 | 1.88 | 1.72 | 1.54 |
| Intercept (g/mi) | 27.2 | 23.8 | 20.4 | 18.8 | 17.2 | 15.4 |
| MIN footprint (ft2) | 42 | 43 | 44 | 45 | 45 | 45 |
| MAX footprint (ft2) | 73 | 72 | 71 | 70 | 70 | 70 |

TABLE 61—FOOTPRINT-BASED STANDARD CURVE COEFFICIENTS FOR CARS—ALTERNATIVE 3

| | 2027 | 2028 | 2028 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| MIN $CO_2$ (g/mi) | 135.9 | 123.8 | 110.6 | 98.2 | 85.3 | 71.8 |
| MAX $CO_2$ (g/mi) | 145.2 | 131.6 | 117.0 | 103.4 | 89.8 | 75.6 |
| Slope (g/mi/ft2) | 0.66 | 0.60 | 0.54 | 0.47 | 0.41 | 0.35 |
| Intercept (g/mi) | 108.0 | 97.9 | 87.0 | 76.9 | 66.8 | 56.2 |
| MIN footprint (ft2) | 42 | 43 | 44 | 45 | 45 | 45 |
| MAX footprint (ft2) | 56 | 56 | 56 | 56 | 56 | 56 |

TABLE 62—FOOTPRINT-BASED STANDARD CURVE COEFFICIENTS FOR TRUCKS—ALTERNATIVE 3

| | 2027 | 2028 | 2028 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| MIN $CO_2$ (g/mi) | 150.3 | 136.8 | 122.7 | 108.8 | 91.8 | 75.7 |
| MAX $CO_2$ (g/mi) | 239.9 | 211.7 | 184.0 | 158.3 | 133.5 | 110.1 |
| Slope (g/mi/ft2) | 2.89 | 2.58 | 2.27 | 1.98 | 1.67 | 1.38 |
| Intercept (g/mi) | 28.9 | 25.8 | 22.7 | 19.8 | 16.7 | 13.8 |
| MIN footprint (ft2) | 42 | 43 | 44 | 45 | 45 | 45 |
| MAX footprint (ft2) | 73 | 72 | 71 | 70 | 70 | 70 |

The proposed standards will result in industry-wide average GHG emissions target of 82 g/mi of $CO_2$ in MY 2032, representing a 56 percent reduction in average emissions levels from the existing MY 2026 standards established in 2021. Alternative 1 is projected to result in an industry-wide average target for the light-duty fleet of 72 g/mi in MY 2032, representing a 61 percent reduction in projected fleet average GHG emissions target levels from the existing MY 2026 standards. Alternative 2 is projected to result in an industry-wide average target of 92 g/mile of $CO_2$ in MY 2032, representing a 50 percent reduction in projected fleet average GHG emissions target levels from the existing MY 2026 standards. Alternative 3 would result in the same MY 2032 industry-wide target as the proposed standards (82 g/mi) albeit at a more gradual rate, as shown in the less stringent targets prior to MY 2031.

Figure 19 compares the projected targets for the proposed standards and the alternatives. Further analysis of the alternatives is provided in Section IV.D.4.

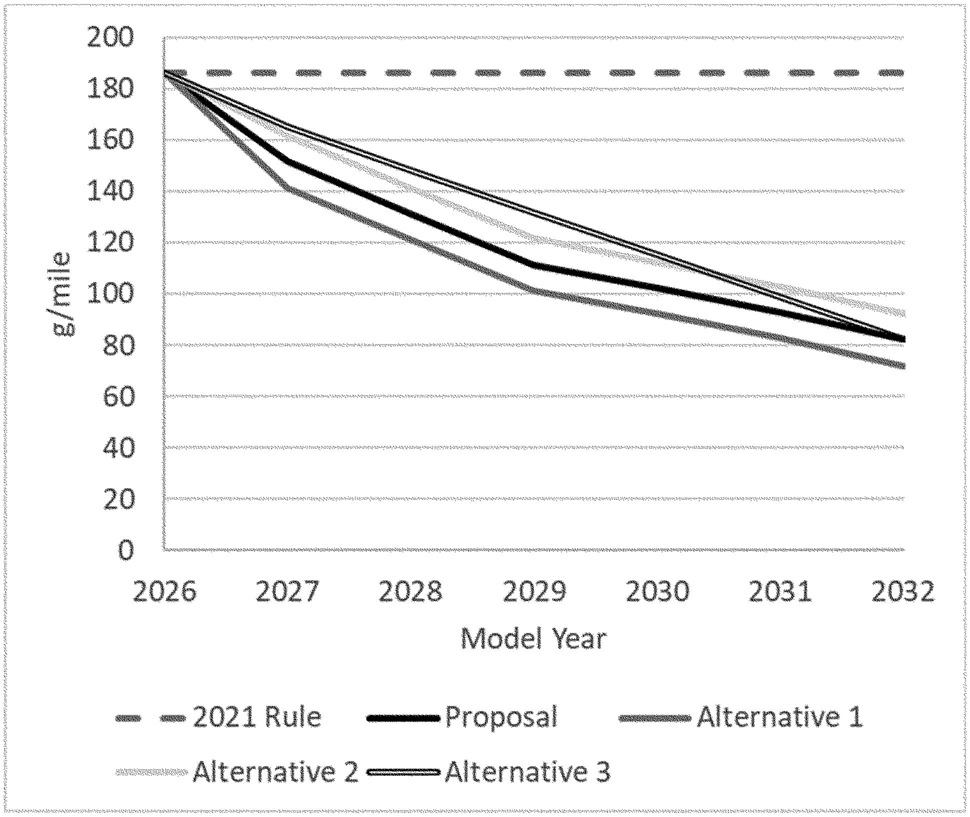

**Figure 19. Comparison of alternatives to proposed standards and 2021 rule stringency.**

### *F. Proposed Certification, Compliance, and Enforcement Provisions*

#### 1. Electric Vehicle Test Procedures

Under the current program, manufacturers and EPA test light-duty BEVs to determine the vehicle's miles per gallon equivalent (MPGe) and the vehicle range. PHEVs are also tested to determine the PHEV's charge depleting range. The results of these tests are used to generate range and fuel economy values published on the fuel economy label.

Currently, BEV testing consists of performing a full charge-depleting test using the multi-cycle test (MCT) outlined in the 2012 or 2017 version of SAE standard J1634, Battery Electric Vehicle Energy Consumption and Range Test Procedure. The multi-cycle test consists of 8 cycles: Four urban dynamometer driving schedule (UDDS) cycles, two highway fuel economy test (HFET) cycles, and two constant speed cycles (CSCs). The test is used to determine the vehicle's usable battery energy (UBE) in DC Watt-hours, cycle energy consumption in Watt-hours per mile (Wh/mi), and AC recharge energy in AC watt-hours. These results are used to determine the BEV's unadjusted range and MPGe.

The MCT generates unadjusted city (UDDS) and highway (HFET) two-cycle test results. These results are adjusted to 5-cycle values which are then published on the fuel economy label. EPA regulations allow manufacturers to multiply their two-cycles using a defined 0.7 adjustment factor or determine a BEV 5-cycle adjustment factor by running all of the EPA 5-cycle tests (FTP, HFET, US06, SC03, and 20 °F FTP). This adjustment is performed to account for the differences between vehicle operation observed on the two-cycle tests and vehicle operation occurring at higher speeds and loads along with hot and cold ambient temperatures not seen on the UDDS or HFET cycles.

PHEVs include both an internal combustion engine and an electric motor and can be powered by the battery or engine or a combination of both power devices. Charge depleting operation is when the electric motor is primarily propelling the vehicle with energy from the battery. Charge sustaining operation is when the internal combustion engine is contributing energy to power the vehicle and maintain a specific state of charge. PHEVs are tested in both charge depleting and charge sustaining operation to determine the electrical range capability of the vehicle and the charge sustaining fuel economy.

PHEV charge depletion testing consists of performing a single cycle charge depleting UDDS test and a single cycle charge depleting HFET test. These tests are specified in the 2010 version of SAE Standard J1711, Recommended Practice for Measuring the Exhaust Emissions and Fuel Economy of Hybrid-Electric Vehicles, Including Plug-In Hybrid Vehicles. The result of these tests is the actual charge depleting distance the vehicle can drive. The actual charge depleting distance is multiplied by a 0.7 adjustment factor to determine the 5-cycle charge depleting range. The UDDS and HFET distances are averaged to determine an estimated all-electric range for the vehicle. SAE Standard J1711 does not specify a methodology for determining UBE when performing charge depleting tests on PHEVs.

As part of this rulemaking, EPA is proposing to adopt battery durability and warranty requirements for light-duty and medium-duty BEVs and PHEVs (see Sections III.F.2 and III.F.3). The adoption of battery durability requirements would create a requirement for additional testing of

BEVs and PHEVs by manufacturers to be performed several times during their useful life, and reporting requirements to demonstrate that the vehicles are meeting the proposed durability requirements.

As described in Section III.F.2, the proposed battery durability program would require manufacturers to develop and implement an on-board battery state-of-health monitor and demonstrate its accuracy through in-use vehicle testing. For this testing, the tests would be based on the currently-used charge depletion tests that are used for range and fuel economy labeling of light-duty BEVs and PHEVs, with the addition of the recording of the vehicle monitor value and comparison of the results from the charge depleting test to the monitor value reported by the vehicle. Specifically, light-duty and Class 2b and 3 BEVs would be tested according to the MCT to determine the vehicle's UBE and range. PHEVs would be tested according to the single cycle UDDS and HFET test to determine the vehicle's charge depleting UBE and range. Class 2b and 3 BEVs and PHEVs would be tested at adjusted loaded vehicle weight (ALVW),[532] consistent with the testing required for measuring criteria and GHG emissions. These testing requirements are described in more detail in Section III.F.2.

In addition to manufacturers performing these dynamometer tests, onboard state-of-health monitor values would be collected from a larger sample of in-use vehicles to demonstrate that the vehicles are meeting the durability requirements, as described further in Section III.F.2. This would not involve additional dynamometer testing but only acquisition of monitor data from in-use vehicles.

The calculations performed for the PHEV charge depleting tests would have an additional step to determine the total charge depletion energy during the single cycle tests. Currently, PHEV charge depletion testing consists of observing when the vehicle is no longer depleting the battery by measuring the net ampere-hours. Once this measurement determines that the vehicle has switched to a mode in which it is maintaining rather than depleting the battery charge, the conclusion of the charge depletion test is identified.

To determine UBE for a PHEV, EPA is proposing that manufacturers measure the DC discharge energy of the PHEV's rechargeable energy storage system (RESS, *i.e.* the high-voltage battery) by measuring the change in state-of-charge in ampere-hours over each cycle and the average voltage of each cycle as required by SAE J1711. The average voltage can be either an average of continuous voltage measurements over the entire cycle, or the average voltage measured prior to the start of the cycle and at the conclusion of the cycle as defined in SAE J1711. The measured DC discharge energy in watt-hours for each cycle would be determined by multiplying the average cycle voltage by the cycle's change in ampere-hours. The DC discharge energy is added for all the charge depleting cycles including the transition cycles used to determine the charge depleting cycle range, $R_{cdc}$ as defined in SAE J1711.

EPA is seeking comment regarding this proposed methodology for determining UBE for PHEVs using the data captured during full charge testing according to the 2010 version of SAE J1711.

EPA is also seeking comment regarding the proposed use of the method described for light-duty vehicle with SAE J1711 for determining UBE for Class 2b and 3 PHEVs. In addition, EPA is seeking comment on whether to perform the tests on Class 2b and 3 PHEVs at ALVW as proposed, or at loaded vehicle weight (LVW), which is curb weight plus 300 pounds.

EPA is also seeking comment regarding the proposed use of the 2017 version of SAE J1634 for determining UBE for class 2b and 3 BEVs. In addition, EPA is seeking comment on whether to perform charge depleting tests on Class 2b and 3 BEVs at ALVW as proposed, or at loaded vehicle weight (LVW), which is curb weight plus 300 pounds.

EPA is not reopening or proposing changes to the MCT test for testing BEVs.

2. Battery Durability

EPA emissions standards are currently and have historically been standards that apply for the full useful life of the vehicle, as is required under CAA section 202(a)(1) (''Such standards shall be applicable to such vehicles and engines for their useful life''). Accordingly, EPA has historically required manufacturers to demonstrate the durability of their engines and emission control systems on vehicles with ICE engines including under our CAA section 206 authority, and has also specified minimum warranty requirements for ICE emission control components. Without durability demonstration requirements, EPA would not be able to assess whether vehicles originally manufactured in compliance with relevant emissions standards would remain compliant over the course of their useful life. Recognizing that PEVs are playing an increasing role in automakers' compliance strategies, and that emissions credit calculations are based on mileage over a vehicle's full useful life, the same logic applies to PEV durability. Under 40 CFR 86.1865–12(k), credits are calculated by determining the grams/mile each vehicle achieves beyond the standard and multiplying that by the number of such vehicles and a lifetime mileage attributed to each vehicle (195,264 miles for passenger automobiles and 225,865 miles for light trucks). Having a lifetime mileage figure for each vehicle is integral to calculating the credits attributable to that vehicle, whether those credits are used for calculating compliance with fleet average standards, or for banking or trading. Compliance with fleet average standards in particular depends on all vehicles in the fleet achieving their certified level of emissions performance throughout their useful life. Without durability requirements applicable to PEVs guaranteeing certain performance over the entire useful life of the vehicles, EPA has no guarantee that a manufacturer's overall compliance with fleet emissions standards would continue throughout that useful life. Similarly, EPA would have no assurance that the proposed standards would achieve the emissions reductions projected by this proposed program. Therefore, EPA is proposing new battery durability monitoring and performance requirements for light-duty BEVs and PHEVs, and battery durability monitoring requirements for Class 2b and 3 BEVs and PHEVs, beginning with MY 2027.

As implemented by manufacturers in current BEVs and PHEVs, lithium-ion battery technology has been shown to be effective and durable for use in these vehicles. It is also well known that the energy capacity of a battery will naturally degrade to some degree with time and usage, resulting in a reduction in driving range as the vehicle ages. The degree of this energy capacity and range reduction effectively becomes an issue of durability if it negatively affects how the vehicle can be used, or how many miles it is likely to be driven during its useful life.

HEV and PHEV manufacturers are currently required to account for potential battery degradation that could result in an increase in $CO_2$ emissions. In addition, vehicle manufacturers are required to demonstrate compliance with criteria pollutant standards using

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[532] ALVW is the numerical average of vehicle curb weight and gross vehicle weight rating.

fully aged emission control components that represent expected degradation during useful life. EPA is applying this well-established requirement to the durability of BEV and PHEV batteries.

The importance of battery durability in the context of zero- and near-zero emission vehicles, such as BEVs and PHEVs, has been cited by several authorities in recent years. In their 2021 Phase 3 report,[533] the National Academies of Science (NAS) identified battery durability as an important issue with the rise of electrification.[534] Several rulemaking bodies have also recognized the importance of battery durability in a world with rapidly increasing numbers of zero-emission vehicles. In 2015 the United Nations Economic Commission for Europe (UN ECE) began studying the need for a Global Technical Regulation (GTR) governing battery durability in light-duty vehicles. In April 2022 it published United Nations Global Technical Regulation No. 22, ''In-Vehicle Battery Durability for Electrified Vehicles,'' [535] or GTR No. 22, which provides a regulatory structure for contracting parties to set standards for battery durability in light-duty BEVs and PHEVs.[536] The European Commission and other contracting parties have also recognized the importance of durability provisions and are working to adopt the GTR standards in their local regulatory structures. In addition, the California Air Resources Board, as part of the Advanced Clean Cars II (ACC II) program, has also included battery durability [537] and warranty [538] requirements as part of a suite of customer assurance provisions designed to ensure that zero-emission vehicles maintain similar standards for usability, useful life, and maintenance as for ICE vehicles. Additional background on UN GTR No. 22 and the California Air Resources Board battery durability and warranty requirements may be found in DRIA Chapter 1.3.

EPA concurs with the emerging consensus that battery durability is an important issue. The ability of a zero-emission vehicle to achieve the expected emission reductions during its lifetime depends in part on the ability of the battery to maintain sufficient driving range, capacity, power, and general operability for a period of use comparable to that expected of a conventional vehicle. Durable and reliable electrified vehicles are therefore critical to ensuring that projected emissions reductions are achieved by this proposed program.

Vehicle manufacturers can use powertrain electrification as an emissions control technology to comply with EPA standards and to generate credits for use in averaging, banking, and trading. EPA believes that, as with other emission control technologies, it is appropriate to set requirements to ensure that electrified vehicles certifying to EPA standards are durable and capable of providing the emissions reductions for which they are credited under the structure of the rule. To expand on the previous discussion, under the EPA GHG program, vehicles of all types (including ICE vehicles as well as PEVs) are assessed on a fleet average basis in which credits that are generated by vehicles that over-comply with their footprint-based standard act to offset debits generated by vehicles that do not themselves meet the proposed standards, and these credits can also be traded among manufacturers. Credits and debits are based on a calculation of Megagrams of $CO_2$ emitted per vehicle over the assumed lifetime mileage of 195,264 miles for cars, and 225,865 miles for light-duty trucks. Generally, credits generated by PEVs will offset debits generated by ICE vehicles. In order for the environmental benefits that are credited to PEVs to be fully realized under this structure, it is important that their potential to achieve a similar mileage during their lifetime be comparable to that of ICE vehicles, and this depends in part on the life of the battery. In particular, and especially for BEVs and PHEVs with shorter driving ranges, loss of a large portion of the original driving range capability as the vehicle ages could reduce total lifetime mileage and the ability for electric miles to displace conventional miles traveled. PHEVs could also experience higher fuel consumption and increased criteria pollutant emissions if the battery undergoes excessive degradation.

EPA is thus including in this proposal a requirement for battery durability that is applicable to BEVs and PHEVs. The requirements and general framework of the proposed battery durability program are largely identical to those outlined in GTR No. 22 and broadly parallel the GTR in terms of the minimum performance requirements, as well as the hardware, monitoring and compliance requirements, the associated statistical methods and metrics that apply to determination of compliance, and criteria for establishing battery durability and monitor families. We are proposing to incorporate the April 14, 2022, version of GTR No. 22 by reference, with the exception of some naming conventions and procedural changes required to adapt the GTR to EPA-based testing and compliance demonstration, and modification of some specific provisions (for example, not requiring an SOCR monitor).

The battery durability requirements consist of two primary components as shown in Table 63. The first component is a requirement for manufacturers to provide a customer-readable battery state-of-health (SOH) monitor for both light-duty and Class 2b and 3 BEVs and PHEVs. The second component is the definition of a minimum performance requirement (MPR) for the SOH of the high voltage battery, applicable only to light-duty BEVs and PHEVs. HEVs and FCEVs are not included in the scope of GTR No. 22 or the proposed durability program.

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[533] National Academies of Sciences, Engineering, and Medicine 2021. ''Assessment of Technologies for Improving Light-Duty Vehicle Fuel Economy 2025–2035''. Washington, DC: The National Academies Press. *https://doi.org/10.17226/26092.*

[534] Among the findings outlined in that report, NAS noted that: ''battery capacity degradation is considered a barrier for market penetration of BEVs,'' (p. 5–114), and that ''[knowledge of] real-world battery lifetime could have implications on R&D priorities, warranty provision, consumer confidence and acceptance, and role of electrification in fuel economy policy.'' (p. 5–115). NAS also noted that ''life prediction guides battery sizing, warranty, and resale value [and repurposing and recycling]'' (p. 5–115), and discussed at length the complexities of SOH estimation, life-cycle prediction, and testing for battery degradation (p. 5–113 to 5–115).

[535] United Nations Economic Commission for Europe, Addendum 22: United Nations Global Technical Regulation No. 22, United Nations Global Technical Regulation on In-vehicle Battery Durability for Electrified Vehicles, April 14, 2022. Available at: *https://unece.org/sites/default/files/2022-04/ECE_TRANS_180a22e.pdf.*

[536] EPA representatives chaired the informal working group that developed this GTR and worked closely with global regulatory agencies and industry partners to complete its development in a form that could be adopted in various regions of the world, including potentially the United States.

[537] State of California, California Code of Regulations, title 13, section 1962.4.

[538] State of California, California Code of Regulations, title 13, section 1962.8.

TABLE 63—APPLICABILITY OF BATTERY DURABILITY REQUIREMENTS TO LIGHT-DUTY AND CLASS 2b/3 VEHICLES

| Proposed requirement | Light-duty BEVs and PHEVs | Class 2b and 3 BEVs and PHEVs |
|---|---|---|
| Battery State of Health (SOH) Monitor | Yes | Yes. |
| Monitor accuracy requirement | Yes | Yes. |
| Minimum Performance Requirement (MPR) | Yes | No. |

Manufacturers would be required to install a battery SOH monitor which estimates, monitors, and communicates the vehicle's state of certified energy (SOCE) as defined in GTR No. 22, and which can be read by the vehicle owner. This would require manufacturers to implement onboard algorithms to estimate the current state of certified energy of the battery, in terms of its current usable battery energy (UBE) expressed as a percentage of the original UBE when the vehicle was new. The state of certified range (SOCR) monitor defined in GTR No. 22 would not be required.

For light-duty BEVs and PHEVs, the information provided by this monitor would be used for demonstrating compliance with a minimum performance requirement (MPR) which specifies a minimum percentage retention of the original UBE when the vehicle was new. As shown in Table 64, under the proposed rule, light-duty BEV and PHEV batteries would be subject to an MPR that requires them to retain no less than 80 percent of their original UBE at 5 years or 62,000 miles, and no less than 70 percent at 8 years or 100,000 miles.

TABLE 64—PROPOSED MINIMUM PERFORMANCE REQUIREMENTS

| Years or mileage | Light-duty BEVs and PHEVs | Class 2b and 3 BEVs and PHEVs |
|---|---|---|
| 5 years or 62,000 miles | 80 percent SOCE | N/A. |
| 8 years or 100,000 miles | 70 percent SOCE | N/A. |

In alignment with GTR No. 22, which does not currently subject UN ECE Category N vehicles of Category 2 (work vehicles that primarily carry goods) to the MPR requirement, Class 2b and 3 PEVs would not be subject to the MPR. In developing GTR No. 22, the EVE IWG chose not to set an MPR for Category 2 PEVs at this time, largely because the early stage of adoption of these vehicles meant that in-use data regarding battery performance of these vehicles was not readily available. MPR requirements for category 2 PEVs were therefore reserved for possible inclusion in a future amendment to the GTR, but monitoring requirements were retained in order to allow information on degradation to be collected from these vehicles to help inform a future amendment. For similar reasons, EPA is retaining the monitor requirement for Class 2b and 3 PEVs but is not requiring the MPR.

The proposed durability requirements would require manufacturers to perform testing beyond what is currently required. Currently, light-duty vehicle manufacturers are required to perform range testing on BEVs and PHEVs, the latter in Charge Depleting mode. These results are currently used to inform the fuel economy label and are not required for vehicle certification. Class 2b/3 vehicles do not currently have this requirement. Under the proposal, manufacturers would be required to determine and report the UBE of light-duty and Class 2b/3 BEVs and PHEVs when new, and demonstrate through in-use vehicle testing that the SOCE monitor meets an accuracy standard.

Under the proposal, manufacturers would group the PEVs that they manufacture into monitor families and battery durability families as defined in GTR No. 22 (and described in more detail in Section III.F.4). Because a certified UBE value is needed for vehicles in each durability family in order to determine monitor accuracy and compliance of that family with the MPR, and the testing program that is currently performed for fuel economy labeling purposes does not necessarily determine such a value for all vehicle configurations that would need it for durability purposes, additional testing of vehicles that would not otherwise need to be tested for labeling purposes may need to be performed at time of certification.

For both light-duty and medium-duty vehicles, as described in the ''Part A'' monitor accuracy provisions outlined in GTR No. 22, manufacturers will be required to meet a standard for accuracy of their on-board SOCE monitors. To determine the accuracy of the monitors, between 3 and 16 vehicles from each monitor family would be recruited and procured in-use at each of 1 year, 3 years, and 5 years. The onboard monitor values for SOCE would be recorded, and each vehicle would then be tested to determine actual (measured) UBE capability of the battery. As described in Section III.F.1, for this testing EPA is proposing to use SAE Standard J1634 for determining UBE for BEVs and is proposing a method for determining UBE for PHEVs based on SAE J1711. The UBE measured by the test would be used to calculate the measured SOCE of the battery, as the measured UBE divided by the certified UBE. The measured SOCE would be compared to the value reported by the SOCE monitor prior to the test. The accuracy of the SOCE monitor must be within 5 percent of the measured SOCE, as defined and determined via the Part A statistical method defined in GTR No. 22.

For light-duty vehicles, in a similar manner to the ''Part B'' compliance provisions of GTR No. 22, once having demonstrated Part A accuracy for the SOCE monitor of vehicles within a monitor family, manufacturers would demonstrate compliance with the MPR by collecting the values of the onboard SOCE monitors of a statistically adequate and representative sample of in-use vehicles, in general no less than 500 vehicles from each battery durability family that shares that monitor family, and reporting the data and results to EPA. The manufacturer would use good engineering judgment in determining that the sample is statistically adequate and representative of the in-use vehicles comprising each durability family, subject to specific provisions in the regulation and approval by EPA. Manufacturers may obtain this sample by any appropriate method, for example by over-the-air data collection or by other means. A battery durability family (described further in a later section) would pass if 90 percent or more of the monitor values read from the sample are above the MPR.

In the case that a monitor family fails the Part A accuracy requirement, the manufacturer would be required to recall the vehicles in the failing monitor family to bring the SOCE monitor into compliance, as demonstrated by passing the Part A statistical test with vehicles using the repaired monitor. In the case that a durability family fails the Part B durability performance requirement, manufacturers would have to adjust their credit balance to remove compliance credits previously earned by those vehicles.

For Part B, GTR No. 22 does not specify a means of data collection, although for many manufacturers it might most easily be achieved via means such as telematics (remote, wireless queries) which is becoming increasingly present in new vehicles. EPA is proposing that manufacturers may use any sampling technique which accurately collects data from the number of vehicles outlined in the GTR. For example, vehicle manufacturers may choose to physically connect to the required number of vehicles and read the SOCE values directly in lieu of a remote, telematics-based data collection.

Many of the organizations and authorities that have examined the issue of battery durability, including the UN Economic Commission for Europe (UN ECE), the European Commission, and the California Air Resources Board, have recognized that monitoring the state of a vehicle's full-charge driving range capability (instead of or in addition to UBE capability) as an indicator of battery durability performance may be an attractive option because driving range is a metric that is more directly experienced and understood by the consumer. To this end, GTR No. 22 requires manufacturers to install a state of certified range (SOCR) monitor in addition to an SOCE monitor. In developing GTR No. 22, the UN ECE felt that developing an accurate SOCR monitor may be more difficult than developing an SOCE monitor. In GTR No. 22 the SOCR monitor is therefore not required to be customer facing, and its information is collected only for information gathering purposes to inform the possible development of an SOCR-based performance requirement in the future. EPA also notes that the California Air Resources Board has based its ACC II battery durability requirement on a range metric instead of an SOCE metric. In this proposal, EPA is not proposing a requirement for an SOCR monitor and is not proposing that the durability performance requirement utilize a range-based metric. However, EPA recognizes the potential advantage that an accurate range-based metric may offer, as well as the value of collecting information to evaluate the performance of an SOCR monitor for possible future adoption. EPA requests comment on the inclusion of a requirement for an SOCR monitor and associated reporting requirements as specified in GTR No. 22.

EPA also recognizes that the California Air Resources Board durability program includes a specific provision that requires manufacturers to disclose and account for any battery reserve capacity that the manufacturer has chosen to initially withhold from use for release later in the life of the vehicle in order to maintain driving range or usable energy capacity after degradation has occurred. This provision of the California regulation is meant to allow consumers to know the state of chemical degradation of the battery independently of apparent range or energy capacity. Although EPA is not proposing a similar requirement, EPA requests comment on including a reserve capacity declaration requirement and use of reserve capacity information in calculating an SOCE or SOCR metric.

EPA also requests comment on all other aspects of the proposed battery durability standards, particularly with respect to: The minimum performance requirements, the testing and compliance requirements for Part A and Part B, and the possibility of adopting more stringent or less stringent battery durability standards.

Additional background on UN GTR No. 22 and the California Air Resources Board battery durability and warranty requirements may be found in DRIA Chapter 1.3.

### 3. Battery and Vehicle Component Warranty

EPA is also proposing new warranty requirements for BEV and PHEV batteries and associated electric powertrain components (*e.g.,* electric machines, inverters, and similar key electric powertrain components). The proposed warranty requirements build on existing emissions control warranty provisions by establishing specific new requirements tailored to the emission control-related role of the high-voltage battery and associated electric powertrain components in the durability and emissions performance of PEVs.

For light-duty BEVs and PHEVs, EPA is proposing to designate the high-voltage battery and associated electric powertrain components as specified major emission control components under CAA section 207(i)(2), subject to a warranty period of 8 years or 80,000 miles. For medium-duty (Class 2b and 3) BEVs and PHEVs, EPA is proposing to specify the warranty period of 8 years or 80,000 miles for the battery and associated electric powertrain components on such vehicles.

As described in the previous section, the National Academies of Science (NAS) in their 2021 Phase 3 report[539] identified battery warranty along with battery durability as an important issue with the rise of electrification. The proposed warranty requirements would be equivalent to those that EPA has the authority to require and has historically applied to other specified major emission control-related components for ICE vehicles under EPA's light-duty vehicle regulations, and would similarly implement and be under the authority of CAA section 207. EPA believes that this practice of ensuring a minimum level of warranty protection should be extended to the high-voltage battery and other electric powertrain components of BEVs and PHEVs for multiple reasons. Recognizing that BEVs and PHEVs are playing an increasing role in manufacturers' compliance strategies, the high-voltage battery and the powertrain components that depend on it are emission control devices critical to the operation and emission performance of BEVs and PHEVs, as they play a critical role in reducing the emissions of PHEVs and in allowing BEVs to operate with zero tailpipe emissions. Further, EPA anticipates that compliance with the proposed program is likely to be achieved with larger penetrations of BEVs and PHEVs than under the current program. Although the projected emissions reductions are based on a spectrum of control technologies, in light of the cost-effective reductions achieved, especially by BEVs, EPA anticipates most if not all automakers will include credits generated by BEVs and PHEVs as part of their compliance strategies, even if those credits are obtained from other manufacturers; thus this is a particular concern given that the calculation of credits for averaging (as well as banking and trading) depend on the battery and emission

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[539] National Academies of Sciences, Engineering, and Medicine 2021. ''Assessment of Technologies for Improving Light-Duty Vehicle Fuel Economy 2025–2035''. Washington, DC: The National Academies Press. *https://doi.org/10.17226/26092.*

performance being maintained for the full useful life of the vehicle. Additionally, warranty provisions are a strong complement to the proposed battery durability requirements. We believe that a component under warranty is more likely to be properly maintained and repaired or replaced if it fails, which would help ensure that credits granted for BEV and PHEV sales represent real emission reductions achieved over the life of the vehicle.

It is our assessment that the high-voltage battery systems and associated electric powertrain components of both light-duty and medium-duty BEVs and PHEVs qualify for warranty designation by the Administrator as provided under CAA section 207(i). The high-voltage battery and the powertrain components that depend on it are emissions control devices critical to the emissions performance of the vehicle, as they play a critical role in reducing the emissions of PHEVs, and in allowing BEVs to operate with zero tailpipe emissions.

CAA section 207(i)(1) specifies that the warranty period for light-duty vehicles is 2 years or 24,000 miles of use (whichever first occurs), except for specified major emission control components (SMECC) described in 207(i)(2), for which the warranty period is 8 years or 80,000 miles of use (whichever first occurs). For other vehicles, CAA 207(i)(1) specifies that the warranty period shall be the period established by the Administrator.

For light-duty vehicles, 207(i)(2) specifically identifies catalytic converters, electronic emissions control units (ECUs), and onboard emissions diagnostic devices as SMECC. Currently, BEV and PHEV battery and electric powertrain components are not so specified, which limits their coverage requirement to the 2 years or 24,000 miles of CAA section 207(i)(1), a period which EPA believes is not sufficient, given the importance of these components to the operation and emissions performance of these vehicles. As discussed in connection with battery durability, this is of particular concern given that the calculation of fleet average performance and of credits for banking and trading depend on the battery and emissions performance being maintained for the full useful life of the vehicle. However, to allow for designation of other pollution control components as SMECC, CAA section 207(i)(2) provides that the Administrator may so designate any other pollution control device or component, subject to the conditions that the device or component was not in general use on vehicles and engines manufactured prior to the model year 1990 and that the retail cost (exclusive of installation costs) of such device or component exceeds $200 (in 1989 dollars), adjusted for inflation or deflation as calculated by the Administrator at the time of such determination.[540] Adjusted for inflation, the $200 retail cost threshold would be about $500 today. As BEVs and PHEVs were not in general use prior to 1990, and their high-voltage battery systems and associated powertrain components exceed this cost threshold, the Administrator proposes to determine that these emission control devices meet the criteria for designation as specified major emission control components. Accordingly, the Administrator proposes to designate these components as specified major emission control components according to his authority under CAA section 207(i)(2).

In addition, for medium-duty (Class 2b and 3) BEVs and PHEVs, the Administrator proposes to establish a warranty period of 8 years or 80,000 miles for the battery and associated electric powertrain components on these vehicles, according to his authority under CAA section 207(i)(1). The proposed program would provide warranty coverage for the emission control components on Class 2b and 3 BEVs and PHEVs equal to that proposed for the same components on light-duty BEVs and PHEVs.

EPA requests comment on all aspects of the proposed warranty provisions for light-duty and medium-duty PEVs, batteries, and associated electric powertrain components.

#### 4. Definitions of Durability Group, Monitor Family, and Battery Durability Family

EPA is proposing revisions to the durability group definition for vehicles with an IC engine, and proposing to add two new grouping definitions, monitor family and battery durability family, for BEVs and PHEVs.

##### i. Proposed Durability Group Revisions

EPA anticipates the adoption and use of gasoline particulate filters (GPFs) to reduce PM emissions to the levels required with the proposed PM standard. Particulate filters are currently utilized on diesel-powered vehicles to meet the existing Tier 3 PM standard. EPA's durability group definition in 40 CFR 86.1820–01 includes a catalyst grouping statistic based on the engine displacement and catalyst volume and loading to define the acceptable range of designs that may be combined into a single durability group. Currently EPA does not require manufacturers to consider PM filters in the determination of the durability group.

PM filters can also be coated with precious metals resulting in the particulate filter performing the functions of a three-way catalyst in addition to reducing particulates. The Agency expects that manufacturers may choose to adopt PM filters with three-way catalyst coatings on some applications to reduce aftertreatment system cost by not increasing the number of substrates. We are accordingly proposing to clarify that manufacturers need to include the volume and precious metal loading of the PM filter along with the corresponding values from catalyst when calculating the catalyst grouping statistic. The volume of the PM filter would not be included in the catalyst grouping statistic if the PM filter does not include precious metals.

The durability group is used to specify groups of vehicles which are expected to have similar emission deterioration and emission component durability characteristics throughout their useful life. The inclusion of a particulate filter on a gasoline-fueled vehicle aftertreatment system can have an impact on the durability characteristics of the aftertreatment system and as such the Agency proposes that this device, or the lack of a PM filter in the aftertreatment system, needs to be included in the durability group determination for internal combustion engine aftertreatment systems. Specifically, we are proposing that vehicles may be included in the same durability group only if all the vehicles have no particulate filter, or if all the vehicles have non-catalyzed particulate filters, or if all the vehicles have catalyzed particulate filters.

We are proposing to apply these updates to durability groups equally for both gasoline and diesel applications. However, diesel vehicles certified under 40 CFR part 86, subpart S, generally use a consistent configuration with particulate filters, so the proposed changes are not likely to lead to changes in certification practices for those vehicles.

We request comment on all aspects of the proposed changes for durability groups in 40 CFR 86.1820–01.

##### ii. BEV and PHEV Monitor Family

As described in Section III.F.2, EPA is proposing battery durability requirements for BEVs and PHEVs. As part of this durability proposal, the Agency is proposing two new groupings for BEVs and PHEVs, a monitor family and a battery durability family. For

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[540] See 42 U.S.C. 7541(i)(2).

BEVs, the new monitor family and new battery durability family would replace the current regulatory requirement to define BEV test and durability groups. Manufacturers would be required to define a durability group, test group, evaporative/refueling family, monitor family, and battery durability family for PHEVs.

To support the proposed monitor accuracy evaluation requirements described in Section III.F.2, manufacturers would install a battery SOH monitor which accurately estimates, monitors, and communicates the SOCE of the high-voltage battery (as defined in GTR No. 22 and described in Section III.F.2) at the current point in the vehicle's lifetime. To evaluate the accuracy of the monitor during the life of the vehicle, manufacturers would procure and test consumer vehicles in-use. The SOCE monitor would be subject to the accuracy standard.

It is expected that the accuracy of the monitors may be similar for vehicles with sufficiently similar design characteristics. To account for this and thus reduce test burden, EPA is proposing to create monitor families for BEVs and PHEVs. As described in GTR No. 22, vehicles that are sufficiently similar in their characteristics such that the monitor can be expected to perform with the same accuracy may be assigned to the same monitor family. The criteria for inclusion in the same monitor family includes characteristics such as the algorithm used for SOCE monitoring, electrified vehicle type (BEV or PHEV), sensor characteristics and sensor configuration, and battery cell characteristics that would not be expected to influence SOCE monitor accuracy.

More specifically, for vehicles to be in the same monitor family: The SOCE monitoring algorithm needs to utilize the same logic and have the same value for all calibration variables used in the algorithm; the algorithm used to determine UBE needs to utilize the same sampling and integration periods and the same integration technique; the locations of the sensor(s) (*i.e.* at the pack, module, or battery cell level) for monitoring DC discharge energy need to be the same; and the accuracy of the sensor(s) and the tolerance of the sensor(s) accuracy used for monitoring energy and range need to be the same. BEVs and PHEVs cannot be included in the same monitor family.

If a manufacturer determines that additional vehicle characteristics affect the accuracy of SOCE estimation, the manufacturer can request the Administrator to allow the creation of additional monitor families. To request additional monitor families, the manufacturer will seek Agency approval and describe in their application the factors which produce SOCE estimation errors and how the monitor family will be divided to reduce the estimation errors.

Manufacturers can request the Administrator include in the same monitor family vehicles for which these characteristics would not otherwise allow them to be in the same monitor family (except for including BEVs and PHEVs in the same monitor family). The manufacturer will need to include data demonstrating that these differences do not cause errors in the estimation of SOCE when seeking Agency approval.

iii. BEV and PHEV Battery Durability Family

It is expected that the degradation of UBE (as indicated by SOCE) may be similar for vehicles with sufficiently similar design characteristics. To account for this and thus reduce test burden, EPA is proposing to create battery durability families for BEVs and PHEVs. As described in GTR No. 22, vehicles that are sufficiently similar in their characteristics such that the UBE may be expected to degrade in the same way may be assigned to the same battery durability family. The following powertrain characteristics and design features would be used to determine battery durability families: Maximum specified charging power, method of battery thermal management, battery capacity, battery (cathode) chemistry, and the net power of the electrical machines. In addition, BEVs and PHEVs cannot be placed in the same battery durability family.

Manufacturers can request the Administrator include in the same battery durability family vehicles for which these characteristics would not otherwise allow them to be in the same battery durability family (except for including BEVs and PHEVs in the same battery durability family). The manufacturer will need to include data with their request which demonstrates that these differences do not impact the durability of the vehicles with respect to maintaining UBE throughout the life of the BEV or PHEV.

If a manufacturer determines that additional vehicle characteristics result in durability differences which impact UBE, the Manufacturer can request the Administrator to allow the creation of additional battery durability families. To request additional battery durability families the manufacturer will seek Agency approval. In their request for approval, the Manufacturer will describe the factors which produce differences in vehicle aging and how the durability grouping will be divided to better capture the differences in expected deterioration.

5. Light-Duty Program Improvements

i. GHG Compliance and Enforcement Requirements

EPA is proposing to clarify the certification compliance and enforcement requirements for GHG exhaust emission standards found in 40 CFR 86.1865–12 to more accurately reflect the intention of the 2010 light-duty vehicle GHG rule (75 FR 253243, May 7, 2010). In the 2010 rule, EPA set full useful life greenhouse gas emissions standards for which each vehicle is required to comply. The preamble to that rule clearly explained that the CAA requires a vehicle to comply with emission standards over its regulatory useful life and affords EPA broad authority for the implementation of this requirement and that EPA has authority to require a manufacturer to remedy any noncompliance issues. EPA also explained that there may be cases where a repairable defect could cause the non-compliance and in those cases a recall could be the appropriate remedy. Alternatively, there may be scenarios in which a GHG non-compliance exists with no repairable cause of the exceedance. Therefore, the remedy can range from adjusting a manufacturer's credit balance to the voluntary or mandatory recall of noncompliant vehicles.

In the 2010 rule EPA clearly intended to use its existing recall authority to remedy greenhouse gas non-compliances when appropriate and to use the authority to correct the greenhouse gas credit balance as a remedy when no practical repair for in-use vehicles could be identified (see 75 FR 25474). However, the regulations did not describe these in-use compliance provisions with as much clarity as the preambular statements. Therefore, EPA is proposing clarifications to 40 CFR 86.1865–12(j) to make clear that EPA may use its existing recall authority to remedy greenhouse gas non-compliances when appropriate and specifically may use such authority to correct a manufacturer's greenhouse gas credit balance as a remedy when no practical repair can be identified.

In the 2010 rule, EPA set vehicle in-use emissions standards for CREE to be 10 percent above the vehicle-level emission test results or model-type value if no subconfiguration test data are available. This 10 percent factor was intended to account for test-to test variability or production variability within a subconfiguration or model type. EPA clearly did not intend for this factor to be used as an allowance for manufacturers to design and produce vehicles which generate $CO_2$ emissions up to 10 percent higher than the actual values they use to certify and to calculate the year end fleet average. In fact, EPA expressed concerns in the rule making that ''this in-use compliance factor could be perceived as providing manufacturers with the ability to design their fleets to generate $CO_2$ emissions up to 10 percent higher than the actual values they use to certify'' (see 75 FR 25476). Given the expectation that in-use vehicles should be designed to perform consistent with the values used to calculate the year end fleet average, EPA is taking comment on whether the Agency should eliminate the 10 percent compliance factor adjustment for the in-use standard. Instead, EPA would apply a 10 percent factor to the threshold used for determining when additional testing is required in the In-Use Confirmatory Program (IUCP).

For the reasons that EPA articulated in the 2010 rulemaking, EPA expects that some in-use vehicles may generate slightly more $CO_2$ than the certified values and some vehicles may emit slightly less, but the average $CO_2$ emissions of a manufacturer's fleet and each model within it should be very close to the levels reported to EPA and used to calculate overall fleet average. The in-use data submitted over the last ten years largely supports this expectation. Nevertheless, EPA believes it is important that manufacturers understand their obligations under the in-use program and that EPA has the appropriate tools to hold manufacturers responsible should they fail to meet these obligations. Therefore, EPA is requesting comment on two different regulatory options, either of which would align with our original intent in the 2010 rule.

The first option is to clarify the regulatory language to make it clear that if a manufacturer's in-use data demonstrates that a manufacturer's $CO_2$ results are consistently higher than the values used for calculation of the fleet average for any class or category of vehicle, EPA may use its authority to correct a manufacturer's greenhouse gas credit balance to ensure the manufacturer's GHG fleet average is representative of the actual vehicles it produces. This means that the credit balance post-correction will reflect the actual in-use performance of the vehicles. In other words, if the manufacturer reports a value of X g/mi in calculating its fleet average, but its vehicles emit X+A g/mi in-use, we may correct the manufacturer's balance by the entire discrepancy (A).

The second option is to set the in-use standards at the vehicle-level emission test results or model-type average value if no subconfiguration test data are available in the GHG report. Under this approach, manufacturers will have the option to voluntarily raise the GHG values submitted in the GHG report if they wish to create an in-use compliance margin. The proposed change in this second option would make the GHG ABT program consistent with all other ABT programs used in the light duty program. In all other ABT programs (*e.g.,* FTP NMOG+$NO_X$, MSAT, SFTP), manufacturers must choose a bin level or Family Emissions Limit (FEL) in which to certify. Manufacturers typically design their vehicle to emit well below the bin level or FEL to establish a compliance margin; however, the fleet average emissions are calculated based on the bin level or FEL, not the actual certification level. In those cases, the fleet average emissions calculated in the ABT report would be representative of the actual fleet as long as the vehicles comply with the certified bin level or FEL. Only the light duty GHG ABT program allowed manufacturers to calculate the fleet average emissions based on the certification level. EPA allowed this with the expectation that vehicles in actual use would not normally emit more $CO_2$ than they did at the time of certification (*i.e.,* $CO_2$ emissions are not expected to increase with time or mileage).

Under either option, EPA is seeking to further clarify our position on this issue: When EPA uses its recall authority or its authority to correct a manufacturer's greenhouse gas credit balance to remedy greenhouse gas non-compliances, EPA may require a remedy that fully accounts for the difference in the actual in-use GHG emissions and the values the manufacturer used to certify and to calculate the year end fleet average. EPA is seeking comment on both proposed options, either of which may be adopted in the final rule.

The overarching principle of compliance to the fleet average standards is that the calculated fleet average in the GHG report must accurately represent the actual fleet of vehicles a manufacture produced. If a manufacturer provides false, inaccurate, or unrepresentative data as part of their GHG report, the manufacturer may be subject to enforcement and EPA may void ab initio the certificates of conformity which relied on that data. Vehicles are covered by a certificate of conformity only if they are in all material respects as described in the manufacturer's application for certification (Part I and Part II) including the GHG report. If vehicles generate substantially more $CO_2$ emissions in actual use than what was reported, those vehicles are not covered by the certificate of conformity. EPA is proposing two changes to the regulatory language that are designed to clarify the Agency's understanding of its authority to void certificates and/or find that vehicles were sold in violation of a condition of a certificate. Currently 40 CFR 86.1850 states that if a manufacturer submits false or incomplete information or renders inaccurate any test data which it submits, or fails to make a good engineering judgment, EPA may deny issuance of, suspend, or revoke a previously issued certificate of conformity. However, suspension or revocation of a certificate of conformity shall extend no further than to forbid the introduction into commerce of vehicles previously covered by the certificate which are still in the possession of the manufacturer. Since the GHG report is not required to be submitted until May 1 of the calendar year after the model year has ended, suspending or revoking a certificate is no longer a relevant remedy. Therefore, because of situations where certificate suspension or revocation is no longer relevant, EPA is proposing to allow the Agency to void ab initio a previously issued certificate of conformity in the list of possible actions the agency may take if a manufacturer commits any of the infractions listed in 40 CFR 86.1850(b). In addition, EPA is proposing edits to 40 CFR 86.1848 to make it clearer that any vehicles sold that fail to meet any condition upon which the certificate was issued are not covered by the certificate and thus were sold in violation of CAA 203(a)(1).

### ii. In-Use Confirmatory Program (IUCP)

Currently, EPA regulations require manufacturers to conduct in-use testing as a condition of certification. Specifically, manufacturers must commit to later procure and test privately-owned vehicles that have been normally used and maintained. The vehicles are tested to determine the in-use levels of criteria pollutants when they are in their first and fourth years of service. This testing is referred to as the In-Use Verification Program (IUVP) testing, which was first implemented as part of EPA's CAP 2000 certification program.[541]

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[541] 64 FR 23906, May 4, 1999.

Another component of the CAP 2000 certification program is the In-Use Confirmatory Program (IUCP). This is a manufacturer-conducted in-use test program that can be used as the basis for EPA to order an emission recall (although it is not the only potential basis for recall). For vehicles tested in the IUVP to qualify for IUCP, there is a threshold of 1.30 times the certification emission standard for criteria emissions (*e.g.,* NMOG+$NO_X$, CO) and an additional requirement that at least 50 percent of the test vehicles for the test group fail for the same substance. If these criteria are met for a test group, the manufacturer is required to test an additional 10 vehicles which are screened for proper use and maintenance.

The 2010 light-duty GHG rule set full useful life greenhouse gas emissions standards for which each vehicle is required to comply and required in-use testing under the In-Use Verification Program (IUVP) testing provisions. At that time, EPA did not set criteria for In-Use Confirmatory Program (IUCP) for GHG but indicated that IUCP will be a valuable future tool for achieving compliance and that EPA would reassess IUCP thresholds for GHG in a future rule when more data is available.[542]

Since the 2010 rule, EPA has received in-use greenhouse gas emissions test results from over 9,500 vehicles. EPA believes there is now sufficient data to establish IUCP threshold criteria based on greenhouse gas emissions and that doing so is warranted.

The 2010 rule established an in-use $CO_2$ standard to be 10 percent above the vehicle-level emission test results or model-type value if no subconfiguration test data are available. Over 95 percent of the test results EPA received complied with this in-use standard based on the 10 percent margin. Therefore, EPA is proposing two options for approaches to setting the in-use GHG standards: Either (1) if the in-use standard continues to include a 10 percent adjustment factor applied to the reported GHG result, set the IUCP threshold criteria to be at least 50 percent of the test vehicles for the test group exceed the relevant in-use $CO_2$ standard; or (2) if the in-use standard is identical to the reported GHG result, set the IUCP threshold criteria to be at least 50 percent of the test vehicles for the test group exceed the relevant in-use $CO_2$ standard by at least 10 percent. In either approach EPA is not proposing an additional criteria based on the average emissions of the test group. The 50 percent failure rate is consistent with the IUCP criteria for criteria emissions that has existed since the CAP 2000 rule was finalized. However, unlike the IUCP criteria for criteria emissions, EPA is not proposing a threshold for the average emissions of the test group (which is 1.3 times for criteria emissions) for a number of reasons. First, unlike criteria pollutants where the in-use standards are generally the same as the certification standards, EPA is proposing a margin of 10 percent above the reported GHG result for the IUCP criteria. Adding an additional multiplier on top of that would be unnecessary, and EPA believes a 10 percent exceedance threshold (either as a part of the in-use standard or as a threshold criteria) is appropriate given the Agency's experience with GHG compliance over the past decade. Second, unlike for criteria pollutants, the $CO_2$ emissions performance of vehicles is generally not expected to deteriorate with age and mileage (see the 2010 rule). Third, unlike with criteria pollutants, the in-use GHG standards are not consistent within a test group and the compliance level is not determined by the same emissions data vehicle. GHG in-use standards can be different for each subconfiguration or model type. Fourth, the review of the data supports ten percent above the reported GHG value as an appropriate criterion, because over 95 percent of the test results EPA received complied with this in-use standard based on the 10 percent margin. The proposed IUCP criteria is intended to capture vehicles with both unusually high increase in $CO_2$ emissions compared to the reported value and an unusually high failure rate.

### iii. Part 2 Application Changes

EPA is also proposing changes to 40 CFR 86.1844–01(e) ''Part 2 Application'' to make it clearer that the part 2 application must include the part numbers and descriptions of the GHG emissions related parts, components, systems, software or elements of design, and AECDs including those used to qualify for GHG credits (*e.g.,* air conditioning credits, off cycle credits, advanced technology vehicle credits) as previously specified in EPA guidance letter CD–14–19. These changes are not intended to alter the existing reporting requirements, but rather to clarify the existing requirement.

EPA is also proposing changes to 40 CFR 86.1844–01(e) ''Part 2 Application'' and 40 CFR 85.2110 to no longer accept paper copies of service manuals, Technical Service Bulletins (TSB), owner's manuals, or warranty booklets. In response to the National Archives and Records Administration (NARA) mandate and OMB's Memorandum for Heads of Executive Departments and Agencies, M–19–21, Transition to Electronic Records, EPA will no longer accept paper copies of these documents.

### iv. Fuel Economy and In-Use Verification Test Procedure Streamlining

The ''Federal Test Procedure'' (FTP) defines the process for measuring vehicle exhaust emissions, evaporative emissions, and fuel economy and is outlined in 40 CFR 1066.801(e). The process includes preconditioning steps to ensure the repeatability of the test results, as described in 40 CFR 86.132–96. EPA proposes two changes to the preconditioning process used for testing of only fuel economy data vehicles (FEDVs) (not emission data vehicles) in order reduce the testing burden while maintaining the repeatability and improving the accuracy of the test results.[543] The proposed changes are related to the fuel drain and refueling step and the preconditioning of the evaporative canister. EPA is also proposing to remove one fuel drain and refueling step for in-use surveillance vehicles. In addition, we are proposing changes to the fuel cap placement during vehicle storage for all emission data and fuel economy vehicles.

Currently, all FEDVs must follow the regulations in for preconditioning before conducting the cold-start portion of the test. Included in this preconditioning is the requirement to drain and refuel the fuel tank twice. We propose to remove the second fuel drain step, that occurs after running the Urban Dynamometer Driving Schedule (UDDS) preconditioning cycle, but before the cold start test. The fuel drain and refuel step was originally included in the test procedure because fresh fuel was important for carbureted engines and could impact the test results. However, with today's fuel injection systems, EPA's assessment is that the refueling of the vehicle with fresh fuel does not impact the measured fuel economy of the vehicle.[544] Removing this step would save a significant amount of fuel for each test run by the manufacturer and run by EPA and reduce the number of voided tests due to mis-fueling and fueling time violations. It would also reduce the labor associated with refueling the vehicle for each test. EPA also proposes to remove this step for in-use vehicle testing on vehicles tested

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[542] 75 FR 25475, May 7, 2010.

[543] See proposed regulations in 40 CFR 86.132–96 and 1066.801(e).

[544] Memo to Docket. ''EPA FTP Streamlining Test Results.'' See Docket EPA–HQ–OAR–2022–0829. March 2023.

under 40 CFR 86.1845–04 (verification testing). It is difficult to drain fuel from an in-use vehicle because they normally do not have fuel drains. Removing this step will save time and fuel from the in-use verification process as well. EPA will still require this step for in-use confirmatory vehicles tested under 40 CFR 86.1846–01.

EPA also proposes to remove the canister loading, and purging as appropriate, steps from the preconditioning for FEDVs. This would provide the following benefits to manufacturers and EPA: The time to run the test would be reduced, less butane would be consumed by the laboratories which reduces the cost of running a test, and the fuel economy measurement accuracy would improve. EPA conservatively estimates that at least 88 kg of butane was consumed by manufacturers in the 2021 calendar year for the purposes of fuel economy testing, based on 909 fuel economy test submissions to EPA and assuming 97 grams of butane per canister. The measurement accuracy would improve because the calculations for fuel economy assume that 100 percent of the fuel consumed during the testing has the carbon balance of the liquid fuel in the tank. The butane vapor that is added to the canister during preconditioning has a different carbon content, and thus causes very small inaccuracies in the fuel economy results. EPA's test program also shows that the canister loading does not have any statistically significant effect on the fuel economy results from the cold start and highway fuel economy tests.[545]

Finally, the regulations in 40 CFR 86.132–96(a) currently state that fuel cap(s) shall be removed during any period when the vehicle is parked outside awaiting testing but may be in place while in the test area. EPA proposes to revise the regulations such that the vehicle shall always be stored in a way that prevents fuel contamination and unnatural loading of the evaporative control system while awaiting testing regardless of location. At this time EPA considers the possibility of contaminates getting into the fuel system while the fuel cap is off to be more significant that any possible ‘‘overloading’’ of the canister. Modern vehicles purge the canister sufficiently during the preconditioning cycles to ensure that tests completed on vehicles that have been parked will not affect testing results significantly. Custodians of test vehicles should avoid parking test vehicles outdoors during hot conditions for long periods of time.

We request comment and data quantifying any effects of removing the second fuel drain and fill step and removing the canister loading steps from the FTP for fuel economy data vehicles and in-use verification vehicles, along with any impacts of keeping the fuel tank cap in place prior to testing.

v. Miscellaneous Amendments

We are proposing to amend the pre-certification exemption in 40 CFR 85.1702 and 85.1706 to clarify that the exemption is limited to companies that already hold a certificate showing that they meet EPA emission standards. This has been a longstanding practice for highway and nonroad engines and vehicles. Companies that are not certificate holders may continue to request a testing exemption under 40 CFR 85.1705.

We are proposing to update the test procedures in 40 CFR 86.113 to reference test fuel specifications in 40 CFR part 1065 for diesel fuel, natural gas, and LPG. We do not expect this change to cause manufacturers to change the test fuels they use for certification, or to prevent any manufacturer from using carryover data to continue certifying vehicles in later model years. In the case of diesel fuel, the two sets of specifications are very similar except that 40 CFR 1065.703 takes a different approach for aromatic content of the fuel by specifying a minimum aromatic content of 100 g/kg. We expect current diesel test fuels to meet this specification. In the case of natural gas, 40 CFR 1065.715 decreases the minimum methane content from 89 to 87 percent, with corresponding adjustments in allowable levels of nonmethane compounds. In this case too, manufacturers would be able to continue meeting test fuel specifications without changing their current practice. In the case of LPG, 40 CFR 86.113–94 directs manufacturers to ask EPA to approve a test fuel. In the absence of any other specific requirements, we would likely rely on the published fuel specifications in 40 CFR 1065.720 even without a direct reference. We request comment on these proposed changes to fuel specifications. In particular, we request comment on any unintended conflict between the old and the new specifications, and on any potential need to adjust test fuel specifications to maintain consistency with existing requirements.

The regulation currently requires manufacturers to include information in the application for certification for fuel-fired heaters (40 CFR 86.1844–01(d)(15)). The regulation also requires manufacturers to account for fuel-fired heater emissions in credit calculations for Tier 2 vehicles (40 CFR 86.1860–04(f)(4)). The Tier 3 regulation inadvertently omitted the requirement related to credit calculations in 40 CFR 86.1860–17. We are proposing to restore the requirement to account for emissions from fuel-fired heaters in credit calculations in 40 CFR 86.1844–01(d)(15).

This proposed rule includes several structural changes that lead to a need to make several changes to the regulations for correct terminology and appropriate organization, including the following examples:

- We are replacing cold temperature NMHC standards with cold temperature $NMOG+NO_X$ standards, and we are adding a cold temperature PM standard. The proposed rule includes updates to refer to cold temperature standards generally, or to cold temperature $NMOG+NO_X$ standards instead of or in addition to cold temperature NMHC standards. 40 CFR 86.1864–10 is similarly adjusted to refer to cold temperature fleet average standards and cold temperature emission credits instead of referencing NMHC.
- We are setting separate emission standards for US06 and SC03 driving schedules rather than setting standards based on a composite calculation for the driving schedules that make up the Supplemental FTP. As a result, we are generally adjusting terminology for Tier 4 vehicles to refer to the specific cycles rather than the Supplemental FTP.
- The existing regulation includes several references to Tier 3 standards (or Tier 3 emission credits, etc.). Those references were generally written to say when regulatory provisions started to apply. Some of those provisions need to continue into Tier 4, but not all. The proposed rule includes new language in several places to clarify whether or how those provisions apply for Tier 4 vehicles.
- The proposed rule eliminates many of the differences in the way we apply emission standards for light-duty and heavy-duty vehicles (we are also starting to refer to heavy-duty vehicles as medium-duty vehicles). As a result, we are proposing the new criteria exhaust emission standards for all these vehicles in 40 CFR 86.1811 rather than continuing to rely on a separate section (40 CFR 86.1816) for heavy-duty vehicles.

The proposal includes several instances of removing regulatory text that has been obsolete for several years. Removing obsolete text is important to prevent people from making errors from thinking that obsolete text continues to

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[545] Ibid.

apply. The final rule may include additional housekeeping amendments to remove obsolete text and to remove or update cross references to obsolete or removed regulatory text.

One case of obsolete text is related to special test procedures as specified in 40 CFR 86.1840–01. Vehicle manufacturers have completed a transition to following the exhaust test procedures specified in 40 CFR part 1066, such that those new test procedures apply instead of the test procedures in 40 CFR part 86, subpart B, starting with model year 2022. Since we address special test procedures in 40 CFR 1066.10©, which in turn relies on 40 CFR 1065.10(c)(2), we no longer need to rely on 40 CFR 86.1840–01 for special test procedures. We note the following aspects of the transition for special test procedures:

- We are proposing to apply the provisions for special procedures equally to all vehicles certified under 40 CFR part 86, subpart S. The special test procedures were written in a way that did not apply for incomplete vehicles certified under 40 CFR part 86, subpart S. This is very likely an artifact of the changing scope of the regulation since 2001.
- We are keeping the reference to infrequently regenerating aftertreatment devices in 40 CFR 86.1840–01 as an example of special test procedures to clarify that we are not proposing to change the way manufacturers demonstrate compliance for vehicles with infrequently regenerating aftertreatment devices. Specifically, we are not proposing to adopt the measurement and reporting requirements that apply for heavy-duty engines under 40 CFR 1065.680.
- We are proposing to apply the provisions related to infrequently regenerating aftertreatment devices equally to all vehicles certified under 40 CFR part 86, subpart S. The provisions in 40 CFR 86.1840–01 were written in a way that they did not apply for medium-duty passenger vehicles. This is very likely an artifact of the changing scope of the regulation since 2001.

We are proposing the following additional amendments:

- Section 85.1510(d): Waiving the requirement for Independent Commercial Importers to apply fuel economy labels to electric vehicles. Performing the necessary measurements to determine label values would generally require accessing high-voltage portions of the vehicles electrical system. Manufacturers can appropriately and safely make these measurements as part of product development and testing. These measurements can pose an unreasonable safety risk when making these measurements on production vehicles. The benefit of labeling information for these vehicles is not enough to outweigh the safety risks of generating that information.
- Section 86.1816–18: The published final rule to adopt the Tier 3 exhaust emission standards for Class 2b and Class 3 vehicles inadvertently increased the numerical value of those standards a trillion-fold by identifying the units as Tg/mile. We are proposing to revert to g/mile as we intended by adopting the Tier 3 standards.

### 6. Light- and Medium-Duty Emissions Warranty for Certain ICE Components

EPA is proposing to designate several emission control components of light-duty ICE vehicles as specified major emission control components. These include components of the diesel Selective Reductant Catalysts (SRC) system, components of the diesel Exhaust Gas Recirculation (EGR) system, and diesel and gasoline particulate filters (DPFs and GPFs). As the result of this designation, these components will have the same warranty requirements as other components that have been established as specified major emission control components.

As described in Section III.F.3, CAA section 207(i) specifies that the warranty period for light-duty vehicles is 2 years or 24,000 miles of use (whichever first occurs), except the warranty period for specified major emission control components is 8 years or 80,000 miles of use (whichever first occurs). The Act defines the term ''specified major emission control component'' to mean only a catalytic converter, an electronic emissions control unit (ECU), and an onboard emissions diagnostic device, except that the Administrator may designate any other pollution control device or component as a specified major emission control component if—

(A) the device or component was not in general use on vehicles and engines manufactured prior to the model year 1990; and

(B) the Administrator determines that the retail cost (exclusive of installation costs) of such device or component exceeds $200 (in 1989 dollars),[546] adjusted for inflation or deflation as calculated by the Administrator at the time of such determination.

EPA believes that GPFs meet the requirements set forth in CAA section 207(i) and should be designated as specified major emission control components. GPFs were not in general use prior to model year 1990 and their cost exceeds the threshold specified in the CAA. EPA anticipates that the PM standards in this proposal will require the application of a GPF. In the event of a GPF failure, PM emissions will most likely exceed the proposed standards. It is imperative that a properly functioning GPF be installed on a vehicle in order to achieve the environmental benefits projected by this proposal.

In order to meet the current emissions standards, diesel vehicles utilize Selective Reductant Catalysts (SRC) as the primary catalytic converter for $NO_X$ emissions controls and well as a Diesel Oxidation Catalyst (DOC) as the primary catalytic converter for CO and hydrocarbons and a Diesel Particulate Filter (DPF) as the primary catalytic converter to control particulate matter (PM). In the event that any one of these components fail, EPA anticipates that the relevant standard will be exceeded. The proper functioning of each of these components is necessary for the relevant emissions benefits to be achieved.

More specifically, the SCR catalytic converter relies on a system of components needed to inject a liquid reductant called Diesel Exhaust Fluid (DEF) into the catalytic converter. This system includes pumps, injectors, $NO_X$ sensors, DEF level and quality sensors, storage tanks, DEF heaters and other components that all must function properly for the catalytic converter to work. These components meet the criteria for designation as specified major emission control components.

Vehicles with diesel engines do not rely solely on aftertreatment to control emissions. Diesel engines utilize Exhaust Gas Recirculation (EGR) to control engine out emissions as a critical element of the emissions control system. Components of the EGR system such as electronic EGR valves and EGR coolers meet the criteria for designation as specified major emission control components.

The emission-related warranty period for heavy duty engines and vehicles under CAA section 207(i) is ''the period established by the Administrator by regulation (promulgated prior to November 15, 1990) for such purposes unless the Administrator subsequently modifies such regulation.'' The regulations specify that the warranty period for light heavy-duty vehicles under 40 CFR 1037.120 is 5 years or 50,000 miles of use (whichever first occurs). EPA is proposing to clarify that this same warranty period applies for medium-duty vehicles certified under 40 CFR part 86, subpart S, except that a longer warranty period of 8 years or

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[546] Equivalent to approximately $500 today.

80,000 miles would apply for engine-related components described in this section as specified major emission control components.

The warranty provisions in CAA section 207 do not explicitly apply to medium-duty passenger vehicles. However, as with the new standards in this proposed rule, we are proposing to apply warranty requirements to medium-duty passenger vehicles in the same way that they apply to light-duty vehicles.

#### 7. Definition of Light-Duty Truck

EPA currently has separate regulatory definitions for light truck for GHG standards and light-duty truck for criteria pollutant standards. Historically this was not an issue because the car versus truck definition was clear. Nearly all vehicles were passenger cars or pickup trucks with open cargo beds. The earliest sport utility vehicles (SUVs) were primarily derived from pickup truck platforms and were therefore considered light trucks. However, current versions of some of these SUVs are now built off of car-based platforms and have carlike features. Current differences between the two light truck definitions leads to some SUVs being certified to GHG standards as a truck and to criteria pollutant standards as a car. To address this concern, we are proposing to transition to a single definition of light-duty truck with the implementation of the Tier 4 criteria pollutant emission standards.

Currently, the first ''light truck'' definition is used for determining compliance with the light-duty GHG emission standards (40 CFR 600.002). This definition matches the definition that NHTSA uses in determining compliance with their fuel economy standards (49 CFR 523.5). This definition contains specific vehicle design characteristics that must be met to qualify a vehicle as a truck.

The second ''light-duty truck'' definition is used for certifying vehicles to the criteria pollutant standards (40 CFR 86.1803–01). This broader definition allows for some SUVs to qualify as trucks even if the specific vehicle does not contain the truck-like design attributes. The definition also includes some ambiguity that requires the manufacturers and EPA to apply judgment to determine the appropriate classification.

To address this concern, we are proposing to revise the definition of light-duty truck used in the criteria pollutant standards to simply refer to the definition of light-truck used in the GHG standards. This proposed change would eliminate any confusion and simplify reporting for manufacturers because each vehicle would be treated consistently as either a car or a truck for all standards and reporting requirements. We request comment on this proposed revision.

### *G. Proposed On-Board Diagnostics Program Updates*

EPA regulations state that onboard diagnostics (OBD) systems must generally detect malfunctions in the emission control system, store trouble codes corresponding to detected malfunctions, and alert operators appropriately. EPA adopted at 40 CFR 86.1806–17 a requirement for manufacturers to meet the 2013 California Air Resources Board (CARB) OBD regulation as a requirement for an EPA certificate, with certain additional provisions, clarifications and exceptions, in the Tier 3 Motor Vehicle Emission and Fuel Standards final rulemaking (79 FR 23414, April 28, 2014). Since that time, CARB has made several updates to their OBD regulations and continues to consider changes periodically. In this NPRM, EPA is proposing to update to the latest version of the CARB OBD regulation (California's 2022 OBD–II requirements that are part of title 13, section 1968.2 of the California Code of Regulations, approved on November 22, 2022). This is accomplished by adding a new section for model year 2027 and later vehicles and only putting in requirements in that section that are not in the new CARB regulation. For example, EPA is adding a new monitoring requirement for gasoline particulate filters (GPFs) since the CARB regulation does not specifically have a requirement for a particulate filter diagnostic for gasoline vehicles and EPA is projecting that manufacturers will utilize GPFs as a control strategy in meeting the proposed PM standards. Details are available in DRIA Chapter 3.3.

### *H. Coordination With Federal and State Partners*

Executive Order 14037 directs EPA and DOT to coordinate, as appropriate and consistent with applicable law, during consideration of this rulemaking. EPA has coordinated and consulted with DOT/NHTSA, both on a bilateral level during the development of the proposed program as well as through the interagency review of the EPA proposal led by the Office of Management and Budget. EPA has set some previous light-duty vehicle GHG emission standards in joint rulemakings where NHTSA also established CAFE standards. Most recently, in establishing standards for model year 2023–2026, EPA and NHTSA concluded that it was appropriate to coordinate and consult but not to engage in joint rulemaking. EPA has similarly concluded that it is not necessary for this EPA proposal to be issued in a joint action with NHTSA. In reaching this conclusion, EPA notes there is no statutory requirement for joint rulemaking and that the agencies have different statutory mandates and their respective programs have always reflected those differences. As the Supreme Court has noted ''EPA has been charged with protecting the public's 'health' and 'welfare,' a statutory obligation wholly independent of DOT's mandate to promote energy efficiency.'' [547] Although there is no statutory requirement for EPA to consult with NHTSA, EPA has consulted significantly with NHTSA in the development of this rule. For example, staff of the two agencies met frequently to discuss various technical issues including modeling inputs and assumptions, shared technical information, and shared views related to the assessments conducted for each rule.

EPA also has consulted with analysts from other Federal agencies in developing this proposal, including the Federal Energy Regulatory Commission, the Department of Energy and several national labs. EPA collaborates with DOE and Argonne National Laboratory on battery cost analyses and critical materials forecasting. EPA, National Renewable Energy Laboratory (NREL) and DOE collaborate on forecasting the development of a national charging infrastructure and projecting regional charging demand for input into EPA's power sector modeling. EPA also coordinates with the Joint Office of Energy and Transportation on charging infrastructure. EPA and the Lawrence Berkeley National Laboratory collaborate on issues of consumer acceptance of plug-in electric vehicles. EPA and the Oak Ridge National Laboratory collaborate on energy security issues. EPA also participates in the Federal Consortium for Advanced Batteries led by DOE and the Joint Office of Energy and Transportation. EPA and DOE also have entered into a Joint Memorandum of Understanding to provide a framework for interagency cooperation and consultation on electric sector resource adequacy and operational reliability.[548]

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[547] *Massachusetts* v. *EPA,* 549 U.S. at 532.

[548] Joint Memorandum on Interagency Communication and Consultation on Electric Reliability, U.S. Department of Energy and U.S. Environmental Protection Agency, March 8, 2023.

E.O. 14037 also directs EPA to coordinate with California and other states that are leading the way in reducing vehicle emissions. EPA has engaged with the California Air Resources Board on technical issues in developing this proposal. EPA has considered certain aspects of the CARB Advanced Clean Cars II program, adopted in August 2022, as discussed elsewhere in this notice. We also have engaged with other states, including members of the National Association of Clean Air Agencies, Northeast States for Coordinated Air Use Management, and the Ozone Transport Commission.

### *I. Stakeholder Engagement*

EPA has conducted extensive engagement with a diverse range of interested stakeholders in developing this proposal. We have engaged with those groups with whom E.O. 14037 specifically directs EPA to engage, including labor unions, states, industry, environmental justice organizations and public health experts. In addition, we have engaged with NGOs representing environmental, public health and consumer interests, automotive manufacturers, suppliers, dealers, utilities, charging providers, local governments, Tribal governments, alternative fuels industries, and other organizations. For example, in April–May 2022, EPA held a series of engagement sessions with various interested stakeholder groups so that EPA could hear early input in developing its proposal. These engagement sessions included all of the identified stakeholder groups. EPA has continued engagement with many of these stakeholders throughout the development of this proposal. EPA looks forward to hearing from all stakeholders through comments on this proposal and during the public hearing.

## IV. Technical Assessment of the Proposed Standards

### *A. What approach did EPA use in analyzing potential standards?*

For this proposal, EPA has conducted a new technical assessment of the proposed standards, along with an assessment of alternative standards and sensitivity cases. The overall approach used here is consistent with our prior rulemakings for GHG and criteria pollutants for light- and medium-duty vehicles. We continue to refer to the extensive body of prior technical work that has underpinned those rules, and where appropriate we have incorporated both updated and new tools, models and data in conducting this assessment. Some of the areas of particular focus are related to the significant developments in vehicle electrification that have continued to occur since our most recent previous technical assessment published with the 2021 rule. Battery costs continue to decline, and vehicle manufacturers have continued to introduce PEV products in increased volumes and new market segments, improving the ability to characterize the cost and performance of best-practice designs. New legislation also has provided significant incentives for both the manufacture and purchase of PEVs, and the expansion of charging infrastructure. Additionally, in light of the projected levels of electrification anticipated under the proposed standards, EPA's new technical assessment contains significantly increased focus on the availability of critical minerals, supply chain development, battery manufacturing capacity, and mineral security.

Our modeling can be broadly divided into two categories. The first category is compliance modeling for the vehicle manufacturers, which includes the potential design and technology application decisions to achieve compliance under the modeled standard. The second category is 'effects' modeling, which is intended to capture how changes in vehicle design and use will impact human health, the environment, and other factors that are relevant to a societal benefits-costs analysis.

As in the 2010 and 2012 rules, EPA is again using the Optimization Model for reducing Emissions of Greenhouse gases from Automobiles (OMEGA) to model vehicle manufacturer compliance with GHG standards. In the 2021 GHG rule EPA used DOT's CAFE Compliance and Effects Modeling System (CCEMS). This approach helped to maintain consistency with the CCEMS modeling used for the 2020 rule allowing for a more direct comparison of results given a single modeling tool having been used for both analyses. For this proposal, EPA is returning to the use of the OMEGA model, and we do so for a few important reasons. For one, the updated version of OMEGA extends the prior version's projections of cost-effective manufacturer compliance decisions by also accounting for the relationship between manufacturer compliance decisions and consumer demand and including important constraints on technology adoption. Also, the updated OMEGA allows for evaluation of the influence of other policies beyond the GHG standards being evaluated, such as state-level ZEV policies. These features make this updated version of OMEGA well-suited for analyzing standards in a market where BEVs are expected to account for a steadily increasing share of new vehicle sales. EPA has utilized the OMEGA model in evaluating the effects of not only the GHG program but the criteria pollutant emissions program as well. Finally, despite the strengths of the CCEMS and its modeling approach, it is designed around the CAFE program and the statute behind that program, while OMEGA is designed around EPA's GHG program and the Clean Air Act.

This model takes as inputs detailed information about existing vehicles, technologies, costs, and definitions of the policies under consideration. From these inputs, the model projects the stock of vehicles and vehicle attributes, and their use over the analysis period. For the analysis supporting this proposal, EPA has developed an updated and peer-reviewed version of the OMEGA model to better account for the significant evolution over the past decade in vehicle markets, technologies, and mobility services. In particular, recent advancements in BEVs and their introduction into the full range of market segments provides strong evidence that increased vehicle electrification can play a central role in achieving greater levels of emissions reduction in the future. Among the key new features of OMEGA is the representation of consumer-producer interactions when modeling compliance pathways and the associated technology penetration into the vehicle fleet. This capability allows us to project the impacts of the producer and consumer incentives contained in the IRA and BIL legislation. Compared to the previous model version, the updated version of OMEGA has extended capability to model a wider range of GHG program provisions, and it has been critical in the assessment of various policy alternatives that were considered for this proposal. OMEGA is described in detail in DRIA Chapter 2.2.

The ALPHA vehicle simulation model is used to estimate emissions, energy rates, and other relevant vehicle performance estimates. These ALPHA simulation results create the inputs to the OMEGA model for the range of technologies considered in this rulemaking. We have built upon our existing library of benchmarked engines and transmissions used in previous rulemakings by adding several new technologies for non-hybrid and hybrid ICE vehicles, and newly refined models of BEV powertrains. For this proposal, we have also adopted an updated approach for representing the ALPHA simulation results in OMEGA, using 'response surfaces' of emissions and energy rates. These continuous technology representations can be applied across vehicles of different size, weight, and performance characteristics without requiring that vehicles be binned into discrete vehicle classes. The response surface approach also simplifies the model validation process, since the absolute values of absolute emissions and energy rates that are produced can be readily checked against actual vehicle test data. This is in contrast to the validation process needed for the incremental effectiveness values that were estimated in previous rulemakings using either a 'lumped parameter model' or direct table lookup of effectiveness. The modeling in ALPHA and generation of response surfaces is described in DRIA Chapter 2.4.

The technology cost estimates used in this assessment are from both new and previously referenced sources, including some values used in recent rulemakings where those remain the best available estimates. Vehicle teardown studies remain an important source of detailed cost estimates, and for this rulemaking EPA has contracted a new teardown study that compares ICE and BEV manufacturing costs for a high-volume crossover utility vehicle. Battery costs are an especially important element for this rulemaking. Consistent with prior rulemakings, we have used DOE's BatPaC model to estimate current battery pack costs which, similar to other technology costs, are assumed to decline over time as production volumes grow and manufacturing efficiencies improve. The costing approaches and assumptions are described in more detail in DRIA Chapter 2.5.

The main function of the OMEGA compliance modeling is to simulate how a manufacturer can meet future GHG standards through the application of technologies. Among multiple pathways that typically exist for achieving compliance, OMEGA aims to find the pathway that minimizes costs for the manufacturer given a set of inputs that includes technology costs and emissions rates. The compliance modeling for this rulemaking also includes constraints on new vehicle production and sales that are informed by our assessment of manufacturer and consumer decisions, and in some cases account for factors that were not included in the technical assessments in our prior rulemakings.

EPA also consulted and considered data and forecasts from government agencies, analyst firms, and industry in order to assess capacity for battery production and to thereby establish appropriate constraints on PEV battery production (in terms of gigawatt-hours (GWh) in a given year) during the time frame of the proposal.[549] This effectively acts as an upper limit on BEV production, particularly during the earlier years of the analysis, and represents, for example, considerations such as availability of critical minerals and the lead time required to construct battery production facilities. The development of the battery GWh constraint and the sources considered are described in detail in DRIA Chapter 3.1.3.2.

Consistent with compliance modeling for past rulemakings, the OMEGA model also limits the rate at which new vehicle designs can be introduced by applying redesign cycle constraints (DRIA Chapter 2.6). EPA has evaluated historic vehicle data (*e.g.,* the rate of product redesigns) to ensure that the technology production pace in the modeling is feasible. In addition to vehicle production constraints, market assumptions and limits on manufacturer pricing cross-subsidization have been implemented to constrain the number of BEVs that can enter the fleet. EPA has evaluated market projections from both public and proprietary sources to calibrate the OMEGA model's representation of the consumer market's ICE–BEV share response. A detailed discussion of the constraints used in EPA's compliance modeling is provided in DRIA Chapter 2.7.

As in prior rulemakings, this assessment is a projection of the future, and is subject to a range of uncertainties. We have assessed a number of sensitivity cases for key assumptions in order to evaluate how they would impact the results.

### *B. EPA's Approach To Considering the No Action Case and Sensitivities*

EPA has assessed the effects of this proposal with respect to a No Action case, for all stringency alternatives and several sensitivities. The Office of Management and Budget (OMB) provides guidance for regulatory analysis through Circular A4. Circular A4 describes, in general, how a regulatory agency should conduct an analysis in support of a future regulation and includes a requirement for assessing the baseline, or ''no action'', condition: ''what the world will be like if the proposed rule is not adopted''. In addition, Circular A4 provides that the regulating agency may also consider ''alternative baselines,'' which EPA has considered via several sensitivities in this proposal. In the development of a No Action case, EPA also considers existing finalized rulemakings. For this proposal, these finalized rules include the 2014 Tier 3 criteria pollutant regulation, the 2016 Phase 2 GHG standards for medium-duty vehicles, and the recently finalized MY 2023–2026 light-duty GHG standards.

EPA recognizes that during the timeframe of our existing standards the industry and market has already developed considerable momentum toward continuing increases in BEV uptake (as discussed at length throughout this preamble). This dynamic raises an important question about what the projected market penetration for BEVs in the absence of the proposed standards will be. EPA also recognizes there are many projections from third parties and various stakeholders for increased BEV penetration into the future. There are a range of assumptions that vary across such projections such as consumer adoption, financial incentives, manufacturing capacity and vehicle price. Vehicle price is also impacted by range and efficiency assumptions (more efficient EVs require smaller batteries to travel the same distance and smaller batteries cost less). Depending on what specific assumptions regarding the future are made, there can be significant variation in future BEV projections. Increasingly favorable consumer sentiment towards BEVs, decreasing costs (either through a reduction in manufacturing costs or through financial incentives), and a broadening number of BEV product offerings all support a projected higher number of new vehicle BEV sales in the future, independent of additional regulatory action. As described in preamble Section I.A.2.ii, EPA reviewed several recent reports and studies containing BEV projections which altogether span a range from 32 to 50 percent of new vehicle sales in 2030 and as high as 67 percent by 2032.

EPA has considered a similar set of factors as those studies conducted by other stakeholders to develop the No Action case for this proposal. EPA's No Action case has been primarily informed by the technical assessment conducted by the agency in support of this proposal. This includes detailed vehicle and battery cost analyses, impacts of consumer and manufacturing financial incentives (such as those provided by the Inflation Reduction

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[549] Sources included, among others, Wood Mackenzie proprietary forecasts of battery manufacturing capacity, battery costs, and critical mineral availability; Department of Energy analyses and forecasts of critical mineral availability and battery manufacturing capacity; and other public sources. See DRIA Chapter 3.1.3.2 for a description of these sources and how they were used.

Act), consumer acceptance studies, vehicle performance modeling and technology applications, and battery manufacturing assessments.

The No Action case in our central analysis reaches 39 percent BEVs in 2032, shown in Table 81, compared to an actual 3 percent BEV share of new vehicles in MY 2021. This projected BEV increase is driven by EPA's projections of an increase in consumer interest and acceptance over that period, the availability of economic incentives for electric vehicles for both manufacturers and consumers provided by the IRA, cost learning for BEV technology over time, and the ongoing effect of the 2021 rulemaking and the associated stringency increases in MYs 2022 through 2026. In the absence of this proposed rulemaking, the MY 2026 standards carry forward indefinitely into future years and define the No Action policy case for the analysis in this proposal. Notably, this projection does not include announcements made by manufacturers about their future plans and corporate goals, or state laws that have recently been adopted or are likely to be adopted in the next decade. While our projected BEV penetrations in the No Action case show a substantial increase over time, the 39 percent value in MY 2032 is lower than some third-party projections and manufacturer announcements.[550] For example, the International Energy Agency (IEA) synthesized industry announcements to date and concluded that if industry follows its announced plans, 50 percent of new vehicle sales in the U.S. would be zero-emission by 2030.[551] The same IEA analysis found that the combined effect of all current policies without consideration of these announcements would result in more than 20 percent BEV sales in 2030. Our own projection of the No Action BEV share of new vehicles falls between these two IEA cases, and well below the higher case of what the industry has announced it will do. While we consider manufacturer announcements as additional evidence that high levels of BEV penetration are feasible, for purposes of this proposal we have not integrated manufacturer announcements directly into our modeling of the No Action baseline. We note here that there are two key reasons why our central No-Action case projections of BEV penetration for this rulemaking are lower than announcements from some manufacturer and some third-party projections. First, our analysis does not include the effect of state-level policies whereas projections from other sources may include those policies. We did not include these policies because many are still not in effect; however, we do anticipate that in the next decade, state-level policies may play an important role in driving BEV penetration. For this reason, we have included a sensitivity No Action case, which includes the ZEV requirements of the California Advanced Clean Car (ACC) II program for California and other participating states. Second, our analysis is based on the assumption that manufacturers follow a purely cost-minimizing compliance strategy. We do not account for strategic business decisions or corporate policies that might cause a manufacturer to pursue a higher-BEV strategy such as the numerous manufacturer announcements and published corporate goals that suggest this approach may underestimate the rate of BEV adoption in a No Action scenario.

As a way to explore the impact that alternative assumptions would have on the future BEV penetrations under the No Action case, the agency has also conducted a range of sensitivities in addition to a central No Action case. Specifically, EPA conducted three categories of sensitivity cases to explore how various input assumptions affected the No Action case as well as the Proposal and the Alternatives. First, EPA explored a sensitivity reflecting state adoption of the California Advanced Clean Cars II (ACC II) program. Second, EPA conducted sensitivities of both higher and lower battery costs. Third, EPA made assumptions about a faster or slower pace of consumer acceptance of BEVs. Our central No Action case projects 39 percent BEVs in MY2032. Across the sensitivity analyses, MY2032 BEV projections ranged from 29 to 66 percent in their respective No Action cases. Each of the sensitivity cases is discussed in more detail in Section IV.E. Our projections through MY 2032 for BEV penetrations in the No Action case are shown in Figure 20.

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[550] A summary of industry announcements and third-party projections of BEV penetrations is provided in Section I.A.2.

[551] International Energy Agency, ''Global EV Outlook 2022,'' p. 107, May 2022. Accessed on November 18, 2022 at *https://iea.blob.core.windows.net/assets/e0d2081d-487d-4818-8c59-69b638969f9e/GlobalElectricVehicleOutlook2022.pdf.*

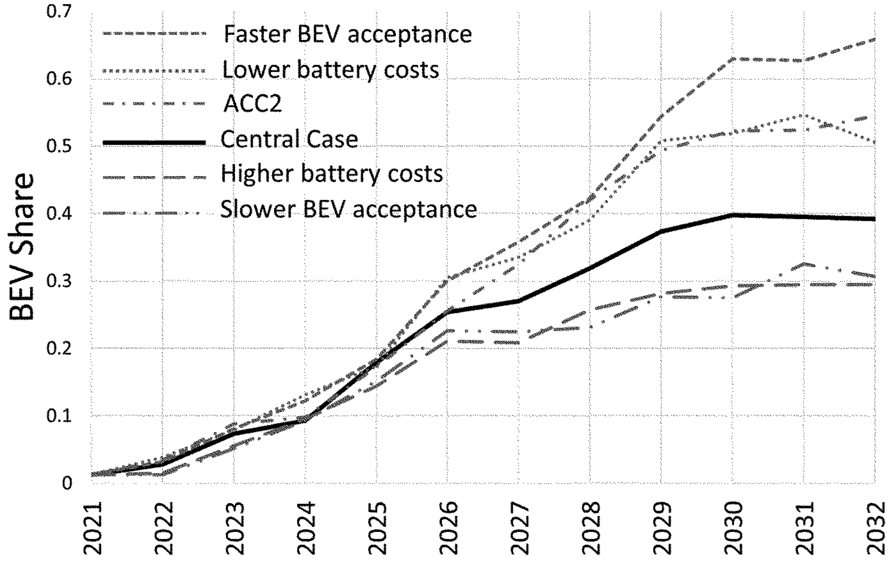

**Figure 20. No Action projections of light-duty BEV penetrations for central and sensitivity cases**

We acknowledge the range of possible assumptions, and on balance, we believe that EPA's approach to assessing potential No Action cases provides a technically robust method of determining the feasibility and costs associated with the emissions reductions required by the proposed standards.

EPA requests comment on our approach to the No Action case, both the methodologies and detailed technical inputs used by EPA to develop the No Action case for this proposal, and also on other approaches EPA may consider as an alternative to the approach used in this proposal. EPA will assess the comments and other information gathered in response to this proposal in determining an appropriate approach to the No Action case for the final rule.

### *C. How did EPA consider technology feasibility and related issues?*

#### 1. Light- and Medium-Duty Technology Feasibility

The levels of stringency considered in this proposal continue a trend of more stringent emission standards established by EPA in prior rulemakings based on EPA's consideration of available and projected technologies consistent with the factors EPA must consider when establishing standards under the Clean Air Act. As with prior rules, as part of the development of this proposed rulemaking, EPA has assessed the feasibility of the proposed standards in light of current and anticipated progress by automakers in developing and deploying new emissions-reducing technologies.

Compliance with the EPA GHG and criteria pollutant standards over the past decade has been achieved predominantly through the application of advanced technologies and improved aftertreatment systems to internal combustion engine (ICE) vehicles. For example, in the analyses performed for the 2012 GHG rule, a significant portion of EPA's analysis included an assessment of technologies available to manufacturers for achieving compliance with the standards. Advanced ICE technologies were identified as playing a major role in manufacturer compliance with the emission reductions required by those rules.

In that same time frame, as the EPA standards have increased in stringency, automakers have relied to an increasing degree on a range of electrification technologies, including hybrid electric vehicles (HEVs) and, in recent years, plug-in hybrid electric vehicles (PHEVs) and battery-electric vehicles (BEVs). As these technologies have been advancing rapidly over the past decade, and as battery costs have continued to decline, automakers have begun to include BEVs and PHEVs (together referred to as PEVs or plug-in electric vehicles) as an integral and growing part of their current and future product lines, leading to an increasing diversity of these clean vehicles planned for high-volume production. HEV and PHEV vehicle architectures not only decrease GHG emissions but provide the vehicle manufacturers with additional technology options for reducing criteria pollutant emissions. Blended ICE and electric operation allow the vehicle manufacturers to control the engine for optimal operating conditions to reduce criteria pollutants. In addition, the inclusion of a higher voltage battery provides the opportunity to preheat the catalyst to reduce cold start emissions. In EPA's 2021 rule that set GHG emission standards for MYs 2023 through 2026, we projected that manufacturers would comply with the 2026 standards with about 17 percent PEVs at the industry-wide level, reflecting the increased cost-effectiveness of PEV technologies in achieving compliance with increasingly stringent emissions standards.

This trend in technology application for light-duty vehicles is evidence of a continuing shift toward electrification as an important technology for both criteria pollutant and GHG compliance. As many advanced ICE technologies have now reached high penetrations across the breadth of manufacturers' product lines, electrification technology becomes increasingly attractive as a cost-effective pathway to further emission reductions. As described in detail in the Executive Summary, manufacturers have increasingly begun to shift research and development investment away from ICE technologies and are allocating large amounts of new investment to electrification technologies. For more discussion of this rapidly increasing trend, see preamble Section I.A.2.

In addition to the light-duty vehicle sector, the medium-duty sector is also experiencing a shift toward electrification in several important market segments. As described in Section I.A.2 of this preamble, numerous commitments to produce all-electric medium-duty delivery vans have been announced by large fleet companies in partnerships with various OEMs. This rapid shift to BEVs in a fleet that is currently predominantly gasoline- and diesel-fueled suggests that the operators of these fleets consider BEV delivery vans the best available and most cost-effective technology for meeting their needs. Owing to the large size of these vehicle fleets, this segment alone is likely to represent a significant portion of the future electrification of the medium-duty vehicle fleet.

These trends in light- and medium-duty vehicle technology suggest that electrification is already poised to play a rapidly increasing role in the onroad fleet and provides further evidence that BEV and PHEV technologies are increasingly seen as an effective and feasible set of vehicle technologies that are available to manufacturers to help comply with increasing levels of emission reductions.

EPA has assessed the feasibility of the proposed standards in light of current and anticipated progress by automakers in developing and deploying new emissions-reducing technologies and has presented the bulk of this analysis in Chapter 3 of the DRIA. DRIA 3.1.1 provides further discussion of recent trends and feasibility of light-duty vehicle technologies that manufacturers have available to meet the proposed standards. DRIA 3.1.2 discusses recent trends in electrification of medium-duty vehicles. The following paragraphs summarize other aspects of PEV feasibility, such as technology costs, consumer acceptance, charging infrastructure, supply chain, manufacturing capacity, critical minerals, and effects of BEV penetration on upstream emissions; the respective chapters of the DRIA provide additional detail.

While EPA has not specifically modeled the adoption of plug-in hybrid electric vehicle (PHEV) architectures in the analysis for this proposal, the agency recognizes that PHEVs can provide significant reductions in GHG emissions and that some vehicle manufacturers may choose to utilize this technology as part of their technology offering portfolio in response to customer demands/needs and in response to EPA emission standards (as some firms are already doing today). PHEVs have been available in the light-duty vehicle market in the U.S. for more than a decade and a number of models are available now across a larger breadth of vehicle types, including sedans, such as the Toyota Prius Prime, and crossover SUVs, such as the Subaru Crosstrek, Ford Escape PHEV, Kia Niro Plug-in Hybrid, Kia Sportage Plug-In Hybrid, Hyundai Tucson Plug-In Hybrid, Mitsubishi Outlander PHEV and Toyota RAV4 Prime. Stellantis currently offers a minivan PHEV in its Chrysler Pacifica Hybrid. Large PHEV SUVs are also currently available, including the Jeep Grand Cherokee and Jeep Wrangler 4xe, the Kia Sorento Plug in Hybrid, the Lincoln Corsair Grand Touring, the Lincoln Aviator, and the Volvo XC90 Recharge.

Although no PHEV pickup truck applications currently exist, EPA believes the PHEV architecture may lend itself well to future pickup truck applications, including some MDV pickup truck applications. One major manufacturer, Stellantis, recently announced at the 2023 Consumer Electronics Show that a range-extender will be an option on their new full-size Ram 1500 REV electric pickup.[552] A PHEV pickup architecture would provide several benefits: Some amount of zero-emission electric range (depending on battery size); increased total vehicle range during heavy towing and hauling operations using both charge depleting and charge sustaining modes (depending on ICE-powertrain sizing); job-site utility with auxiliary power capabilities similar to portable worksite generators, and the efficiency improvements normally associated with strong hybrids that provide regenerative braking, extended engine idle-off, and launch assist for high torque demand applications. Depending on the vehicle architecture, PHEVs used in pickup truck applications may also offer additional capabilities, similar to BEV pickups, with respect to torque control and/or torque vectoring to reduce wheel slip during launch in trailer towing applications. In addition, PHEVs may help provide a bridge for consumers that may not be ready to adopt a fully electric vehicle.

The MY 2023 Jeep Grand Cherokee 4xe with the ''Trailhawk'' package is an example of a large SUV with significant tow capability and similar packages may eventually be used in pickup truck applications. The vehicle has a 6,125 pound GVWR and a 12,125-pound GCWR using a combination of a 270 bhp turbocharged GDI engine with P2 and P0 electric machines of 100kW and 33kW, respectively. The vehicle also uses a 17.3 kWh (nominal size) battery pack that provides 25 miles of all-electric range. The MY 2023 Jeep Wrangler 4xe uses a similar powertrain and battery pack. The Wrangler 4xe equipped with the ''Rubicon'' package has a 6,400-pound GVWR and a 9,200-pound GCWR.

EPA requests comment on the types of PHEVs EPA could consider in our analysis for the final rulemaking, including whether or not EPA should explicitly model PHEVs in light-duty and MDV pickup applications. EPA also requests comment on recommendations for likely PHEV architectures that should be investigated, and any relevant performance or utility data that may help inform our modeling and analyses. EPA has initiated contract work with Southwest Research Institute to investigate likely technology architectures of both PHEV and internal combustion engine range-extended electric light-duty and MDV pickup trucks that we anticipate will provide data in time for the final rule. In addition, within DRIA Chapter 2.6.1.4 ''PHEV Powertrain Costs,'' EPA provides component technology descriptions and cost estimates that include the major components needed to manufacture a PHEV, including batteries, e-motors, power electronics and other ancillary systems. EPA requests comment on our PHEV cost estimates contained in the DRIA. EPA may rely upon those estimates and other information gathered in response to this proposal and EPA's on-going technical work for estimating the costs for PHEVs for the final rule.

Many light-duty and medium-duty PHEVs purchased for commercial use would be eligible for the Commercial Clean Vehicle Credit (45W) under the IRA, which provides a credit of up to $7,500 for qualified vehicles with gross vehicle weight ratings (GVWRs) of under 14,000 pounds and up to $40,000 for qualified vehicles above 14,000 pounds GVWR. As the amount of the credit depends on the GVWR and the incremental cost of the vehicle relative a comparable ICE vehicle, EPA also requests comment on estimating the amount of the credit that will on average apply to commercial MDV PHEVs, such as PHEV pickups, and other commercial PHEVs and BEVs.

### 2. Approach To Estimating Electrification Technology Costs

Among the various technology costs that are relevant to technology feasibility, costs for electrification technology are of particular interest due to the increased penetrations of

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[552] Kiley, D. Ram 1500 BEV Expected To Hit Market With 500 Miles of Range. ''Wards Auto'', January 5, 2023. *https://www.wardsauto.com/print/389039.*

electrified vehicles that are projected in the compliance analysis.

This section provides a general review of how battery and other electrification component costs were developed for this analysis. A more detailed discussion of the development of the electrification cost estimates used in the proposal, and the sources we considered, may be found in DRIA Chapter 2.

To develop battery cost estimates for PEVs, EPA relied on a number of resources. First, as part of our ongoing research activities, we followed recent and anticipated trends in PEV battery design and configuration in order to understand the general design parameters of batteries that are appearing in high-production PEV models and whose cost therefore should be modeled in the analysis. To identify appropriate pack designs, we sought to model batteries with pack topologies, cell sizes, and chemistry that are similar to those seen in emerging high-production battery platforms, such as for example the GM Ultium battery platform, the VW MEB vehicle platform, and the Hyundai E–GMP vehicle platform. EPA considers these platforms to exemplify the trend toward BEV-specific vehicle platforms with battery packs of several capacities that are constructed from various numbers of modules that utilize one or two standard cell sizes of relatively large capacity, generally forming a flat battery pack assembly suitable for residing in the vehicle floor.

EPA then used Argonne National Laboratory's BatPaC model version 5.0 as a key tool to generate base year (2022) direct manufacturing cost estimates for battery packs of such a design, as they are likely to be experienced today in a well optimized, high-volume battery production facility. As described in more detail in DRIA Chapter 2.5.2.1.2, we generated a population of pack costs for various pack energy capacities (kWh) and developed curve fits to express base year cost per kWh as a function of gross kWh,[553] for a number of annual production volumes.

To determine battery manufacturing costs in future years of the analysis, we first looked to industry forecasts and other literature regarding expected cost reductions for typical BEV battery packs in future years, expected to result from factors commonly cited in these forecasts, such as improved manufacturing efficiency and increasing production volumes. We then used this information to derive a nominal reference trajectory for future battery pack cost per kWh for an average BEV battery pack. The development of the reference trajectory is described in DRIA 2.5.2.1.3.

This generic reference trajectory was used as a reference point with which to qualitatively compare BEV battery costs per kWh that are output by the OMEGA model. When the OMEGA model generates a compliant fleet in a given future year of the analysis, battery costs for BEVs in that year are determined dynamically, by applying a learning cost reduction to the base year cost. The learning factor is calculated based on the cumulative GWh of battery production necessary to supply the number of BEVs that OMEGA has thus far placed in the analysis fleet, up to that analysis year. This is consistent with ‘‘learning by doing,’’ a standard basis for representing cost reductions due to learning in which a specific percentage cost reduction occurs with each doubling of cumulative production over time. This dynamic method of assigning a cost reduction due to learning means that OMEGA runs that result in different cumulative battery production levels will result in somewhat different battery costs.

Because it is concerned with projecting a compliant U.S. fleet, OMEGA estimates only the cumulative GWh of battery production needed to supply the U.S. PEV fleet. On a global scale, and across other battery applications such as stationary storage or other classes of vehicles, cumulative GWh of battery production is likely to be much larger than that for the U.S. fleet alone, and could potentially lead to a greater potential for learning to occur over the same time frame. Therefore, our use of cumulative U.S. production may be conservative with respect to the potential for volume-based learning to occur. EPA invites comment on whether and how EPA should consider the issue of global battery production in the context of our application of learning for the final rule analysis.

As an example of the pack direct manufacturing costs used in the analysis, Figure 21 shows the sales-weighted average battery pack direct manufacturing cost per kWh generated by OMEGA for the central case of the proposal, alongside the reference trajectory. The Proposal costs compare quite favorably to the reference trajectory and vary generally as expected. From 2022 to 2025 they are somewhat lower, due to the substantially larger average pack size (96 to 103 kWh) compared to the 75 kWh of the reference trajectory. Post-2027, the Proposal costs are also lower than the reference trajectory, again due in part to the larger pack size, and increasingly, to the growing cumulative production volume due to the additional BEVs driven by the proposal.

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[553] As described in DRIA Chapter 2, larger packs tend to achieve a lower cost per kWh, and this tendency is evident in BatPaC results.

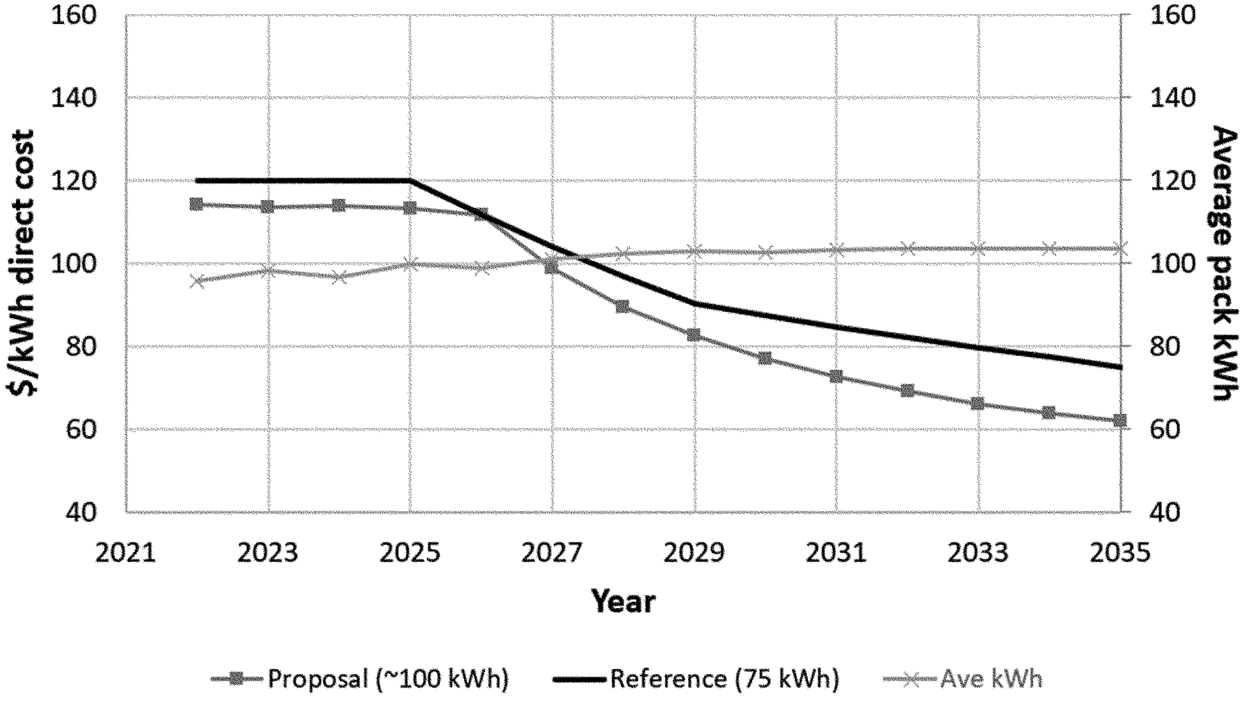

Figure 21. Example of pack direct manufacturing cost per kWh and average pack kWh generated by OMEGA.

The average pack size for BEVs generated by OMEGA is plotted on the right axis. The 96 kWh to 103 kWh average pack capacity is due in part to their use in relatively large vehicles, such as large SUVs and light trucks, which form a significant part of the OMEGA modeled compliance fleet and to which OMEGA directs a significant amount of electrification in its identification of a least cost compliance pathway. Another factor is the use of a 300-mile driving range for all BEVs in the analysis, which is a longer average range than in some other studies but which EPA believes is an appropriate modeling choice to reflect currently prevailing range expectations by consumers.[554] More discussion of the OMEGA model and the OMEGA results can be found in Section IV.C and in the DRIA.

To reflect the anticipated effect of the Inflation Reduction Act (IRA) on battery production costs to manufacturers, we applied a further battery cost reduction based on the Section 45X Advanced Manufacturing Production Tax Credit. This provision of the IRA provides a $35 per kWh tax credit for manufacturers of battery cells, and an additional $10 per kWh for manufacturers of battery modules, as well as a credit equal to 10 percent of the manufacturing cost of electrode active materials and another 10 percent for the manufacturing cost of critical minerals (all applicable only to manufacture in the United States). The credits, with the exception of the critical minerals credit, are available immediately to manufacturers who meet the U.S. production requirement and phase out from 2030 to 2032.

We assumed that manufacturer ability to take advantage of the $35 cell credit and the $10 module credit would ramp up linearly from 60 percent of total cells and modules in 2023 (a conservative estimate of the current percentage of U.S.-based battery and cell manufacturing likely to be eligible today for the credit)[555] [556] [557] to 100 percent in 2027, and then ramping down by 25 percent per year as the law phases out the credit from 2030 (75 percent) through 2033 (zero percent). Although a large percentage of 2023 U.S. BEV battery and cell manufacturing is represented by the production of one OEM, we expect that the many large U.S. battery production facilities that are being actively developed by suppliers and other OEMs (as described in Section IV.C.6 of this Preamble) will allow benefit of the credit to be accessible to all manufacturers by 2027.

Because RPE is meant to be a multiplier against the direct manufacturing cost, and the 45X credit does not reduce the actual direct manufacturing cost at the factory but only compensates the cost after the fact, we felt that it was most appropriate to apply the 45X credit to the marked-up cost. The 45X cell and module credits per kWh were applied by first marking up the direct manufacturing cost by the 1.5 RPE factor to determine the indirect cost (*i.e.,* 50 percent of the manufacturing cost), then deducting the credit amount from the marked-up cost to create a post-credit marked-up cost. The post-credit direct manufacturing cost would then become the post-credit marked-up cost minus the indirect cost. Details on the application of the 45X credit in OMEGA can be found in DRIA 2.5.2.1.

EPA did not apply a further cost reduction to represent the 10 percent electrode active material or critical mineral production credits under 45X,

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[554] For light-duty, OMEGA uses a 300 mile range for BEVs. For medium-duty, OMEGA uses a 300 mile range for pickup BEVs and a 150 mile range for van BEVs.

[555] U.S. Department of Energy, ''FOTW #1192, June 28, 2021: Most U.S. Light-Duty Plug-In Electric Vehicle Battery Cells and Packs Produced Domestically from 2018 to 2020,'' June 28, 2021. *https://www.energy.gov/eere/vehicles/articles/fotw-1192-june-28-2021-most-us-light-duty-plug-electric-vehicle-battery.*

[556] Argonne National Laboratory, ''Lithium-Ion Battery Supply Chain for E-Drive Vehicles in the United States: 2010–2020,'' ANL/ESD–21/3, March 2021.

[557] U.S. Department of Energy, ''Vehicle Technologies Office Transportation Analysis Fact of the Week #1278, Most Battery Cells and Battery Packs in Plug-in Vehicles Sold in the United States From 2010 to 2021 Were Domestically Produced,'' February 20, 2023.

which are also available to be utilized by manufacturers. Although not explicitly modeled, these credits could have a substantial impact on reducing battery costs for some manufacturers in the short term and many in the long term, and so their exclusion from the currently modeled cost estimates represents a conservative assumption. EPA requests comment on how the effect of these specific credits might be quantitatively represented in battery production cost for the final rule analysis.

The IRA also includes consumer purchase incentives, which do not affect battery manufacturing cost, but reduce vehicle purchase cost to consumers.

A substantial Clean Vehicle Credit (CVC, or IRS 30D) of up to $7,500 is available to eligible buyers of eligible PEVs, subject to a number of requirements such as location of final assembly (in North America), critical minerals and battery component origin, vehicle retail price, and buyer income. Similarly, a Commercial Clean Vehicle Credit (CCVC, or IRS 45W) of up to $7,500 is available for light-duty vehicles purchased for commercial use. Guidance by the Internal Revenue Service indicates that vehicles leased to consumers (rather than sold) are commercial vehicles that will qualify for the full credit to be paid to the lessor.[558] EPA recognizes that this guidance could lead to increased relevance of the CCVC for vehicles and buyers that would not otherwise be eligible for the CVCC, and that this could constitute an additional PEV cost reduction for certain consumers. Relevant considerations in quantifying the extent to which the CVCC may influence cost of PEVs to consumers would include factors such as the degree to which the value of the CVCC credit (paid to lessor) would be represented in reduced payments to the lessee, and the degree to which manufacturers and dealers that currently sell vehicles outright choose to switch to a leasing model.

Because of the requirements of the 30D credit and the uncertainties regarding utilization of the 45W credit, EPA is not assuming that all BEV sales will qualify for the full $7,500 30D or 45W credit. A portion of the market that is unable to capture the 30D credit may be capable of utilizing the 45W credit. For these reasons, in the OMEGA model we have applied a portion of the $7,500 maximum from either incentive. For 2023 we estimated that an average credit amount (across all PEV purchases) of $3,750 per vehicle could reasonably be expected to be realized through a combination of the 30D and 45W tax credits. For later years, we recognized that the attractiveness of the credits to manufacturers and consumers would likely increase eligibility over time. To reflect this, we ramped the value linearly to $6,000 by 2032, the last year of the credits. We did not ramp to the full theoretical value of $7,500, in expectation that not all purchases will qualify for 30D due to MSRP or income limitations, and that not all PEVs are likely to enter the market through leasing.

The credit amount is modeled in OMEGA as a direct reduction to the consumer purchase costs,[559] and therefore has an influence on the shares of BEVs demanded by consumers. The purchase incentive is assumed to be realized entirely by the consumer and does not impact the vehicle production costs for producer. For more discussion and the values used by OMEGA, please see DRIA Chapter 2.6.8.

EPA also considered potential impacts on battery manufacturing cost that might result from the proposed battery durability and warranty requirements described in Sections III.F.2 and III.F.3. Because the durability minimum performance requirement and the minimum battery warranty are similar to currently observed industry practices regarding durability performance and warranty terms, EPA does not expect that the proposed requirements will result in an increase in battery manufacturing costs.

Forecasting of future battery costs is a very active research area, particularly at this time of rapidly increasing demand in an actively evolving industry. As new forecasts of battery cost become available, EPA plans to consider this information for the final rule analysis. One example of the potential for new information to emerge periodically on this active topic is the recently released report (December 6, 2022) from Bloomberg New Energy Finance (BNEF) describing the results of their annual Battery Price Survey, which indicates that after years of steady decline, the global average price for lithium-ion battery packs (volume-weighted across the passenger, commercial, bus, and stationary markets) climbed by about 7 percent in 2022, from $141 per kWh the year before to $151 per kWh in 2022.[560] [561] For passenger BEV batteries the average price paid was reported to be $138 per kWh. Although the BNEF report is useful to understand trends in prices that are reported as being paid across the industry, it is difficult to compare the BNEF costs to the modeled costs in our analysis, which apply to a specific class of pack design manufactured in large quantities at a large manufacturing facility, to fulfill large orders for a major OEM. In contrast, the survey respondents are likely to include both large and small purchasers of diverse battery packs whose designs and average gross capacities may differ from those modeled in the analysis. Recognizing these and other uncertainties, EPA believes that our proposed battery cost estimates are reasonable based on the record at this time. To improve upon these estimates for the final rule analysis, EPA plans to continue to monitor emerging studies and will review the cost estimates based on available information and public comment. We also plan to work with ANL to continue updating our estimates of battery cost for current and future years, by adjusting key inputs to the BatPaC model to represent expected improvements to production processes, forecasts of future mineral costs, and design improvements. This will allow refinement of the scaling factors based on BatPaC modeling in addition to our consideration of industry forecasts.

In Figure 22 we compare the example battery costs of Figure 21 to the high and low battery cost sensitivities that were examined in the 2021 rule. The dotted lines show the high- and low-cost sensitivities in the 2021 rule, applicable to a 60-kWh pack as per the discussion that was provided in the 2021 rule. For comparison to the current proposal, the solid line shows the example OMEGA cost per kWh shown in Figure 21. The average battery size generated for BEVs by OMEGA is larger than the 60 kWh example from the 2021 rule, at about 100 kWh.

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[558] Internal Revenue Service, ''Topic G—Frequently Asked Questions About Qualified Commercial Clean Vehicles Credit,'' February 3, 2023. *https://www.irs.gov/newsroom/topic-g-frequently-asked-questions-about-qualified-commercial-clean-vehicles-credit.*

[559] As described in Chapter 4.1 of the DRIA, the modeling of consumer demand for ICE and BEV vehicles considers purchase and ownership costs as components of a ''consumer generalized cost'' for the ICE and BEV options. The purchase cost reflects the vehicle purchase price and any assumed purchase incentives under 30D of the IRA.

[560] Bloomberg New Energy Finance, ''Rising Battery Prices Threaten to Derail the Arrival of Affordable EVs,'' December 6, 2022. Accessed on December 6, 2022 at: *https://www.bloomberg.com/news/articles/2022-12-06/rising-battery-prices-threaten-to-derail-the-arrival-of-affordable-evs.*

[561] Bloomberg New Energy Finance, ''Lithium-ion Battery Pack Prices Rise for First Time to an Average of $151/kWh,'' December 6, 2022. Accessed on December 6, 2022 at: *https://about.bnef.com/blog/lithium-ion-battery-pack-prices-rise-for-first-time-to-an-average-of-151-kwh/.*

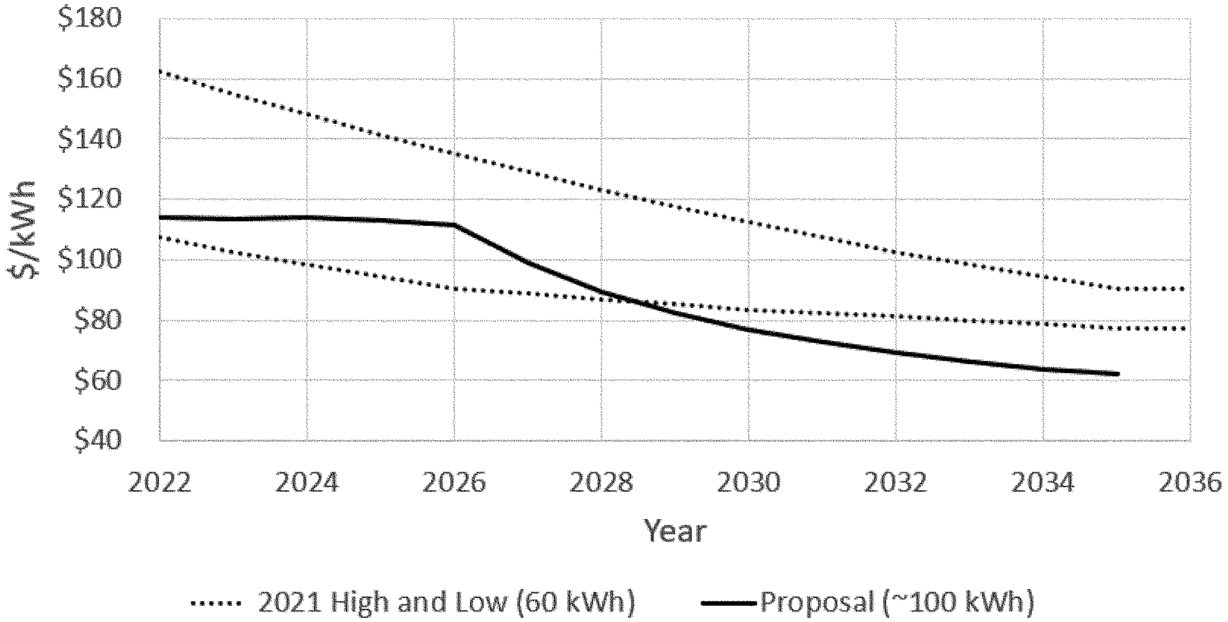

**Figure 22. Comparison of average BEV battery costs in proposal central case to high and low sensitivities in the 2021 rule analysis.**[562]

It can be seen that the average battery costs in the current proposal remain with the band delineated by the high and low sensitivities of the 2021 final rule analysis, out to MY 2028–2029. At MY 2029, the cost begins to decline below the lower sensitivity in the 2021 rule. In general, part of the lower cost is due to the larger pack capacity. Also, in the central case of the 2021 final rule analysis, we had chosen to hold the battery cost learning rate constant after MY 2029, essentially subjecting it to a floor that was meant to represent uncertainty about the potential for continued reductions due to rising demand and prices for critical minerals that were beginning to become apparent at the time of the rulemaking. We had noted that this was a conservative assumption, reflecting uncertainty at the time about what the appropriate level of learning would be in light of emerging cost increases for critical minerals. We also noted that we would continue to study the potential for cost reductions in batteries during and after the time frame of the rule, noting that pending updates to the ANL BatPaC model, as well as collection of emerging data on forecasts for future mineral prices and production capacity, would make it possible to more confidently characterize the rate of decline in battery costs, and that we would incorporate this information in the current proposal.

Since then, these developments have improved our ability to understand the potential for cost reductions past 2029, in place of the lower limit we had assumed in the 2021 analysis. While predicting the actual cost of batteries this far into the future is highly uncertain, most analysts expect continued progress to occur as a result of continued improvement in battery manufacturing and battery chemistry during this extended future timeframe.

Forecasting of future battery costs is subject to a great deal of uncertainty due to factors such as the ongoing and active development of the technology and rapidly increasing demand. EPA welcomes comment on the battery costs used in this analysis and how to best represent future expectations of trends in battery costs, as well as additional data and information that EPA should consider in assessing battery costs for the final rule analysis.

Detailed discussion of the development of the battery cost estimates used in the proposal and the sources we considered may be found in DRIA Chapter 2.

EPA has also updated the non-battery powertrain costs that were used to determine the direct manufacturing cost of electrified powertrains. We referred to a variety of industry and academic sources, focusing primarily on teardowns of components and vehicles conducted by leading engineering firms. These included the 2017 teardown of the Chevy Bolt conducted by Munro and Associates for UBS;[563] a 2018 teardown of several electrified vehicle components conducted by Ricardo for the California Air Resources Board;[564] a set of commercial teardown reports published in 2019 and 2020 by Munro & Associates;[565] [566] [567] [568] [569] [570] and the

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[562] For valid comparison to the example costs reported in the 2021 final rule, the costs depicted in the figure represent a 60-kWh pack and thus are slightly higher than the cost trajectory shown in DRIA Chapter 2.5.2.1.3 (''Trajectory of future battery pack manufacturing costs for a 75 kWh BEV pack'') which represents a 75-kWh pack.

[563] UBS AG, ''Q-Series: UBS Evidence Lab Electric Car Teardown—Disruption Ahead?'' UBS Evidence Lab, May 18, 2017.

[564] California Air Resources Board, ''Advanced Strong Hybrid and Plug-In Hybrid Engineering Evaluation and Cost Analysis,'' CARB Agreement 15CAR018, prepared for CARB and California EPA by Munro & Associates, Inc. and Ricardo Strategic Consulting, April 21, 2017.

[565] Munro and Associates, ''Twelve Motor Side-by-Side Analysis,'' provided November 2020.

[566] Munro and Associates, ''6 Inverter Side-by-Side Analysis,'' provided January 2021.

[567] Munro and Associates, ''3 Inverter Side-by-Side Analysis,'' provided November 2020.

[568] Munro and Associates, ''BMW i3 Cost Analysis,'' dated January 2016, provided November 2020.

2021 NAS Phase 3 report.[571] Throughout the process of compiling the results of these studies, we collaborated with technical experts from the California Air Resources Board and NHTSA. More discussion of the technical basis for the non-battery electrified vehicle cost estimates used in the proposal may be found in DRIA Chapter 2.

We also commissioned a new full-vehicle teardown study comparing a gasoline-fueled VW Tiguan to the battery-electric VW ID.4, conducted for EPA by FEV of America.[572] The study was designed to compare the manufacturing cost and assembly labor requirements for two comparable vehicles, one an ICE vehicle and one a BEV, both of which were built on respective dedicated-ICE[573] and dedicated-BEV[574] platforms by the same manufacturer. The teardown applies a bill-of-materials approach to both vehicles and derives cost and assembly labor estimates for each component. The report was delivered to EPA in February 2023 and will undergo a contractor-managed peer review process to be completed by mid-2023. The results of this study will be used to inform the analysis for the final rulemaking where appropriate. For example, component costs for the BEV and ICE vehicle may be used to support or update our battery or non-battery costs for electrified vehicles, or our costs for ICE vehicles; assembly labor data may be used to further inform the employment analysis; and any other qualitative or quantitative information that may be drawn from the report may be used in the analysis. An additional task under this work assignment was for FEV to review the non-battery electric powertrain costs EPA has described in Chapter 2.6.1 of the DRIA, with respect to the cost values used and the method of scaling these costs across different vehicle performance characteristics and vehicle classes, and to suggest alternative values or scalings where applicable. More details about the goals of the teardown study can be found in DRIA 2.5.2.2.3. The complete teardown report, the associated bill-of-materials data worksheets, and the FEV review of non-battery costs and scaling are available in the Docket.[575] [576] EPA may rely on this information and other information gathered in response to this proposal and EPA's ongoing technical work for estimating the costs for ICE vehicles and PEVs for the final rule.

EPA requests comment on all aspects of the battery and non-battery costs used in this analysis, including the base year costs, the forecast and estimation of future battery costs, assumptions relating to driving range, and similar issues that would affect modeling of battery and non-battery costs. EPA also requests comment on alternative ways to account for the effect of the IRA provisions, including the 45X, 30D, 45W, and other relevant provisions, in the estimation of battery or vehicle production cost to manufacturers or other impacts on the cost of PEVs to consumers, and will consider such comments for the analysis for the final rulemaking. We also request comment on our application of learning to battery cost reduction, and evidence and data related to the potential use of global battery production volumes instead of domestic volumes in that context, and/or the use of battery production volumes in related sectors.

### 3. Analysis of Power Sector Emissions

As PEVs are anticipated to represent a significant share of the future U.S. light- and medium-duty vehicle fleet, EPA has developed new approaches to estimate the upstream emissions (*i.e.,* from electricity generation and transmission) of increased PEV charging demand as part of the assessment of the proposed standards. Electric generation was modeled using EPA's Power Sector Modeling Platform, which in turn uses the Integrated Planning Model (IPM).[577] IPM provides projections of least-cost capacity expansion, electricity dispatch, and emission control strategies for meeting energy demand and environmental, transmission, dispatch, and reliability constraints represented within 74 regions of the 48 contiguous United States. The power sector modeling used for determining the PEV upstream emissions inventory and costs for the proposal and alternatives included changes to the platform to better represent the impacts of both the Bipartisan Infrastructure Law (BIL) and the Inflation Reduction Act (IRA) on electric power generation.

The regionalization of IPM and the anticipation of a highly regionalized initial rollout of electric vehicles under the California ZEV program necessitated modeling of the regionalization of PEV charge demand in order to fully capture emissions and other impacts on the electric power sector. National-level VMT and charge demand from scenarios modeled within the OMEGA compliance model were regionalized into the 74 IPM regions using the EVI–X modeling suite of electric vehicle charging infrastructure analysis tools developed by the National Renewable Energy Laboratory (NREL) combined with a PEV likely adopter model. Chapter 5 of the DRIA contains a detailed description of the analysis of PEV charging demand, electric generation and the resulting emissions and cost for different projected vehicle electrification scenarios.

Power sector modeling results of generation and grid mix from 2030 to 2050 and $CO_2$ emissions from 2028 to 2050 for the contiguous United States (CONUS) are shown in Figure 23. Power sector $CO_2$ emissions for the proposal are compared to a no-action case in Figure 24. Power sector modeling results are summarized in more detail within Chapter 5 of the DRIA. The results show significant continued year-over-year growth in both total generation and the use of renewables for electric generation (Figure 23) and year-over-year reductions in $CO_2$ emissions (Figure 24). Emissions of $NO_X$ (Figure 25), $SO_2$ (Figure 26), $PM_{2.5}$, and other EGU emissions followed similar general trends to the $CO_2$ emissions results. The largest differences in modeled EGU emissions between the proposal and No Action case were in 2035, when $CO_2$, $NO_X$ and $SO_2$ were approximately 7 percent, 6 percent and 9 percent higher, respectively. It should be noted, however, that this represents EGU emissions only and does not include anticipated emissions reductions from vehicle tailpipe or refinery emissions. By 2050, modeled EGU $PM_{2.5}$, and $NO_X$ emissions increased by less than 3 percent for the proposal than for a No Action case and by less than 5 percent for $CO_2$ and $SO_2$ emissions.

Power sector modeling results showed that the increased use of renewables will largely displace coal and (to a lesser

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[569] Munro and Associates, ''2020 Tesla Model Y Cost Analysis,'' provided November 2020.

[570] Munro and Associates, ''2017 Tesla Model 3 Cost Analysis,'' dated 2018, provided November 12, 2020.

[571] National Academies of Sciences, Engineering, and Medicine 2021. ''Assessment of Technologies for Improving Light-Duty Vehicle Fuel Economy 2025–2035''. Washington, DC: The National Academies Press. *https://doi.org/10.17226/26092.*

[572] FEV Consulting Inc., ''Cost and Technology Evaluation, Conventional Powertrain Vehicle Compared to an Electrified Powertrain Vehicle, Same Vehicle Class and OEM,'' prepared for Environmental Protection Agency, EPA Contract No. 68HERC19D00008, February 2023.

[573] VW MQB A2 (''Modularer Querbaukasten'' or ''Modular Transversal Toolkit'', version A2) global vehicle platform.

[574] VW MEB (''Modularer E-Antriebs Baukasten'' or ''modular electric-drive toolkit) global vehicle platform.

[575] Memo to Docket ID No. EPA–HQ–OAR–2022–0829, titled ''Cost and Technology Evaluation, Conventional Powertrain Vehicle Compared to an Electrified Powertrain Vehicle, Same Vehicle Class and OEM.''

[576] Memo to Docket ID No. EPA–HQ–OAR–2022–0829, titled ''EV Non-Battery Cost Review by FEV.''

[577] *https://www.epa.gov/power-sector-modeling.*

extent) natural gas EGUs and will primarily be driven by provisions of the IRA. By 2035, power sector modeling results also showed that non-hydroelectric renewables (primarily wind and solar) will be the largest source of electric generation (approximately 46 percent of total generation), and they would account for more than 70 percent of generation by 2050. This displacement of coal EGUs by renewables was also the primary factor in the year-over-year reductions in $CO_2$, $NO_X$, $SO_2$, $PM_{2.5}$, and other EGU emissions. Impacts on EGU GHG and criteria pollutant emissions due to grid-related IRA provisions were substantially larger than the impact of increased electricity demand due to increased electrification of light and medium-duty vehicles within the proposal. As EGU emissions continue to decrease between 2028 and 2050 due to increasing use of renewables, and as vehicles increasingly electrify, the power sector GHG and criteria pollutant emissions associated with light- and medium-duty vehicle operation will continue to decrease.

Power sector modeling also showed a significant increase in the use of batteries for grid storage. When modeling PEV charge demand for both the proposal and for a No Action case, grid battery storage capacity increased from approximately zero capacity in 2020 to approximately 70 GW in 2030 and 170 GW in 2050, representing the equivalent of approximately 100 GWh and 300 GWh of annual generation, respectively. The increase in grid battery storage was primarily due to modeling of incentives put in place under the IRA.

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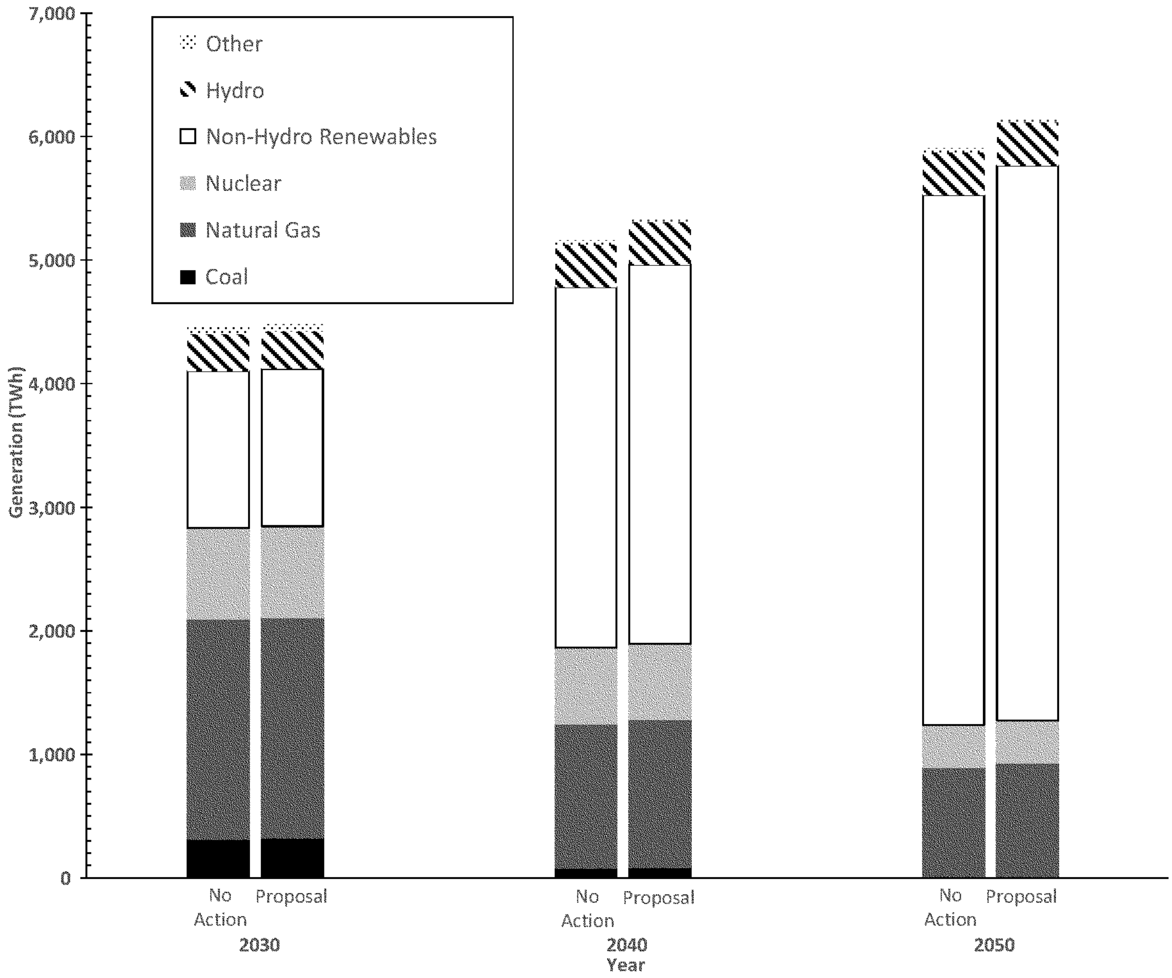

**Figure 23. 2030 - 2050 power sector grid mix for the No Action case (left side of each pair of bars representing each year) compared to the proposal (right side of each pair of bars).**

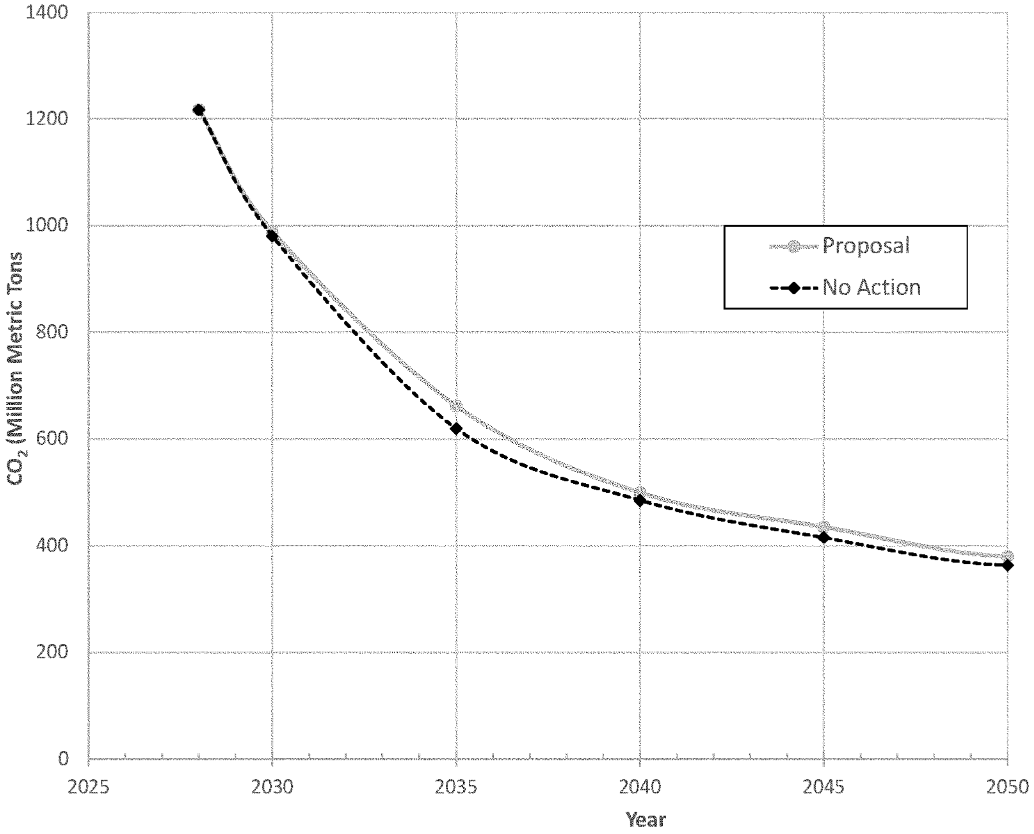

**Figure 24. 2028 through 2050 CONUS CO₂ emissions from electricity generation for the proposal (gray line) compared to a No Action case (black dashed line).**

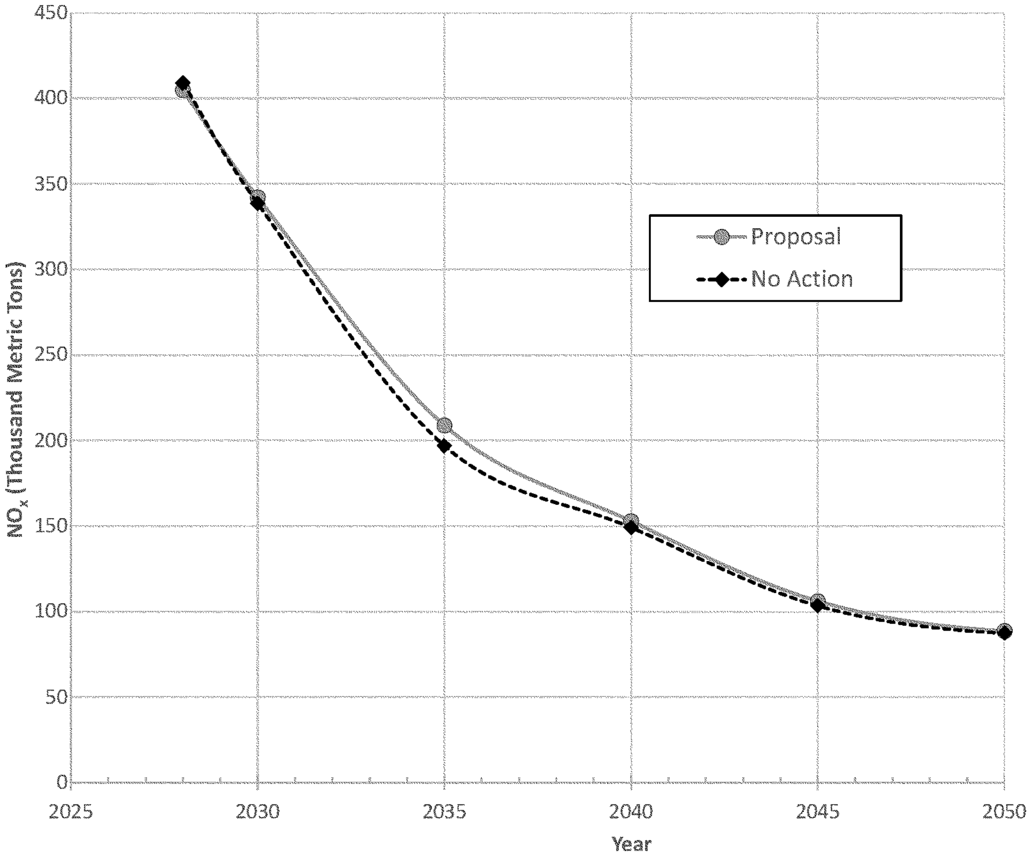

**Figure 25. 2028 through 2050 CONUS NO$_x$ emissions from electricity generation for the proposal (gray line) compared to a No Action case (black dashed line).**

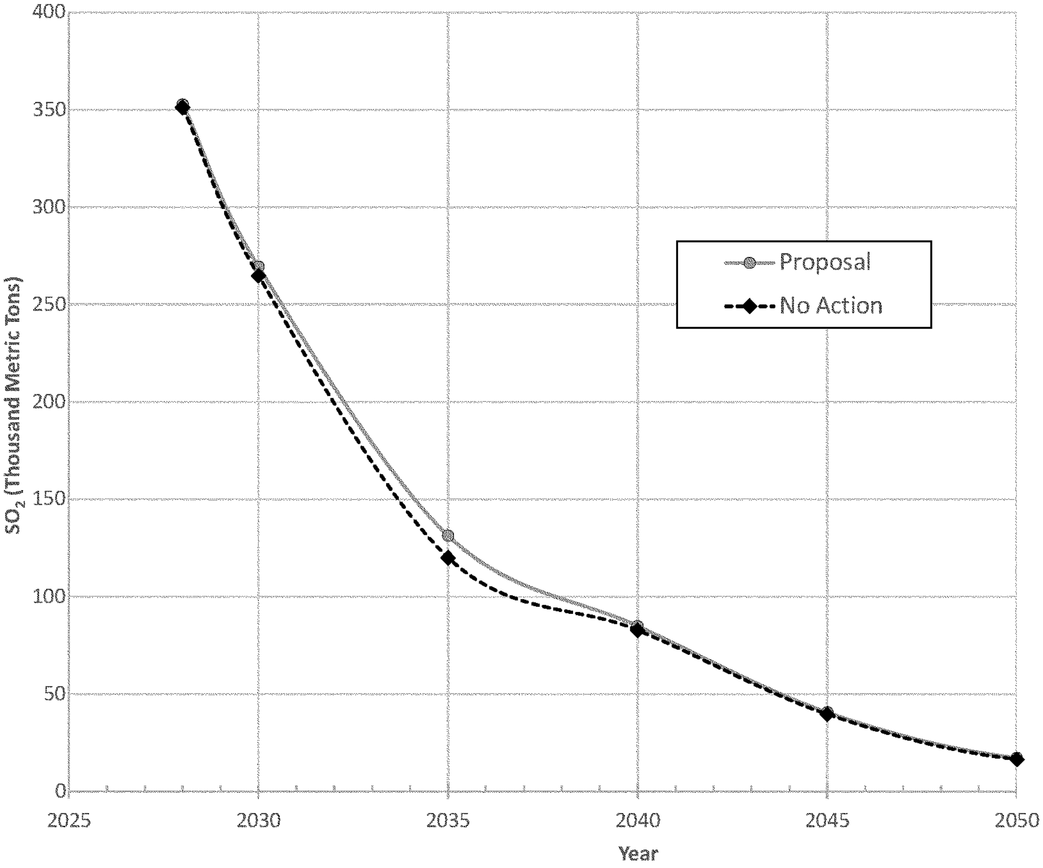

**Figure 26. 2028 through 2050 CONUS $SO_2$ emissions from electricity generation for the proposal (gray line) compared to a No Action case (black dashed line).**

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4. PEV Charging Infrastructure Considerations

Charging infrastructure has been growing rapidly in the past few years. There are over 50,000 non-residential public and private charging stations in the U.S. today with more than 140,000 electric vehicle supply equipment (EVSE) ports (or outlets that can charge vehicles simultaneously).[578] This is an increase from just over 85,000 EVSE ports as of the end of 2019.[579] While estimates for future infrastructure needs vary widely in the literature, an NREL report found that the overall ratio of EVSE ports to the number of PEVs on the road today generally compares favorably to projected needs in two national studies.[580] Of course, keeping up with charging needs as PEV adoption grows will require continued expansion of charging infrastructure.

EPA anticipates a mix of public and private investments will be available to help meet these future infrastructure needs. The Bipartisan Infrastructure Law (BIL) provides up to $7.5 billion over five years to build out a national PEV charging network.[581] Two-thirds of this funding is for the National Electric Vehicle Infrastructure (NEVI) Formula Program with the remaining $2.5 billion for the Charging and Fueling Infrastructure (CFI) Discretionary Grant Program. Both programs are administered under the Federal Highway Administration with support from the Joint Office of Energy and Transportation. The first phase of NEVI funding—a formula program for states—was launched in 2022 and initial plans for all 50 states, DC, and Puerto Rico have now been approved. Together, this initial $1.5 billion of investments will help deploy or expand charging infrastructure on about 75,000 miles of highway.[582] In March 2023, the first funding opportunity was opened under the CFI Program with up to $700 million to deploy PEV charging and hydrogen, propane, or natural gas fueling infrastructure in communities and along corridors.[583] Ensuring equitable access to charging is one of the stated goals of these infrastructure funds. Accordingly,

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[578] U.S. DOE, Alternative Fuels Data Center, "Electric Vehicle Charging Infrastructure Trends". Accessed February 28, 2023, at *https://afdc.energy.gov/fuels/electricity_infrastructure_trends.html.*

[579] Ibid.

[580] Brown, A. et al., "Electric Vehicle Charging Infrastructure Trends from the Alternative Fueling Station Locator: Second Quarter 2022," December 2022, Golden, CO: National Renewable Energy Laboratory. NREL/TP–5400–84263. Accessed March 6, 2023, at *https://www.nrel.gov/docs/fy23osti/84263.pdf.*

[581] Enacted as the Infrastructure Investment and Jobs Act, Public Law 117–58. 2021. Accessed January 10, 2023, at *https://www.congress.gov/bill/117th-congress/house-bill/3684.*

[582] U.S. DOT, FHWA, "Historic Step: All Fifty States Plus D.C. and Puerto Rico Greenlit to Move EV Charging Networks Forward, Covering 75,000 Miles of Highway," September 27, 2022. Accessed January 10, 2023, at *https://highways.dot.gov/newsroom/historic-step-all-fifty-states-plus-dc-and-puerto-rico-greenlit-move-ev-charging-networks.*

[583] Joint Office of Energy and Transportation, "Biden-Harris Admin Opens First Round Applications for $2.5 Billion Program to Build EV Charging in U.S. Communities," March 14, 2023. Accessed March 31, 2023, at *https://driveelectric.gov/news/#charging-fueling-infrastructure.*

FHWA instructed states to incorporate public engagement in their planning process for the NEVI Formula Program, including reaching out to Tribes, and rural, underserved, and disadvantaged communities.[584] Both the formula funding and discretionary grant program are subject to the Justice40 target that 40 percent of the benefits go to disadvantaged communities. Other programs with funding authorizations under the BIL that could be used in part to support charging infrastructure installations include the Congestion Mitigation & Air Quality Improvement Program, National Highway Performance Program, and Surface Transportation Block Grant Program among others.[585]

The Inflation Reduction Act (IRA) signed into law on August 16, 2022, can also help reduce the costs for deploying infrastructure.[586] The IRA extends the Alternative Fuel Refueling Property Tax Credit (Section 13404) through Dec 31, 2032, with modifications. Under the new provisions, residents in low-income or rural areas would be eligible for a 30 percent credit for the cost of installing residential charging equipment up to a $1,000 cap. Businesses would be eligible for up to 30 percent of the costs associated with purchasing and installing charging equipment in these areas (subject to a $100,000 cap per item) if prevailing wage and apprenticeship requirements are met and up to 6 percent otherwise. The Joint Committee on Taxation estimates the cost of this tax credit from FY 2022–2031 to be $1.738 billion,[587] which reflects a significant level of support for charging infrastructure and other eligible alternative fuel property.

States, utilities, auto manufacturers, charging network providers, and others are also investing in and supporting PEV charging infrastructure deployment. California announced plans in 2021 to invest over $300 million in light-duty charging infrastructure and nearly $700 million in medium- and heavy-duty ZEV infrastructure.[588] Several states including New Jersey and Utah offer partial rebates for residential, workplace, or public charging while others such as Georgia and DC offer tax credits.[589] The NC Clean Energy Technology Center identified more than 200 actions taken across 38 states and DC related to providing financial incentives for electric vehicles and or charging infrastructure in 2022, a four-fold increase over the number of actions in 2017.[590] The Edison Electric Institute estimates that electric companies have already invested nearly $3.7 billion.[591] And over 60 electric companies and cooperatives serving customers in 48 states and the District of Columbia have joined together to advance fast charging through the National Electric Highway Coalition.[592] Auto manufacturers are investing in charging infrastructure by offering consumers help with costs to install home charging or providing support for public charging. For example, GM will pay for a standard installation of a Level 2 (240 VAC) outlet for customers purchasing or leasing a new Bolt.[593] GM is also partnering with charging provider EVgo to deploy over 2,700 DCFC ports[594] and charging provider FLO to deploy as many as 40,000 L2 ports.[595] Volkswagen, Hyundai, and Kia all offer customers complimentary charging at Electrify America's public charging stations (subject to time limits or caps) in conjunction with the purchase of select new EV models.[596] Ford has agreements with several charging providers to make it easier for their customers to charge and pay across different networks[597] and plans to install publicly accessible DCFC ports at nearly 2,000 dealerships.[598] Mercedes-Benz recently announced that it is planning to build 2,500 charging points in North America by 2027.[599] Tesla has its own network with over 17,000 DCFC ports and nearly 10,000 Level 2 ports in the United States.[600] Tesla recently announced that by 2024, 7,500 or more existing and new ports (including 3,500 DCFC) would be open to all PEVs.[601]

Other charging networks are also expanding. Francis Energy, which has fewer than 1,000 EVSE ports today,[602] aims to deploy over 50,000 by the end of the decade.[603] Electrify America

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[584] U.S. DOT, FHWA, ''The National Electric Vehicle Infrastructure (NEVI) Formula Program Guidance,'' February 10, 2022. Accessed January 10, 2023, at *https://www.fhwa.dot.gov/environment/alternative_fuel_corridors/nominations/90d_nevi_formula_program_guidance.pdf.*

[585] Ibid.

[586] Inflation Reduction Act of 2022, Public Law 117–169, 2022. Accessed December 2, 2022, at *https://www.congress.gov/117/bills/hr5376/BILLS-117hr5376enr.pdf.*

[587] Joint Committee on Taxation, ''Estimated Budget Effects of the Revenue Provisions of Title I—Committee on Finance, of an Amendment in the Nature of a Substitute to H.R. 5376, ''An Act to Provide for Reconciliation Pursuant to Title II of S. Con. Res. 14,'' as Passed by the Senate on August 7, 2022, and Scheduled for Consideration by the House of Representatives on August 12, 2022'' JCX–18–22, August 9, 2022. Accessed January 11, 2023, at *https://www.jct.gov/publications/2022/jcx-18-22/.*

[588] California Energy Commission, ''CEC Approves $1.4 Billion Plan for Zero-Emission Transportation Infrastructure and Manufacturing,'' November 15, 2021. Accessed January 11, 2023, at *https://www.energy.ca.gov/news/2021-11/cec-approves-14-billion-plan-zero-emission-transportation-infrastructure-and.*

[589] Details on eligibility, qualifying expenses, and rebate or tax credit amounts vary by state. See DOE Alternative Fuels Data Center, State Laws and Incentives. Accessed January 11, 2023, at *https://afdc.energy.gov/laws/state.*

[590] Apadula, E. et al., ''50 States of Electric Vehicles Q4 2022 Quarterly Report & 2022 Annual Review Executive Summary,'' February 2023, NC Clean Energy Technology Center. Accessed March 8, 2023, at *https://nccleantech.ncsu.edu/wp-content/uploads/2023/02/Q4-22_EV_execsummary_Final.pdf.* (**NOTE:** Includes actions by states and investor-owned utilities.)

[591] EEI, ''Issues & Policy: National Electric Highway Coalition''. Accessed January 11, 2023, at *https://www.eei.org/issues-and-policy/national-electric-highway-coalition.* (**NOTE:** $3.7 billion total includes infrastructure deployments and other customer programs to advance transportation electrification.)

[592] Ibid.

[593] Chevrolet, ''Installation Made Easy. Home Charging Installation on Us.'' Accessed March 3, 2023, at *https://www.chevrolet.com/electric/living-electric/home-charging-installation.*

[594] GM, ''To Put 'Everybody In' an Electric Vehicle, GM introduces Ultium Charge 360,'' Accessed January 11, 2023, at *https://media.gm.com/media/us/en/gm/home.detail.html/content/Pages/news/us/en/2021/apr/0428-ultium-charge-360.html.*

[595] Joint Office of Transportation and Energy, ''Private Sector Continues to Play Key Part in Accelerating Buildout of EV Charging Networks,'' February 15, 2023. Accessed March 6, 2023, at *https://driveelectric.gov/news/#private-investment.*

[596] Details of complimentary charging and eligible vehicle models vary by auto manufacturer. See: *https://www.vw.com/en/models/id-4.html, https://www.hyundaiusa.com/us/en/electrified/charging, and https://owners.kia.com/content/owners/en/kia-electrify.html.*

[597] Ford, ''Ford Introduces North America's Largest Electric Vehicle Charging Network, Helping Customers Confidently Switch to an All-Electric Lifestyle,'' October 17, 2019. Accessed January 11, 2023, at *https://media.ford.com/content/fordmedia/fna/us/en/news/2019/10/17/ford-introduces-north-americas-largest-electric-vehicle-charting-network.html.*

[598] Joint Office of Transportation and Energy, ''Private Sector Continues to Play Key Part in Accelerating Buildout of EV Charging Networks,'' February 15, 2023. Accessed March 6, 2023, at *https://driveelectric.gov/news/#private-investment.*

[599] Reuters, ''Mercedes to launch vehicle-charging network, starting in North America,'' January 6, 2023. Accessed January 11, 2023, at *https://www.reuters.com/business/autos-transportation/mercedes-launch-vehicle-charging-network-starting-north-america-2023-01-05/.*

[600] DOE, Alternative Fuels Data Center, ''Electric Vehicle Charging Station Locations''. Accessed February 28, 2023, at *https://afdc.energy.gov/fuels/electricity_locations.html#/find/nearest?fuel=ELEC.*

[601] The White House, ''Fact Sheet: Biden-Harris Administration Announces New Standards and Major Progress for a Made-in-America National Network of Electric Vehicle Chargers,'' February 15, 2023. Accessed March 6, 2023, *at https://www.whitehouse.gov/briefing-room/statements-releases/2023/02/15/fact-sheet-biden-harris-administration-announces-new-standards-and-major-progress-for-a-made-in-america-national-network-of-electric-vehicle-chargers/.*

[602] DOE, Alternative Fuels Data Center, ''Electric Vehicle Charging Station Locations''. Accessed March 6, 2023, at *https://afdc.energy.gov/fuels/electricity_locations.html#/find/nearest?fuel=ELEC.*

[603] Joint Office of Transportation and Energy, ''Private Sector Continues to Play Key Part in

plans to more than double its network size[604] to 10,000 fast charging ports across 1,800 U.S. and Canadian stations by 2026. This is supported in part by a $450 million investment from Siemens and Volkswagen Group.[605] Blink plans to invest over $60 million to grow its network over the next decade. Charging companies are also partnering with major retailers, restaurants, and other businesses to make charging available to customers and the public. For example, EVgo is deploying DCFC at certain Meijer locations, CBL properties, and Wawa. Volta is installing DCFC and L2 ports at select Giant Food, Kroger, and Stop and Shop stores, while ChargePoint and Volvo Cars are partnering with Starbucks to make charging available at select Starbucks locations.[606] Other efforts will expand charging access along major highways, including at up to 500 Pilot and Flying J travel centers (through a partnership between Pilot, GM, and EVgo) and 200 TravelCenters of America and Petro locations (through a partnership between TravelCenters of America and Electrify America).[607] BP plans to invest $1 billion toward charging infrastructure by the end of the decade, including through a partnership to provide charging at various Hertz locations across the country that could support rental and ridesharing vehicles, taxis, and the general public.[608]

We assess the infrastructure needs and the associated costs for this proposal from 2027 to 2055. We start with estimates of electricity demand for the PEV penetration levels in the proposal compared to those in the No Action case using the methodology described in Section IV.C.3.[609] A suite of NREL models is used to characterize the quantity and mix of EVSE ports that could meet this demand, including EVI-Pro to simulate charging demand from typical daily travel, EVI-RoadTrip to simulate demand from long-distance travel, and EVI-OnDemand to simulate demand from ride-hailing applications. EVSE ports are broken out by charging location (home, work, or public) and by charging type and power level: AC Level 1 (L1), AC Level 2 (L2), and DC fast charging with a maximum power of 50 kW, 150 kW, 250 kW, or 350 kW (DC–50, DC–150, DC–250, and DC–350). We anticipate that the highest number of ports will be needed at homes, growing from under 12 million in 2027 to over 75 million in 2055 under the proposal. This is followed by workplace charging, estimated at about 400,000 EVSE ports in 2027 and over 12.7 million in 2055. Finally, we estimate public charging needs growing from just over 110,000 ports to more than 1.9 million in that timeframe.[610] Figure 27 illustrates the growth in charging network size needed for the proposal and No Action case over select years.[611]

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Accelerating Buildout of EV Charging Networks,'' February 15, 2023. Accessed March 6, 2023, at *https://driveelectric.gov/news/#private-investment.*

[604] DOE, Alternative Fuels Data Center, ''Electric Vehicle Charging Station Locations''. Accessed March 6, 2023, at *https://afdc.energy.gov/fuels/electricity_locations.html#/find/nearest?fuel=ELEC.*

[605] Joint Office of Transportation and Energy, ''Private Sector Continues to Play Key Part in Accelerating Buildout of EV Charging Networks,'' February 15, 2023. Accessed March 6, 2023, at *https://driveelectric.gov/news/#private-investment.*

[606] Ibid.

[607] Ibid.

[608] Ibid.

[609] The No Action case referred to as part of the infrastructure cost analysis was based on earlier work with lower projected PEV penetration rates than the No Action case used for compliance modeling and described in Section IV.B. (See discussion in DRIA Chapter 5.3.2.6.)

[610] The number of EVSE ports needed to meet a given level of electricity demand will vary based on assumptions about the mix of charging ports, charging preferences, and other factors. See DRIA Chapter 5 for a more detailed description of the assumptions underlying the EVSE port counts shown here.

[611] See DRIA Chapter 5 for estimated port counts for each year from 2027 to 2055 in the proposal and No Action case.

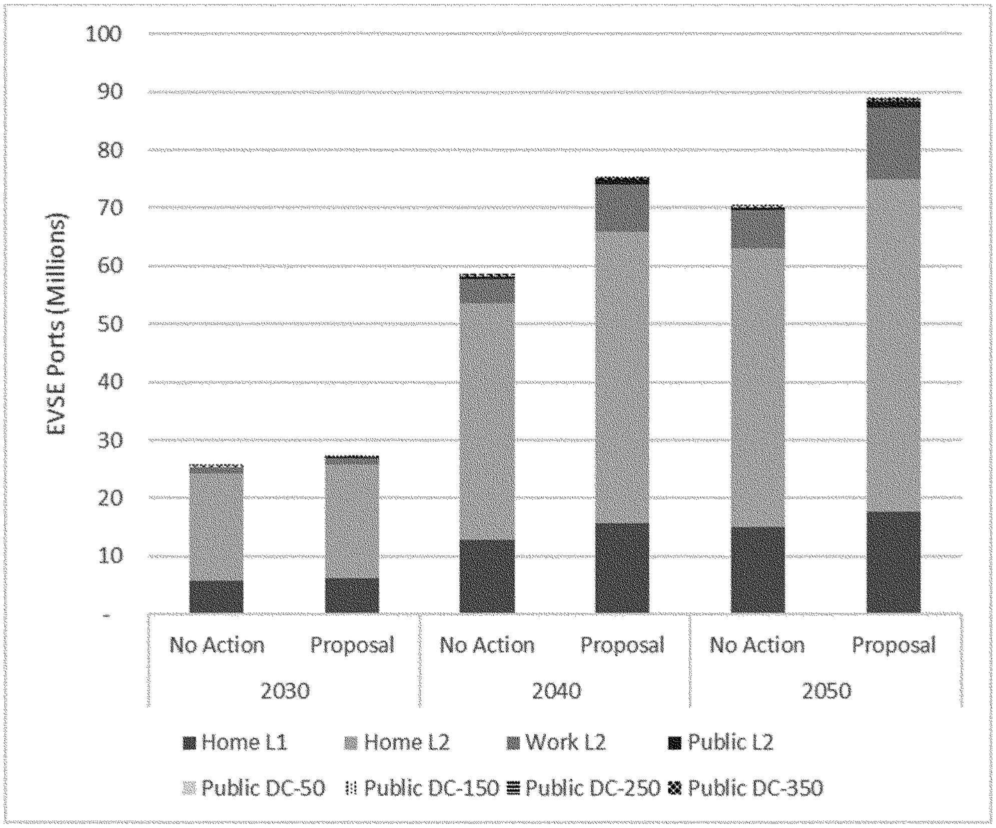

**Figure 27. EVSE port counts by charging location and type for the No Action case (left side of each pair of bars) and the proposal (right side of each pair of bars) for select years.**

We estimate the costs to deploy the number of EVSE ports needed each year (2027–2055) to achieve the modeled network sizes for the proposal and No Action case.[612] Costs for each EVSE port are sourced from recent literature and are intended to reflect upfront hardware and installation costs. PEVs typically come with a charging cord that can be used for L1 charging by plugging it into a standard 120 V outlet, and, in some cases, for L2 charging by plugging into a 240 V outlet. We include the cost for this cord as part of the vehicle costs described in DRIA Chapter 2, and therefore we do not include it here. We make the simplifying assumption that PEV owners opting for L1 home charging already have access to a 120 V outlet and therefore do not incur installation costs.[613] Table 65 shows our assumed costs per EVSE port.

TABLE 65—COSTS (HARDWARE AND INSTALLATION) PER EVSE PORT

[2019 dollars][614]

| Home | | | Work | Public | | | | |
|---|---|---|---|---|---|---|---|---|
| L1 | SFH L2 | Other L2 | L2 | L2 | DC–50 | DC–150 | DC–250 | DC–350 |
| $0 | $1,100 | $3,700 | $5,900 | $5,900 | $56,000 | $121,000 | $153,000 | $185,000 |

There are many factors that can impact equipment and installation costs, including whether a charging unit has multiple EVSE ports, how many ports are installed per site as well as regional differences. Costs also vary in the literature. EPA welcomes comments on additional studies or information that EPA should consider in assessing PEV charging infrastructure costs for the final rule.

See DRIA Chapter 5 for a more complete discussion of this analysis including low and high sensitivities not shown here. The final PEV charging infrastructure costs are presented in Section VIII of this Preamble.

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[612] We assume a 15-year equipment lifetime for EVSE ports. We did not estimate costs for EVSE maintenance or repair though we note that this may be able to extend equipment lifetimes. See discussion in DRIA Chapter 5.

[613] For Level 2 home charging, some PEV owners may opt to simply install or upgrade to a 240 V outlet for use with a charging cord while others may choose to purchase or install a wall-mounted or other Level 2 charging unit. We assume a 50%:50% mix for the costs shown in Table 65.

[614] Costs shown are expressed in 2019 dollars, consistent with the original sources from the literature.

EPA acknowledges that there may be additional infrastructure needs and costs beyond those associated with charging equipment itself. While planning for additional electricity demand is a standard practice for utilities and not specific to PEV charging, the buildout of public and private charging stations (particularly those with multiple high-powered DC fast charging units) could in some cases require upgrades to local distribution systems. For example, a recent study found power needs as low as 200 kW could trigger a requirement to install a distribution transformer.[615] The use of onsite power control systems, battery storage or renewables may be able to reduce the need for some distribution upgrades; station operators may also opt to install these to mitigate demand charges associated with peak power.[616] However, there is considerable uncertainty associated with the uptake of these technologies as well as with future distribution upgrade needs, and we do not model them directly as part of our infrastructure cost analysis. We welcome comments on this and other aspects of our cost analysis.

As discussed in the previous section, we model changes to power generation due to the increased electricity demand anticipated in the proposal as part of our upstream analysis. We project the additional generation needed to meet the demand of the light- and medium-duty PEVs in the proposal to be relatively modest compared to the No Action case, ranging from less than 0.4 percent in 2030 to approximately 4 percent in 2050 (as shown in Figure 23). The U.S. electricity end use between the years 1992 and 2021 increased by around 25% [617] without any adverse effects on electric grid reliability or electricity generation capacity shortages. As the proposal is estimated to increase electric power end use by electric vehicles by between 0.1% (2028) and 4.2% (2055)—approximately 18% of the increase that occurred between 1995 and 2021—grid reliability is not expected to be adversely affected by the modest increase in electricity demand associated with electric vehicle charging.

The private sector and the government share responsibility for the reliability of the electric power grid. Most of the electric power grid—the commercial electric power transmission and distribution system comprising power lines and other infrastructure—is owned and operated by private industry. However, Federal, state, local, Tribal, and territorial governments also have significant roles in enhancing the reliability of the electric power grid.[618] The Federal government plays a key role in enhancing electric power grid reliability.[619] For instance, the Department of Homeland Security (DHS) is responsible for coordinating the overall Federal effort to promote the security and reliability of the nation's critical infrastructure sectors; the Department of Energy (DOE) leads Federal efforts to ensure that the nation's energy delivery system is secure, resilient, and reliable, including research and technology development by national laboratories; and the Federal Energy Regulatory Commission (FERC) regulates wholesale electricity markets and is responsible for reviewing and approving mandatory electric Reliability Standards, which are developed by the North American Electric Reliability Corporation (NERC). NERC is the federally designated U.S. electric reliability organization which develops and enforces Reliability Standards; annually assesses seasonal and long-term reliability; monitors the bulk power system through system awareness; and educates, trains, and certifies industry personnel. These efforts help to keep the U.S. electric power grid is reliable.[620] We also consulted with FERC and EPRI staff on bulk power system reliability and related issues.

U.S. electric power utilities routinely upgrade the nation's electric power system to improve grid reliability and to meet new electric power demands. For example, when confronted with rapid adoption of air conditioners in the 1960s and 1970s, U.S. electric power utilities successfully met the new demand for electricity by planning and building upgrades to the electric power distribution system. Likewise, U.S. electric power utilities planned and built distribution system upgrades required to service the rapid growth of power-intensive data centers and server farms over the past two decades. U.S. electric power utilities have already successfully designed and built the distribution system infrastructure required for 1.4 million battery electric vehicles.[621] Utilities have also successfully integrated 46.1 GW of new utility-scale electric generating capacity into the grid (EIA, 2022).[622]

When taking into consideration ongoing upgrades to the U.S. electric power grid, and that the U.S. electric power utilities generally have more capacity to produce electricity than is consumed (EIA, 2022), the expected increase in electric power demand attributable to vehicle electrification is not expected to adversely affect grid reliability due to the modest increase in electricity demand associated with electric vehicle charging. Moreover, distribution system infrastructure became the largest share of capital expenditures for U.S. investor-owned utilities (IOUs) in 2018, according to the Edison Electric Institute (EEI).[623] EEI also projected that such expenditures would constitute one-third of total IOU spending in 2022.

The California Public Utilities Commission (CPUC) [624] and the California Energy Commission (CEC) [625] have been actively engaged in Vehicle-Grid Integration (VGI) efforts for over a decade, along with the California Independent System Operator [626] (California ISO), large private and public electrical utilities (SCE, PG&E, SDG&E, etc.), most major automakers (Ford, GM, FCA, BMW, Audi, Nissan,

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[615] Borlaug, B. et al., ''Heavy-duty truck electrification and the impacts of depot charging on electricity distribution systems,'' Nat Energy 6, 673–682 (2021). Accessed on January 11, 2023, at *https://doi.org/10.1038/s41560-021-00855-0.*

[616] Alexander, M. et al., ''Assembly Bill 2127: Electric Vehicle Charging Infrastructure Assessment,'' July 2021, California Energy Commission. Accessed March 9, 2023, at *https://www.energy.ca.gov/programs-and-topics/programs/electric-vehicle-charging-infrastructure-assessment-ab-2127.*

[617] Annual Energy Outlook 2022, U.S. Energy Information Administration, March 3, 2022 (*https://www.eia.gov/outlooks/aeo/narrative/introduction/sub-topic-01.php*).

[618] Federal Efforts to Enhance Grid Resilience. General Accounting Office, GAO–17–153, 1/25/2017. *https://www.gao.gov/assets/gao-17-153.pdf.*

[619] Electricity Grid Resilience. General Accounting Office, GAO–21–105403, 9/20/2021, *https://www.gao.gov/assets/gao-21-105403.pdf.*

[620] *https://www.nerc.com/AboutNERC/Pages/default.aspx.*

[621] U.S. DOE Alternative Fuels Data Center, Maps and Data—Electric Vehicle Registrations by State, *https://afdc.energy.gov/data/.*

[622] EIA, Electric Power Annual 2021, November 2022. *https://www.eia.gov/electricity/annual/html/epa_01_01.html.*

[623] *https://www.eei.org/-/media/Project/EEI/Documents/Issues-and-Policy/Finance-And-Tax/bar_cap_ex.pdf?la=en&hash=3D08D74D12F1CCA51EE89256F53EBABEEAAF4673.*

[624] Order Instituting Rulemaking to Continue the Development of Rates and Infrastructure for Vehicle Electrification. California Public Utilities Commission, Rulemaking 18–12–006, 12/21/2020.

[625] Chhaya, Sunil, Norman McCollough, Viswanath Ananth, Arindam Maitra, Ramakrishnan Ravikumar, Jamie Dunckley—Electric Power Research Institute; George Bellino—Clean Fuel Connection, Eric Cutter, Energy & Environment Economics, Michael Bourton, Kitu Systems, Inc., Richard Scholer, Fiat Chrysler Automobiles, Charlie Botsford, AeroVironment, Inc., 2019. Distribution System Constrained Vehicle-to-Grid Services for Improved Grid Stability and Reliability. California Energy Commission. Publication Number: CEC–500–2019–027.

[626] California Independent System Operator (CAISO). 2014. California VGI Roadmap: Enabling Vehicle-based Grid Services. *https://www.caiso.com/Documents/Vehicle-GridIntegrationRoadmap.pdf.*

Toyota, Honda, and others), and EV charger companies, the Electric Power Research Institute (EPRI), and various other research organizations.

These ongoing research efforts have demonstrated the ability of U.S. electric utilities to reschedule up to 20 percent of electric vehicle charging loads occurring at any hour of the day to any other hour of the day.[627] Conversely, these research efforts have also demonstrated the ability of U.S. electric power utilities to reschedule up to 30 percent of electric vehicle charging loads occurring at any hour of day to any particular hour of that day. As the expected increase in electric power demand resulting from PEV charging in this proposal will be well under 20 percent, we do not anticipate it to pose grid reliability issues.

The ability to shift and curtail electric power is a feature that can improve grid operations and, therefore, grid reliability. Integration of electric vehicle charging into the power grid, by means of vehicle-to-grid software and systems that allow management of vehicle charging time and rate, has been found to create value for electric vehicle drivers, electric grid operators, and ratepayers.[628] Management of PEV charging can reduce overall costs to utility ratepayers by delaying electric utility customer rate increases associated with equipment upgrades and may allow utilities to use electric vehicle charging as a resource to manage intermittent renewables. The development of new electric utility tariffs, including those for submetering for electric vehicles, will also help to facilitate the management of electric vehicle charging.

We also note that DOE is engaged in multiple efforts to modernize the grid and improve resilience and reliability. For example, in November 2022, DOE announced $13 billion in funding opportunities under BIL to support transmission and distribution infrastructure. This includes $3 billion for smart grid grants with a focus on PEV integration among other topics.[629]

### 5. Consumer Acceptance

Consumer uptake of zero-emission vehicle technology is expected to continue to grow with the key enablers of PEV acceptance, namely increasing market presence, more model choices, expanding infrastructure, and decreasing costs to consumers.[630] First, annual sales of light-duty PEVs in the U.S. have grown robustly and are expected to continue to grow. New PEV sales represented 2.2 percent (1.7 percent BEV and 0.5 percent PHEV) of new light-duty vehicle sales in 2020 (Davis and Boundy 2021; U.S. Environmental Protection Agency 2021b), and annual PEV market share in 2021 was 4.6 percent (3.4 percent for BEVs and 1.2 percent for PHEVs). As of May 2022, actual PEV market share was 6.6 percent (5.2 percent for BEVs and 1.4 percent for PHEVs).[631] This history of robust growth combined with vehicle manufacturers' plans to expand of PEV production strongly suggests that PEV market share will continue to grow rapidly. Second, the number of PEV models available to consumers is increasing, meeting to consumers demand for a variety of body styles and price points. Specifically, the number of BEV and PHEV models available for sale in the U.S. has more than doubled from about 24 in MY 2015 to about 60 in MY 2021, with offerings in a growing range of vehicle segments.[632] Recent model announcements indicate that this number will increase to more than 80 models by MY 2023,[633] and more than 180 models by 2025.[634] Third, the expansion of charging infrastructure has been keeping up with PEV adoption. This trend is widely expected to continue, particularly in light of very large public and private investments. Lastly, while the initial purchase price of BEVs is currently higher than for most ICE vehicles, the price difference is likely to narrow or become insignificant as the cost of batteries fall and PEV production rises in the coming years.[635] Among the many studies that address cost parity, an emerging consensus suggests that purchase price parity is likely to be achievable by the mid-2020s for some vehicle segments and models, and TCO parity even sooner for a broader segment of the market.[636] [637]

EPA, in coordination with the Lawrence Berkeley National Laboratory, conducted a peer-reviewed literature review of consumer acceptance of PEVs. In this literature review, we present what we refer to as the ''4A framework,'' consisting of awareness, access, approval, and adoption, that we use to define acceptance and organize a comprehensive review of the scientific literature on this topic.[638] Through that review, we identify enablers and obstacles to consumer acceptance of PEVs. Across all stages of the 4A framework, we find that the enablers and obstacles of PEV acceptance are largely external to the consumer. We conclude that there is no evidence in the reviewed literature to suggest anything immutable within consumers or inherent to PEVs that irremediably obstructs acceptance. Rather, acceptance of PEVs is achievable among mainstream consumers. For more information on LD vehicle purchase considerations, see DRIA Chapter 4.1.

### 6. Supply Chain, Manufacturing, and Mineral Security Considerations

Although the market share of PEVs in the U.S. is already rapidly growing, EPA recognizes that the proposed standards may accelerate this trend. Assessing the feasibility of incremental penetrations of PEVs that may result from the proposed standards includes consideration of the capability of the supply chain to provide the required quantities of critical minerals, components, and battery manufacturing capacity. This section provides a general review of how we considered supply chain and manufacturing considerations in this analysis, the sources we considered, and how we used this information in the analysis. It also provides a high-level discussion of the security implications

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[627] Lipman, Timothy, Alissa Harrington, and Adam Langton. 2021. Total Charge Management of Electric Vehicles. California Energy Commission. Publication Number: CEC–500–2021– 055.

[628] Chhaya, S., et al., ''Distribution System Constrained Vehicle-to-Grid Services for Improved Grid Stability and Reliability; Publication Number: CEC–500–2019–027, 2019. Accessed December 13, 2022 at *https://www.energy.ca.gov/sites/default/files/2021-06/CEC-500-2019-027.pdf.*

[629] DOE, ''Biden-Harris Administration Announces $13 Billion to Modernize and Expand America's Power Grid,'' November 18, 2022. Accessed January 11, 2023, at *https://www.energy.gov/articles/biden-harris-administration-announces-13-billion-modernize-and-expand-americas-power-grid.*

[630] Jackman, D K, K S Fujita, H C Yang, and M Taylor. 2023. Literature Review of U.S. Consumer Acceptance of New Personally Owned Light Duty Plug-in Electric Vehicles. Washington, DC: U.S. Environmental Protection Agency.

[631] *https://www.autosinnovate.org/resources/electric-vehicle-sales-dashboard.*

[632] *Fueleconomy.gov*, 2015 Fuel Economy Guide and 2021 Fuel Economy Guide.

[633] Environmental Defense Fund and M.J. Bradley & Associates, ''Electric Vehicle Market Status—Update, Manufacturer Commitments to Future Electric Mobility in the U.S. and Worldwide,'' April 2021.

[634] Environmental Defense Fund and ERM, ''Electric Vehicle Market Update: Manufacturer Commitments and Public Policy Initiatives Supporting Electric Mobility in the U.S. and Worldwide,'' September 2022.

[635] International Council on Clean Transportation, ''Assessment of Light-Duty Electric Vehicle Costs and Consumer Benefits in the United States in the 2022–2035 Time Frame,'' October 2022.

[636] Ibid.

[637] Environmental Defense Fund and ERM, ''Electric Vehicle Market Update: Manufacturer Commitments and Public Policy Initiatives Supporting Electric Mobility in the U.S. and Worldwide,'' September 2022.

[638] Jackman, D K, K S Fujita, H C Yang, and M Taylor. 2023. Literature Review of U.S. Consumer Acceptance of New Personally Owned Light Duty Plug-in Electric Vehicles. Washington, DC: U.S. Environmental Protection Agency.

of increased demand for minerals and other commodities used to manufacture electrified vehicles. Additional details on these aspects of the analysis may be found in DRIA Chapter 3.1.3, including how we used this information to develop modeling constraints on PEV penetration for the compliance analysis.

In performing this analysis, we considered the ability for global and domestic manufacturing and critical mineral capacity to respond to the projected demand for zero-emission vehicles that manufacturers may choose to produce to comply under the various Alternatives. We consulted with industry and government agency sources (including DOE, USGS, and several analysis firms) to collect information on production capacity, price forecasts, global mineral markets, and related topics, and have considered this information to inform our assumptions about future manufacturing capabilities and costs. We have included consideration of the influence of critical minerals and materials availability as well as vehicle and battery manufacturing capacities on production of PEVs at various market penetration scenarios.

We believe that the proposed rate of stringency is appropriate in light of this assessment. It is also our assessment that widespread automotive electrification in the U.S. will not lead to a critical long-term dependence on foreign imports of minerals or components, nor that increased demand for these products will become a vulnerability to national security. First, in many cases the reason that these products are often sourced from outside of the U.S. is not because the products cannot be produced in the U.S., but because other countries have already invested in developing a supply chain for their production. It is likely that a domestic supply chain for these products would develop over time as U.S. manufacturers work to secure reliable and geographically proximate supplies of the components and materials needed to build the products they manufacture, and to remain competitive in a global market where electrification is already proceeding rapidly. Second, many automakers, suppliers, startups, and related industries have already recognized the need for increased domestic production capacity as a business opportunity and are basing business models on building out various aspects of the supply chain. Third, Congress and the Administration have taken significant steps to accelerate this activity by funding, facilitating, and otherwise promoting the rapid growth of U.S. supply chains for these products through the Inflation Reduction Act, the Bipartisan Infrastructure Law, and numerous Executive Branch initiatives. EPA has confidence that these efforts are effectively addressing supply chain concerns. Finally, utilization of critical minerals is different from the utilization of foreign oil, in that oil is consumed as a fuel while minerals become a constituent of manufactured vehicles. Minerals that are imported for vehicle production remain in the vehicle and can be reclaimed through recycling. Each of these points will be expanded in more detail in the following sections.

### i. Critical Minerals

Critical minerals are commonly taken to include a large diversity of products, ranging from relatively plentiful materials that are constrained primarily by production capacity and refining, such as aluminum, to those that are both relatively rare and costly to process, such as the rare-earth metals that are used in magnets for permanent-magnet synchronous motors (PMSMs) and some semiconductor products. Extraction, processing, and recycling of certain critical minerals (for example, lithium, cobalt, nickel, manganese, graphite, and rare earth metals) are important parts of the supply chain supporting the production of electrified vehicle components.

These minerals are also experiencing increasing demand across many other sectors of the global economy, not just the transportation industry, as the world seeks to reduce carbon emissions. As with any emerging technology, a transition period must take place in which a robust supply chain develops to support production of these products. At the present time in the U.S. many of these minerals are commonly sourced from global suppliers and do not yet benefit from a fully developed domestic supply chain. As demand for these materials increases due to increasing production of PEVs, current mining and processing capacity across the world will be driven to expand over time. The process of establishing new mining capacity, as well as processing capacity for the mined product, can be subject to uncertain issues such as permitting, investor expectations of demand and future prices, and many others, making it difficult to predict with precision the rate at which new capacity will be brought online in the future. For example, depending on the source (hardrock mining or brine), lithium mining capacity can take from five to ten years to develop a new mine or mineral source, and has in some cases taken longer. However, industry interest and motivation toward developing these resources has become very high and is expected to remain so, as the demand outlook for lithium and other battery minerals is very robust. For example, rapid growth in lithium demand has driven new development of resources and robust growth in supply, which is likely a factor in recently observed reductions in lithium price, with strong profit margins remaining even afterward.[639] Due to such factors the price of lithium is likely to stabilize at or near its historical levels by the mid-2020s,[640] a perspective also supported, for example, in proprietary battery price forecasts such as those EPA has examined from Wood Mackenzie.[641] [642] This expected stabilization of prices after a period of elevation is a common feature of commodity markets that experience rapid growth in demand, and further supports the outlook that sufficient chemical product will be available to meet growing demand.

The U.S. Geological Survey (USGS) lists 50 minerals as ''critical to the U.S. economy and national security.'' [643] [644] According to USGS, the Energy Act of 2020 defines a ''critical mineral'' as ''a non-fuel mineral or mineral material essential to the economic or national security of the U.S. and which has a supply chain vulnerable to disruption.'' [645] Critical minerals are not

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[639] New York Times, ''Falling Lithium Prices Are Making Electric Cars More Affordable,'' March 20, 2023. Accessed on March 23, 2023 at *https://www.nytimes.com/2023/03/20/business/lithium-prices-falling-electric-vehicles.html.*

[640] Sun et al., ''Surging lithium price will not impede the electric vehicle boom,'' *Joule,* doi:10.1016/j.joule. 2022.06.028 (*https://dx.doi.org/10.1016/j.joule.2022.06.028*).

[641] Wood Mackenzie, ''Battery & raw materials—Investment horizon outlook to 2032,'' September 2022 (filename: brms-q3–2022-iho.pdf). Available to subscribers.

[642] Wood Mackenzie, ''Battery & raw materials—Investment horizon outlook to 2032,'' accompanying data set, September 2022 (filename: brms-data-q3–2022.xlsx). Available to subscribers.

[643] U.S. Geological Survey, ''U.S. Geological Survey Releases 2022 List of Critical Minerals,'' February 22, 2022. Available at: *https://www.usgs.gov/news/national-news-release/us-geological-survey-releases-2022-list-critical-minerals.*

[644] The full list includes: Aluminum, antimony, arsenic, barite, beryllium, bismuth, cerium, cesium, chromium, cobalt, dysprosium, erbium, europium, fluorspar, gadolinium, gallium, germanium, graphite, hafnium, holmium, indium, iridium, lanthanum, lithium, lutetium, magnesium, manganese, neodymium, nickel, niobium, palladium, platinum, praseodymium, rhodium, rubidium, ruthenium, samarium, scandium, tantalum, tellurium, terbium, thulium, tin, titanium, tungsten, vanadium, ytterbium, yttrium, zinc, and zirconium.

[645] U.S. Geological Survey, ''U.S. Geological Survey Releases 2022 List of Critical Minerals,'' February 22, 2022. Available at: *https://www.usgs.gov/news/national-news-release/us-geological-survey-releases-2022-list-critical-minerals.*

necessarily short in supply but are seen as essential to the manufacture of products that are important to the economy or national security. The risk to their availability may stem from geological scarcity, geopolitics, trade policy, or similar factors.[646]

Emission control catalysts for ICE vehicles utilize critical minerals including cerium, palladium, platinum, and rhodium. These are also required for PHEVs due to the presence of the ICE. Critical minerals most relevant to lithium-ion battery production include cobalt, graphite, lithium, manganese, and nickel, which are important constituents of electrode active materials, their presence and relative amounts depending on the chemistry formulation. Aluminum is also used for cathode foils and in some cell chemistries. Rare-earth metals are used in permanent-magnet electric machines, and include several elements such as dysprosium, neodymium, and samarium.

Some of the electrification technologies that use critical minerals have alternatives that use other minerals or eliminate them entirely. For these, automakers in some cases have some flexibility to modify their designs to reduce or avoid use of minerals that are difficult or expensive to procure. For example, in some PEV battery applications it is feasible and increasingly common to employ an iron phosphate cathode which has lower energy density but does not require cobalt, nickel, or manganese. Similarly, rare earths used in permanent-magnet electric machines have potential alternatives in the form of ferrite or other advanced magnets, or the use of induction machines or advanced externally excited motors, which do not use permanent magnets.

This discussion therefore focuses on minerals that are most critical for battery production, including nickel, cobalt, graphite, and lithium.

Availability of critical minerals for use in battery production depends on two primary considerations: Production of raw minerals from mining (or recycling) operations, and refining operations that produce purified and processed substances (precursors, electrolyte solutions, and finished electrode powders) made from the raw minerals, that can then be made into battery cells.

As shown in Figure 28, in 2019 about 50 percent of global nickel production occurred in Indonesia, Philippines, and Russia, with the rest distributed around the world. Nearly 70 percent of cobalt originated from the Democratic Republic of Congo, with some significant production in Russia and Australia, and about 20 percent in the rest of the world. More than 60 percent of graphite production occurred in China, with significant contribution from Mozambique and Brazil for another 20 percent. About half of lithium was mined in Australia, with Chile accounting for another 20 percent, and China about 10 percent.

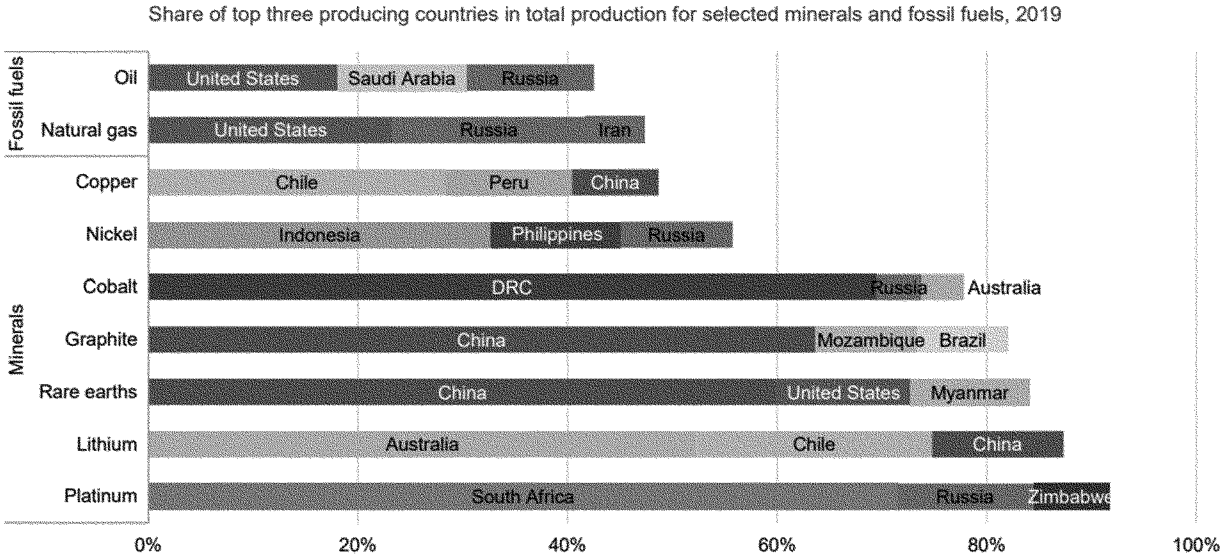

**Figure 28. Share of top three producing countries for critical minerals and fossil fuels in 2019 (IEA).** [647]

According to the Administration's 100-day review under E.O. 14017, of the major actors in mineral refining, 60 percent of lithium refining occurred in China, with 30 percent in Chile, and 10 percent in Argentina. 72 percent of cobalt refining occurred in China, with another 17 percent distributed among Finland, Canada, and Norway. 21 percent of Class 1 nickel refining occurred in Russia, with 16 percent in China, 15 percent in Japan, and 13 percent in Canada.[648] Similar conclusions were reached in an analysis by the International Energy Agency, shown in Figure 29.

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[646] International Energy Agency, "The Role of Critical Minerals in Clean Energy Transitions," World Energy Outlook Special Report, Revised version. March 2022.

[647] International Energy Agency, "The Role of Critical Minerals in Clean Energy Transitions," World Energy Outlook Special Report, Revised version. March 2022.

[648] The White House, "Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth," 100-Day Reviews under Executive Order 14017, June 2021 (p. 121).

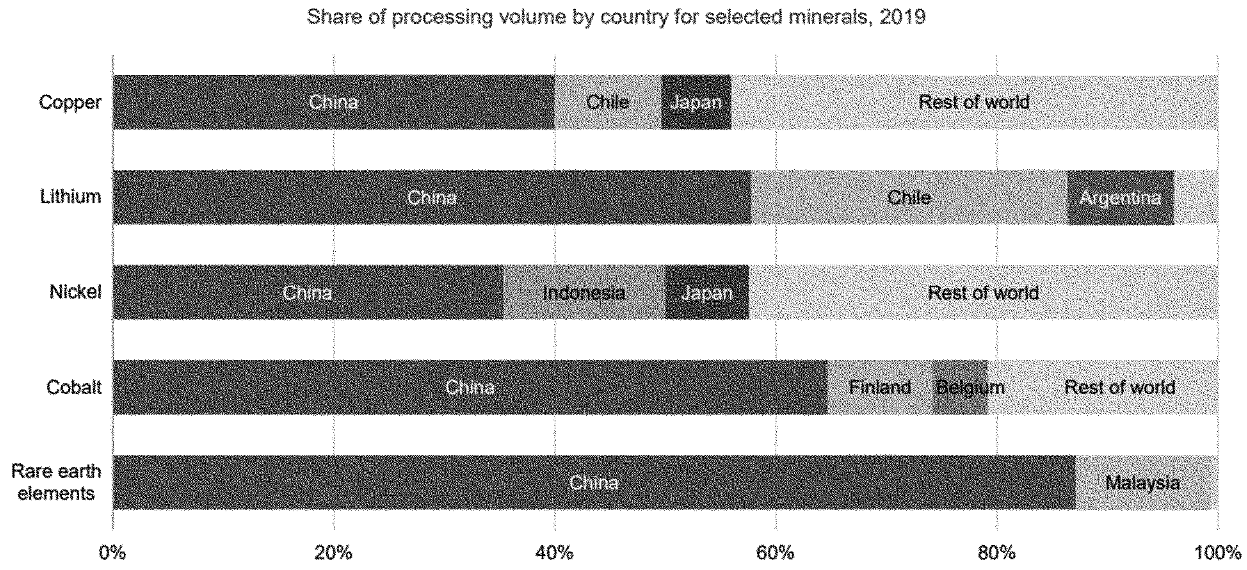

**Figure 29. IEA accounting of share of refining volume of critical minerals by country (IEA).**[649]

Currently, the U.S. is lagging behind much of the rest of the world in critical mineral production. Although the U.S. has nickel reserves, and opportunity also exists to recover significant nickel from mine waste remediation and similar activities, it is more convenient for U.S. nickel to be imported from other countries, with 68 percent coming from Canada, Norway, Australia, and Finland, countries with which the U.S. has good trade relations.[650] According to the USGS, ample reserves of nickel exist in the U.S. and globally, potentially constrained only by processing capacity.[651] The U.S. has numerous cobalt deposits but few are developed while some have produced cobalt only in the past; about 72 percent of U.S. consumption is imported.[652] Similar observations may be made about graphite and lithium. Significant lithium deposits do exist in the U.S. in Nevada and California as well as several other locations,[653] [654] and are currently the target of development by suppliers and automakers.[655] U.S. deposits of natural graphite also exist but graphite has not been produced in the U.S. since the 1950s and significant known resources are largely undeveloped.[656]

As described in the following sections, the development of mining and processing capacity in the U.S. is a primary focus of efforts on the part of both industry and the Administration toward building a robust domestic supply chain for electrified vehicle production and will be greatly facilitated by the provisions of the BIL and the IRA as well as large private business investments that are already underway and continuing.

ii. Battery and Mineral Production Capacity

Although much of the content needed for electrified vehicle manufacture is currently imported from other countries, a number of prominent examples of rapid U.S. manufacturing growth and supply chain development already indicate that this is rapidly changing. For example, even though most global battery manufacturing capacity is currently located outside the U.S., most of the batteries and cells present in the domestic PEV fleet were manufactured in the U.S. Specifically, about 57 percent of cells and 84 percent of assembled packs sold in the U.S. from 2010 to 2021 were produced in the U.S.[657] [658] This indicates that U.S. PEV production has not been exclusively reliant on foreign manufacture of batteries and cells, and suggests that it need not become so as PEV penetration increases. Many manufacturers are rapidly building battery and cell manufacturing facilities in the U.S. and are also taking steps to secure domestically sourced minerals and related commodities to supply production for these plants. Highlights of these developments and what they mean for the domestic supply chain going forward are described in this section.

Battery manufacturing, in terms of constructed and planned plant capacity for assembly of cells and packs, does not appear to pose a critical constraint to expected uptake of PEVs, either globally or domestically. A 2021 report from Argonne National Laboratory (ANL)[659] examined the state of the global supply

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[649] International Energy Agency, "The Role of Critical Minerals in Clean Energy Transitions," World Energy Outlook Special Report, Revised version. March 2022.

[650] The White House, "Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth," 100-Day Reviews under Executive Order 14017, June 2021.

[651] Ibid.

[652] U.S. Geological Survey, "Cobalt Deposits in the United States," June 1, 2020. Available at *https://www.usgs.gov/data/cobalt-deposits-united-states.*

[653] U.S. Geological Survey, "Mineral Commodity Summaries 2022—Lithium", January 2022. Available at *https://pubs.usgs.gov/periodicals/mcs2022/mcs2022-lithium.pdf.*

[654] U.S. Geological Survey, "Lithium Deposits in the United States," June 1, 2020. Available at *https://www.usgs.gov/data/lithium-deposits-united-states.*

[655] Investing News, "Which Lithium Juniors Have Supply Deals With EV Makers?," February 8, 2023. Accessed on March 24, 2023 at *https://investingnews.com/lithium-juniors-ev-supply-deals/.*

[656] U.S. Geological Survey, "USGS Updates Mineral Database with Graphite Deposits in the United States," February 28, 2022.

[657] Argonne National Laboratory, "Lithium-Ion Battery Supply Chain for E-Drive Vehicles in the United States: 2010–2020," ANL/ESD–21/3, March 2021.

[658] U.S. Department of Energy, "Vehicle Technologies Office Transportation Analysis Fact of the Week #1278, Most Battery Cells and Battery Packs in Plug-in Vehicles Sold in the United States From 2010 to 2021 Were Domestically Produced," February 20, 2023.

[659] Argonne National Laboratory, "Lithium-Ion Battery Supply Chain for E-Drive Vehicles in the United States: 2010–2020," ANL/ESD–21/3, March 2021.

chain for electrified vehicles and included a comparison of recent projections of future global battery manufacturing capacity and projections of future global battery demand from various analysis firms out to 2030, as seen in Figure 30. The three most recent projections of capacity (from BNEF, Roland Berger, and S&P Global in 2020–2021) that were collected by ANL exceed the corresponding projections of demand by a significant margin in every year for which they were projected, suggesting that global battery manufacturing capacity is generally expected to respond strongly to increasing demand.

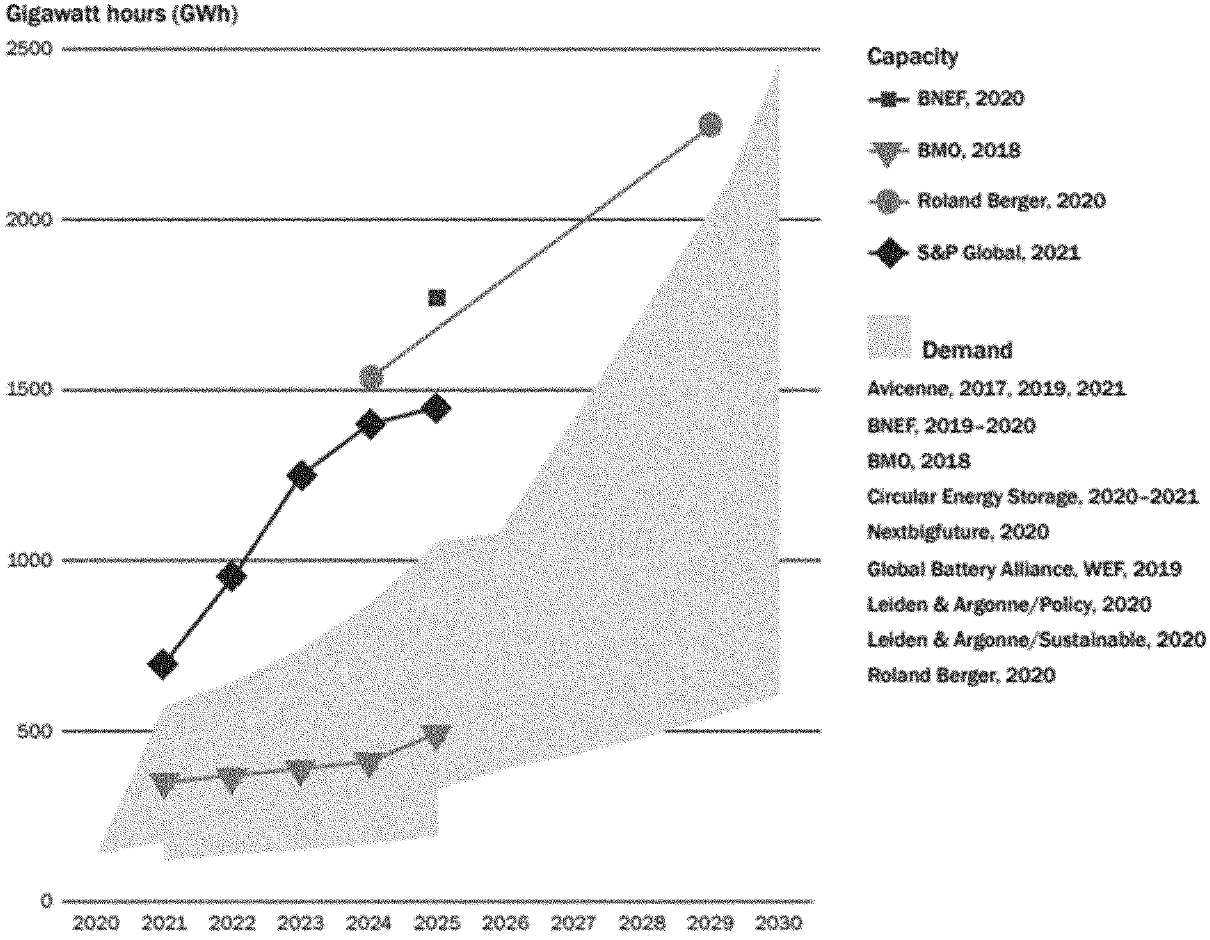

**Figure 30. Future global Li-ion battery demand and production capacity, 2020-2030.**[660,661]

Global demand for zero-emission vehicles has led to widespread and ongoing investment in manufacturing capacity for the vehicles and their components, including electric machines, power electronics, and batteries. The need to further develop a robust domestic supply chain for these components has accordingly received broad attention in the industry. As described in Section I.A.2.ii of this Preamble, manufacturers are increasingly adopting product plans with high levels of electrification and are continuing to make very large investments toward increasing manufacturing capacity and securing sources and suppliers for critical minerals, materials, and components.

As also noted, one analysis indicates that 37 of the world's automakers are planning to invest a total of almost $1.2 trillion by 2030 toward electrification,[662] a large portion of which will be used for construction of manufacturing facilities for vehicles, battery cells and packs, and materials, supporting up to 5.8 terawatt-hours of battery production and 54 million BEVs per year globally.[663] Similarly, an analysis by the Center for Automotive Research shows that a significant shift in North American investment is occurring toward electrification technologies, with $36 billion of about $38 billion in total automaker manufacturing facility investments

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[660] Argonne National Laboratory, ''Lithium-Ion Battery Supply Chain for E-Drive Vehicles in the United States: 2010–2020,'' ANL/ESD–21/3, March 2021.

[661] Federal Consortium for Advanced Batteries, ''National Blueprint for Lithium Batteries 2021–2030,'' June 2021 (Figure 2). Available at *https://www.energy.gov/sites/default/files/2021-06/FCAB%20National%20Blueprint%20Lithium%20Batteries%200621_0.pdf.*

[662] Reuters, ''A Reuters analysis of 37 global automakers found that they plan to invest nearly $1.2 trillion in electric vehicles and batteries through 2030,'' October 21, 2022. Accessed on November 4, 2022 at *https://graphics.reuters.com/AUTOS-INVESTMENT/ELECTRIC/akpeqgzqypr/.*

[663] Reuters, ''Exclusive: Automakers to double spending on EVs, batteries to $1.2 trillion by 2030,'' October 25, 2022. Accessed on November 4, 2022 at *https://www.reuters.com/technology/exclusive-automakers-double-spending-evs-batteries-12-trillion-by-2030-2022-10-21/.*

announced in 2021 being slated for electrification-related manufacturing in North America, with a similar proportion and amount on track for 2022.[664]

According to the Department of Energy, at least 13 new battery plants, most of which will include cell manufacturing, are expected to become operational in the U.S. in the next four years.[665] Among these, in partnership with SK Innovation, Ford is building three large new battery plants in Kentucky and Tennessee [666] and a fourth in Michigan.[667] General Motors is partnering with LG Chem to build another three plants in Tennessee, Michigan, and Ohio, and considering another in Indiana. LG Chem has also announced plans for a cathode material production facility in Tennessee, said to be sufficient to supply 1.2 million high-performance electric vehicles per year by 2027.[668] Contemporary Amperex (CATL) is considering construction of plants in Arizona, Kentucky, and South Carolina. Panasonic, already partnering with Tesla for its factories in Texas and Nevada, are planning two new factories in Oklahoma and Kansas. Toyota plans to be operational with a plant in Greensboro, North Carolina in 2025, and Volkswagen in Chattanooga, Tennessee at about the same time. According to a May 2022 forecast by S&P Global, announcements such as these could result in a U.S. annual manufacturing capacity of 382 GWh by 2025,[669] or 580 GWh by 2027,[670] up from roughly 60 GWh[671] [672] today. A more recent forecast by the Department of Energy, as shown in Figure 31, illustrates the rapid recent growth in new plant announcements, estimating that announcements for North America to date will enable an estimated 838 GWh of annual capacity by 2025, 896 GWh by 2027, and 998 GWh by 2030, the vast majority of which is cell manufacturing capacity, enough to supply from 10 to 13 million BEVs per year.[673]

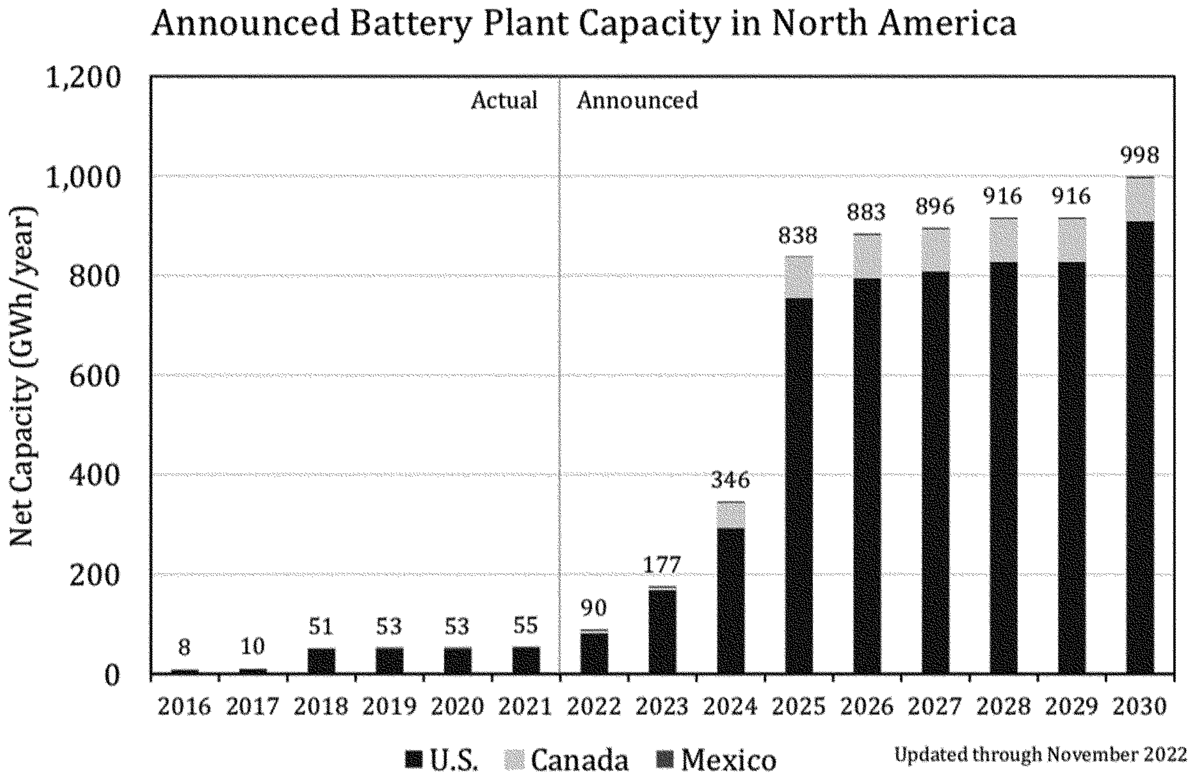

**Figure 31. Announced capacity for battery plants in North America, as of November 2022.**

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[664] Center for Automotive Research, "Automakers Invest Billions in North American EV and Battery Manufacturing Facilities," July 21, 2022. Retrieved on November 10, 2022 at *https://www.cargroup.org/automakers-invest-billions-in-north-american-ev-and-battery-manufacturing-facilities/.*

[665] Department of Energy, Fact of the Week #1217, "Thirteen New Electric Vehicle Battery Plants Are Planned in the U.S. Within the Next Five Years," December 20, 2021.

[666] Ford Media Center, "Ford to Lead America's Shift to Electric Vehicles with New Mega Campus in Tennessee and Twin Battery Plants in Kentucky; $11.4B Investment to Create 11,000 Jobs and Power New Lineup of Advanced EVs," Press Release, September 27, 2021.

[667] Ford Media Center, "Ford Taps Michigan for New LFP Battery Plant; New Battery Chemistry Offers Customers Value, Durability, Fast Charging, Creates 2,500 More New American Jobs," Press Release, February 13, 2023.

[668] LG Chem, "LG Chem to Establish Largest Cathode Plant in US for EV Batteries," Press Release, November 22, 2022.

[669] S&P Global Market Intelligence, "US ready for a battery factory boom, but now it needs to hold the charge," October 3, 2022. Accessed on November 22, 2022 at *https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/us-ready-for-a-battery-factory-boom-but-now-it-needs-to-hold-the-charge-72262329.*

[670] S&P Global Mobility, "Growth of Li-ion battery manufacturing capacity in key EV markets," May 20, 2022. Accessed on November 22, 2022 at *https://www.spglobal.com/mobility/en/research-analysis/growth-of-liion-battery-manufacturing-capacity.html.*

[671] Federal Consortium for Advanced Batteries, "National Blueprint for Lithium Batteries 2021–2030," June 2021.

Available at *https://www.energy.gov/sites/default/files/2021-06/FCAB%20National%20Blueprint%20Lithium%20Batteries%200621_0.pdf.*

[672] S&P Global Mobility, "Growth of Li-ion battery manufacturing capacity in key EV markets," May 20, 2022. Accessed on November 22, 2022 at *https://www.spglobal.com/mobility/en/research-analysis/growth-of-liion-battery-manufacturing-capacity.html.*

[673] Argonne National Laboratory, "Assessment of Light-Duty Plug-in Electric Vehicles in the United States, 2010–2021," ANL–22/71, November 2022.

For comparison, Figure 32 shows the annual gross battery production needed for BEVs in the U.S. new vehicle fleet in the central case of the Proposal analysis. The annual battery production required for the compliant fleet generated by OMEGA is about 925 GWh in 2030, less than the 998 GWh of North American capacity projected for the same year in Figure 31. Demand reaches about 1,050 GWh per year in 2032. These figures compare to a maximum of about 620 GWh under the No Action case.

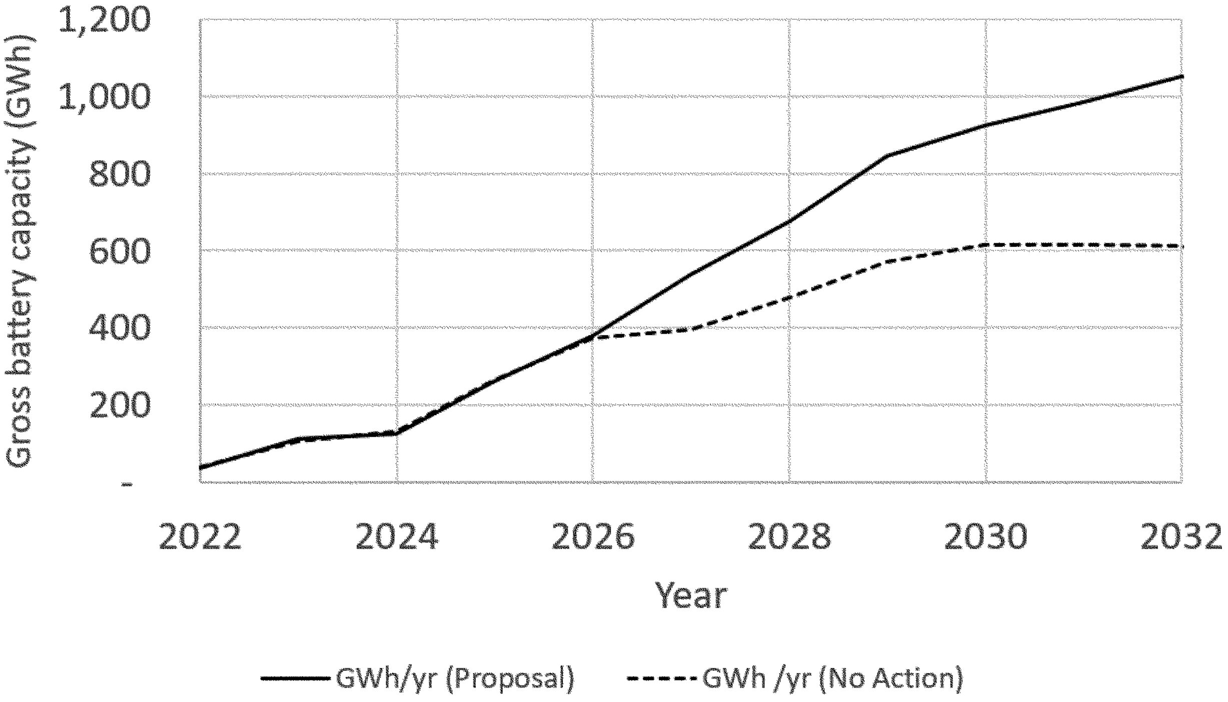

**Figure 32: Annual battery production (GWh) required for BEVs in the Central analysis case of the Proposal.**

In order to produce at the levels indicated when fully built out, the North American battery plants represented in Figure 31 will require access to sufficient inputs in the form of cathode and anode powders, foils, separators, parts, and other commodities. In conjunction with these construction plans, manufacturers are also moving to secure supplies of the minerals and components necessary to produce batteries at these facilities. For example, Ford has recently moved to secure sources of raw materials for its battery needs;[674] [675] General Motors has signed similar supply chain agreements, for battery materials [676] [677] [678] as well as for rare-earth metals for electric machines;[679] and Tesla has also moved to secure a domestic lithium supply.[680] Announcements in this general vein occur frequently and are evidence of widespread industry attention to this business need.

In addition, the Inflation Reduction Act (IRA) and the Bipartisan Infrastructure Law (BIL) are providing significant support to accelerate these efforts to build out a U.S. supply chain for mineral, cell, and battery production. The IRA offers sizeable incentives and other support for further development of domestic and North American manufacture of these vehicles and components. According to the Congressional Budget Office, an estimated $30.6 billion will be realized by manufacturers through the Advanced Manufacturing Production Credit, which includes a tax credit to manufacturers for battery production in the U.S. According to one third party estimate based on information from Benchmark Mineral Intelligence, the recent increase in U.S. battery manufacturing plant announcements could increase this figure to $136 billion or more.[681] Another $6.2 billion or more may be realized through expansion of the Advanced Energy Project Credit, a 30 percent tax credit for investments in projects that reequip, expand, or establish certain energy manufacturing facilities.[682] The IRA also provides for Clean Vehicle Credits of up to $7,500 toward the purchase or lease of clean vehicles with significant critical mineral and battery component content

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[674] Green Car Congress, ''Ford sources battery capacity and raw materials for 600K EV annual run rate by late 2023, 2M by end of 2026; adding LFP,'' July 22, 2022.

[675] Ford Motor Company, ''Ford Releases New Battery Capacity Plan, Raw Materials Details to Scale EVs; On Track to Ramp to 600K Run Rate by '23 and 2M+ by '26, Leveraging Global Relationships,'' Press Release, July 21, 2022.

[676] Green Car Congress, ''GM signs major Li-ion supply chain agreements: CAM with LG Chem and lithium hydroxide with Livent,'' July 26, 2022.

[677] Grzelewski, J., ''GM says it has enough EV battery raw materials to hit 2025 production target,'' The Detroit News, July 26, 2022.

[678] Hall, K., ''GM announces new partnership for EV battery supply,'' The Detroit News, April 12, 2022.

[679] Hawkins, A., ''General Motors makes moves to source rare earth metals for EV motors in North America,'' The Verge, December 9, 2021.

[680] Piedmont Lithium, ''Piedmont Lithium Signs Sales Agreement With Tesla,'' Press Release, September 28, 2020.

[681] Axios.com, ''Axios What's Next,'' February 1, 2023. Accessed on March 1, 2023 at *https://www.axios.com/newsletters/axios-whats-next-1185bdcc-1b58-4a12-9f15-8ffc8e63b11e.html?chunk=0&utm_term=emshare#story0.*

[682] Congressional Research Service, ''Tax Provisions in the Inflation Reduction Act of 2022 (H.R. 5376),'' August 10, 2022.

manufactured in North America. Together, these provisions create a strong motivation for manufacturers to support the continued development of a North American supply chain and already appear to be proving influential on the plans of manufacturers to procure domestic or North American mineral and component sources and to construct domestic manufacturing facilities to claim the benefits of the act.[683] [684]

In addition, the BIL provides $7.9 billion to support development of the domestic supply chain for battery manufacturing, recycling, and critical minerals.[685] Notably, it supports the development and implementation of a $675 million Critical Materials Research, Development, Demonstration, and Commercialization Program administered by the Department of Energy (DOE),[686] and has created numerous other programs in related areas, such as for example, critical minerals data collection by the U.S. Geological Survey (USGS).[687] Provisions extend across several areas including critical minerals mining and recycling research, USGS energy and minerals research, rare earth elements extraction and separation research and demonstration, and expansion of DOE loan programs in critical minerals and zero-carbon technologies.[688] [689] The Department of Energy is working to facilitate and support further development of the supply chain, by identifying weaknesses for prioritization and rapidly funding those areas through numerous programs and funding opportunities.[690] [691] [692] According to a final report from the Department of Energy's Li-Bridge alliance,[693] ''the U.S. industry can double its value-added share by 2030 (capturing an additional $17 billion in direct value-add annually and 40,000 jobs in 2030 from mining to cell manufacturing), dramatically increase U.S. national and economic security, and position itself on the path to a near-circular economy by 2050.'' [694] The $7.9 billion provided by the BIL for U.S. battery supply chain projects [695] represents a total of about $14 billion when industry cost matching is considered.[696] [697] Other recently announced projects will utilize another $40 billion in private funding.[698] According to DOE's Li-Bridge alliance, the total of these commitments already represents more than half of the capital investment that Li-Bridge considers necessary for supply chain investment to 2030.[699]

Further, the DOE Loan Programs Office is administering a major loans program focusing on extraction, processing and recycling of lithium and other critical minerals that will support continued market growth,[700] through the Advanced Technology Vehicles Manufacturing (ATVM) Loan Program and Title 17 Innovative Energy Loan Guarantee Program. This program includes over $20 billion of available loans and loan guarantees to finance critical materials projects. Some examples of recent projects, amounting to $3.4 billion in loan support, are outlined in DRIA 3.1.3.2.

Although predicting mineral supply and demand into the future is highly uncertain, it is possible to identify general trends likely to occur in the future. As seen in Figure 33 and Figure 34, preliminary projections prepared by Li-Bridge for DOE,[701] and presented to the Federal Consortium for Advanced Batteries (FCAB) [702] in November 2022, indicate that global supplies of cathode active material (CAM) and lithium chemical product are expected to be sufficient through 2035.

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[683] Subramanian, P., ''Why Honda's EV battery plant likely wouldn't happen without new climate credits,'' Yahoo Finance, August 29, 2022.

[684] LG Chem, ''LG Chem to Establish Largest Cathode Plant in US for EV Batteries,'' Press Release, November 22, 2022.

[685] Congressional Research Service, ''Energy and Minerals Provisions in the Infrastructure Investment and Jobs Act (Pub. L. 117–58)'', February 16, 2022. *https://crsreports.congress.gov/product/pdf/R/R47034*.

[686] Department of Energy, ''Biden-Harris Administration Launches $675 Million Bipartisan Infrastructure Law Program to Expand Domestic Critical Materials Supply Chains,'' August 9, 2022. Available at *https://www.energy.gov/articles/biden-harris-administration-launches-675-million-bipartisan-infrastructure-law-program*.

[687] U.S. Geological Survey, ''Bipartisan Infrastructure Law supports critical-minerals research in central Great Plains,'' October 26, 2022. Available at *https://www.usgs.gov/news/state-news-release/bipartisan-infrastructure-law-supports-critical-minerals-research-central*.

[688] Congressional Research Service, ''Energy and Minerals Provisions in the Infrastructure Investment and Jobs Act (Pub. L. 117–58)'', February 16, 2022. *https://crsreports.congress.gov/product/pdf/R/R47034*.

[689] International Energy Agency, ''Infrastructure and Jobs act: Critical Minerals,'' October 26, 2022. *https://www.iea.org/policies/14995-infrastructure-and-jobs-act-critical-minerals*.

[690] Department of Energy, Li-Bridge, ''Building a Robust and Resilient U.S. Lithium Battery Supply Chain,'' February 2023.

[691] The White House, ''Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth,'' 100-Day Reviews under Executive Order 14017, June 2021.

[692] Federal Consortium for Advanced Batteries, ''National Blueprint for Lithium Batteries 2021–2030,'' June 2021.

Available at *https://www.energy.gov/sites/default/files/2021-06/FCAB%20National%20Blueprint%20Lithium%20Batteries%200621_0.pdf*.

[693] *https://www.anl.gov/li-bridge*.

[694] Department of Energy, Li-Bridge, '' Building a Robust and Resilient U.S. Lithium Battery Supply Chain,'' February 2023.

[695] Congressional Research Service, ''Energy and Minerals Provisions in the Infrastructure Investment and Jobs Act (Pub. L. 117–58)'', February 16, 2022. *https://crsreports.congress.gov/product/pdf/R/R47034*.

[696] Department of Energy, Li-Bridge, ''Building a Robust and Resilient U.S. Lithium Battery Supply Chain,'' February 2023 (p. 9).

[697] Department of Energy, EERE Funding Opportunity Exchange, EERE Funding Opportunity Announcements. Accessed March 4, 2023 at *https://eere-exchange.energy.gov/Default.aspx#FoaId0596def9-c1cc-478d-aa4f-14b472864eba*.

[698] Federal Reserve Bank of Dallas, ''Automakers' bold plans for electric vehicles spur U.S. battery boom,'' October 11, 2022. Accessed on March 4, 2023 at *https://www.dallasfed.org/research/economics/2022/1011*.

[699] Department of Energy, Li-Bridge, ''Building a Robust and Resilient U.S. Lithium Battery Supply Chain,'' February 2023 (p. 9).

[700] Department of Energy Loan Programs Office, ''Critical Materials Loans & Loan Guarantees,'' *https://www.energy.gov/sites/default/files/2021-06/DOE-LPO_Program_Handout_Critical_Materials_June2021_0.pdf*.

[701] Slides 6 and 7 of presentation by Li-Bridge to Federal Consortium for Advanced Batteries (FCAB), November 17, 2022.

[702] *https://www.energy.gov/eere/vehicles/federal-consortium-advanced-batteries-fcab*.

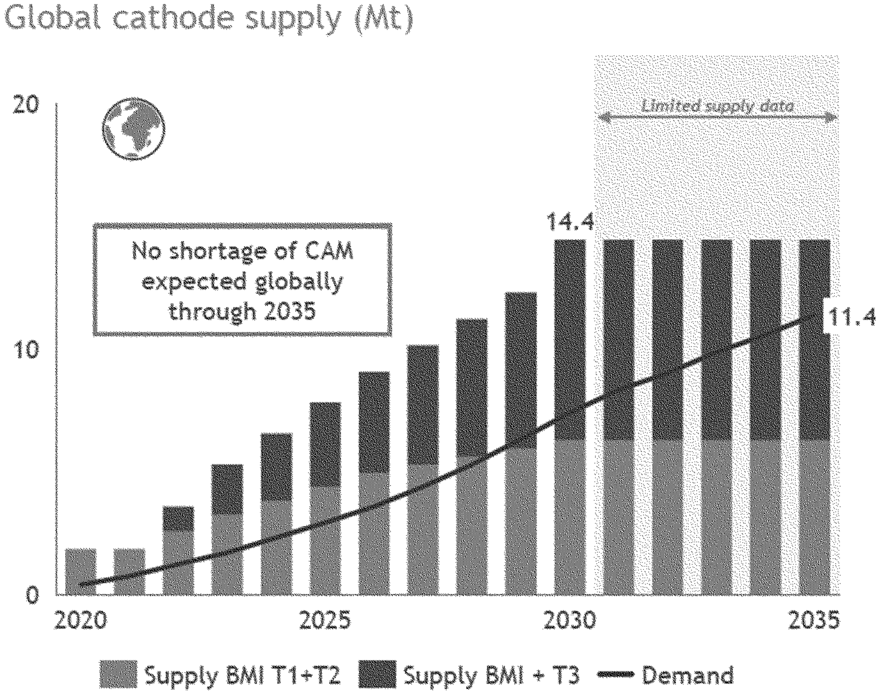

Figure 33. DOE Li-Bridge assessment of global CAM supply and demand.

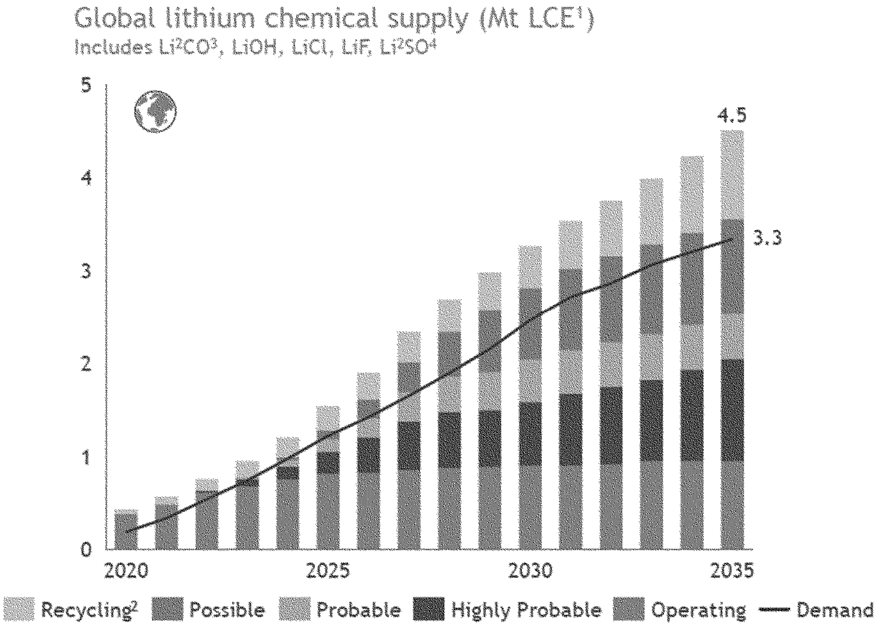

Figure 34. DOE Li-Bridge assessment of global lithium chemical supply and demand.

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Similarly, the International Energy Agency (IEA) published its Global EV Outlook 2022 which examined the outlook for supply and demand for lithium, cobalt, and nickel between 2020 and 2030 under several demand scenarios.[703] As shown in Figure 35, it found that the supply should be sufficient for their ''Stated Policies'' (STEPS) scenario, in which the projected demand represents ''existing policies and measures, as well as policy ambitions and targets that have been legislated by governments around the world,'' and includes ''current EV-related policies and regulations and future developments based on the expected impacts of announced deployments and plans from industry

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[703] International Energy Agency, ''Global EV Outlook 2022,'' p. 185, May 2022.

stakeholders.'' Under their ''Announced Pledges'' (APS) scenario, a higher demand scenario which ''assumes that the announced ambitions and targets made by governments around the world, including the most recent ones, are met in full and on time,'' nickel and cobalt would still be at sufficient supply, but lithium would begin to fall short after 2025.

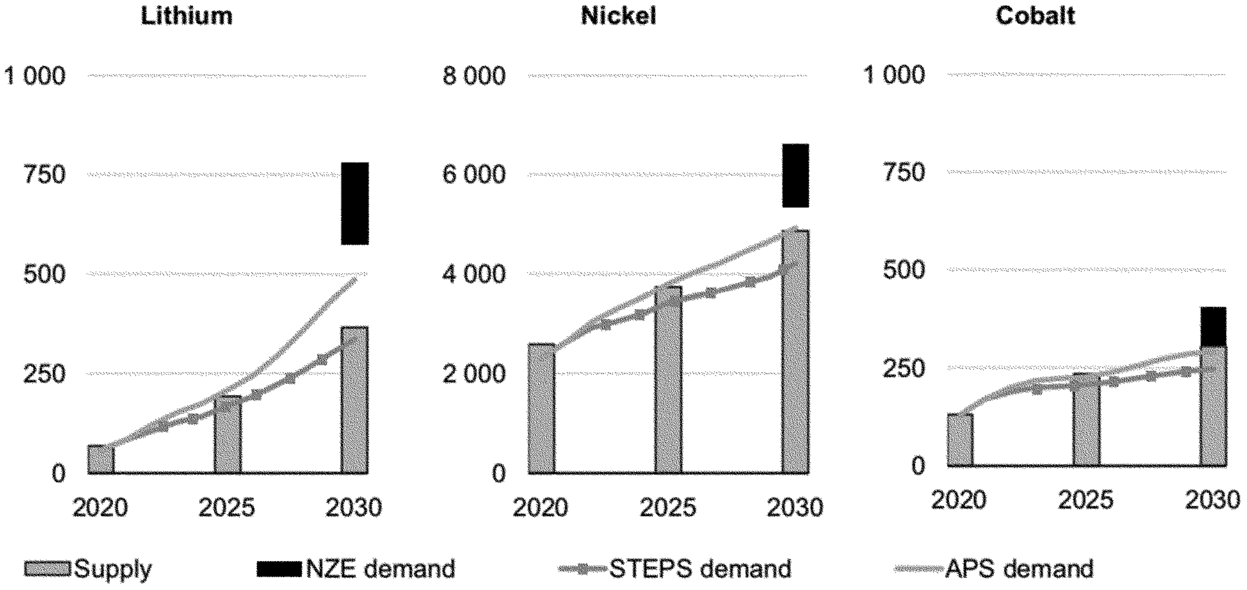

Figure 35. IEA projections of total demand and supply for lithium, nickel, and cobalt, 2020-2030.

Although the IEA Global EV Outlook 2022 was published in May 2022, more recent information indicates that the market is responding robustly to demand[704] and lithium supplies are expanding as new resources are characterized, projects continue through engineering economic assessments, and others begin permitting or construction. For example, in October 2022, the IEA projected that global Lithium Carbonate Equivalent (LCE) production from operating mines and those under construction would sufficiently meet primary demand until at least 2028 under the Stated Policies Scenario.[705] Even 2028 is likely a very conservative estimate. In March 2023, DOE communicated to EPA that an ongoing DOE assessment of U.S. lithium resource development projects had identified additional resources not represented in leading assessments. For example, DOE determined that a December 2022 BNEF projection that lithium mine production could meet end-use demand until at least 2028 did not include additional U.S. resources later identified by DOE and Argonne National Laboratory.[706] Specifically, the BNEF data included only three U.S. projects: Silver Peak (phase I and II), Rhyolite Ridge (phase I), and Carolina Lithium (phase I). As depicted in Figure 36, adding to the BNEF assessment, DOE and Argonne National Laboratory had identified 19 additional lithium production projects in the United States in addition to the three identified in the December 2022 BNEF data. Some of these projects are likely to ramp in before 2030 and if considered in the other projections likely would advance lithium sufficiency well beyond 2028. For example, the 19 U.S. projects potentially represent an additional 1,000 kilotons per year LCE not accounted for in the BNEF analysis,[707] which would be enough to meet the BNEF Net-Zero demand projection, as depicted in Figure 36. Note that these do not include recycling projects, which could increase domestic lithium supply beyond that shown, nor an additional five U.S. projects for which potential LCE production capacity is not yet established. The identification of these additional projects exemplify the dynamic nature of the industry and the likely conservative aspect of existing assessments.

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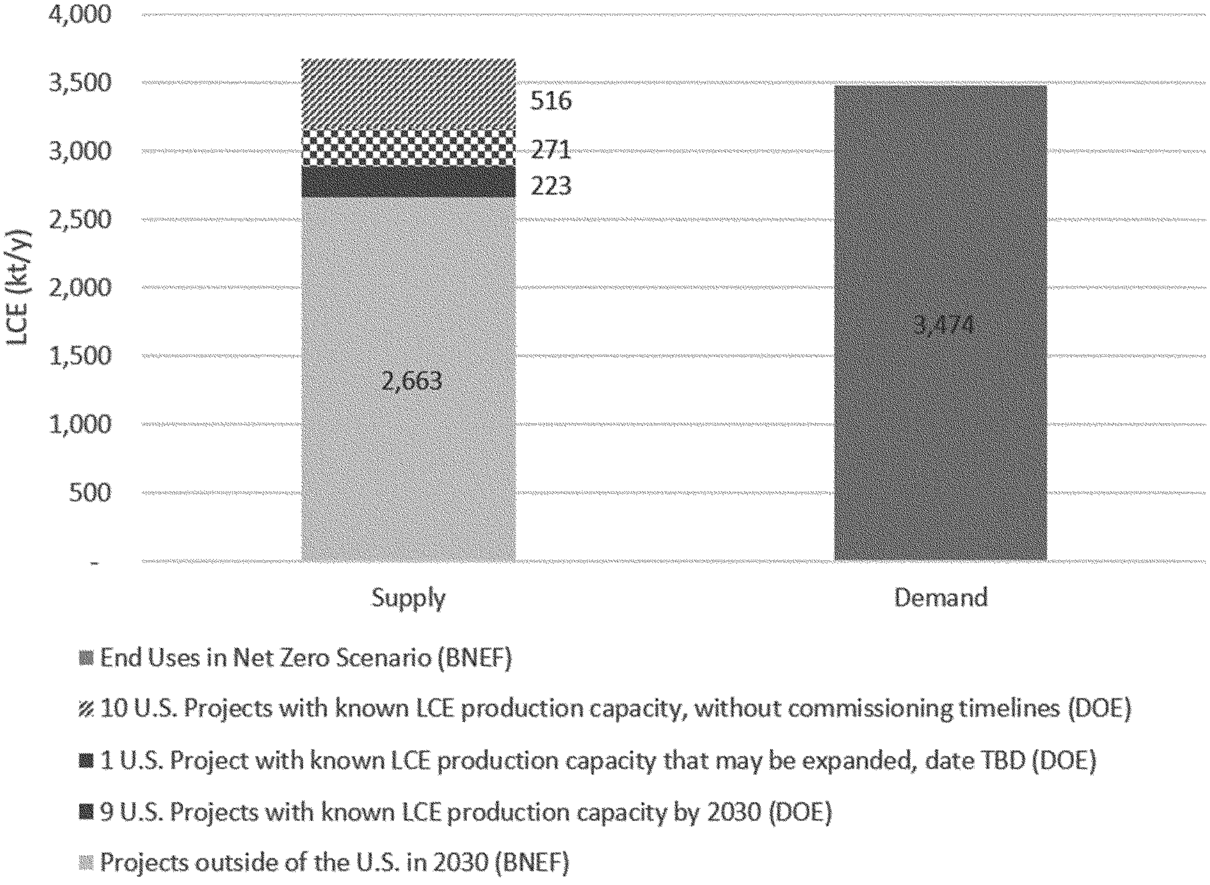
[704] Bloomberg New Energy Finance, ''Lithium-ion Battery Pack Prices Rise for First Time to an Average of $151/kWh,'' December 6, 2022. Accessed on December 6, 2022 at: *https://about.bnef.com/blog/lithium-ion-battery-pack-prices-rise-for-first-time-to-an-average-of-151-kwh/.*

[705] International Energy Agency, ''Committed mine production and primary demand for lithium, 2020–2030,'' October 26, 2022. Accessed on March 9, 2023 at *https://www.iea.org/data-and-statistics/charts/committed-mine-production-and-primary-demand-for-lithium-2020-2030.*

[706] Department of Energy, communication to EPA titled ''Lithium Supplies—additional datapoints and research,'' March 8, 2023. See memorandum to Docket ID No. EPA–HQ–OAR–2022–0829 titled ''DOE Communication to EPA Regarding Critical Mineral Projects.''

[707] Department of Energy, communication to EPA titled ''Lithium Supplies—additional datapoints and research,'' March 8, 2023. See Memo to Docket ID No. EPA–HQ–OAR–2022–0829, titled ''DOE Communication to EPA Regarding Critical Mineral Projects.''



NOTE: Data excludes five mining projects in the U.S. without known LCE capacity.

**Figure 36: DOE compilation of global lithium supply and demand.**

Recent unexpected drops (as of March 2023) in lithium prices are believed to have been the result of robust growth in lithium supply from developments similar to these,[708] and further supports the expectation of a stabilization in commodity prices, which in turn supports an expectation that sufficient supply will be developed.

In addition, the Inflation Reduction Act's requirement that qualification for $3,750 of the Clean Vehicle Credit depends in part on sourcing of critical minerals from the U.S. or countries with which the U.S. has a free trade agreement has spurred other countries to consider action that would expand lithium supply. For example, the European Union is seeking to promote rapid development of Europe's battery supply chains by considering targeted measures such as accelerating permitting processes and encouraging private investment. To these ends the European Parliament proposed a Critical Raw Materials Act on March 16, 2023, which includes these and other measures to encourage the development of new supplies of critical minerals not currently anticipated in market projections.[709] [710] [711]

In DRIA 3.1.3.2 and 3.1.3.3 we detail these and many other examples that demonstrate how momentum has picked up in the lithium market since IEA's May 2022 report. For more discussion, please see DRIA Chapters 3.1.3.2 and 3.1.3.3.

In the critical mineral analysis outlined in DRIA Chapter 3.1.3.2, we selected lithium supply as the primary mineral-based limiting factor in constraining the potential rate of BEV penetration for modeling purposes. Of the IEA scenarios considered, in those that anticipated a potential shortfall in any mineral, lithium demand was the first to show potential for exceeding supply in some scenarios. In addition, with respect to other cathode and anode minerals, we note that there is some flexibility in choice of these minerals, as in many cases, opportunity will exist to reduce cobalt and manganese content or to substitute with iron-phosphate chemistries that do not utilize nickel, cobalt or manganese, or use other forms of carbon in the anode, or in conjunction with silicon. However, all currently produced chemistries require lithium in the electrolyte and the cathode, and these have no viable

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[708] New York Times, "Falling Lithium Prices Are Making Electric Cars More Affordable," March 20, 2023. Accessed on March 23, 2023 at *https://www.nytimes.com/2023/03/20/business/lithium-prices-falling-electric-vehicles.html.*

[709] European Union, "7th High-Level Meeting of the European Battery Alliance: main takeaways by the Chair Maroš Šefčovič and the Council Presidency," March 1, 2023. Accessed on March 9, 2023 at *https://single-market-economy.ec.europa.eu/system/files/2023-03/Main%20takeaways_7th%20High-Level%20Meeting%20of%20EBA.pdf.*

[710] New York Times, "U.S. Eyes Trade Deals With Allies to Ease Clash Over Electric Car Subsidies," February 24, 2023.

[711] European Parliament, "Proposal for a regulation of the European Parliament and of the Council establishing a framework for ensuring a secure and sustainable supply of critical raw materials," March 16, 2023. *https://single-market-economy.ec.europa.eu/publications/european-critical-raw-materials-act_en.*

substitute at this time.[712] Accordingly, in DRIA 3.1.3.2 we focused on lithium availability as a potential limiting factor on the rate of growth of PEV production, and thus the most appropriate basis for establishing a modeling constraint on the rate of PEV penetration into the fleet over the time frame of the proposed rule. In that analysis, we conclude that lithium supply is likely to be adequate to meet anticipated demand as demand increases and supply grows.

Despite recent short-term fluctuations in price, the price of lithium is expected to stabilize at or near its historical levels by the mid-2020s.[713] [714] This perspective is also supported by proprietary battery price forecasts by Wood Mackenzie that include the predicted effect of temporarily elevated mineral prices and show battery costs falling again past 2024.[715] [716] This is consistent with the BNEF battery price outlook 2022 which expects battery prices to start dropping again in 2024, and BNEF's 2022 Battery Price Survey which predicts that average pack prices should fall below $100/kWh by 2026.[717] Taken together these outlooks support the perspective that lithium is not likely to encounter a critical shortage as supply responds to meet growing demand. For more discussion of the mineral supply outlook for the time frame of the proposed rule, see Chapter 3.1.3.2 of the DRIA.

EPA has considered this information on the development of the supply chain to meet future PEV production needs and has represented this information in developing modeling constraints for use by the OMEGA model that represent limitations on annual rate of growth of PEV production imposed by the rate of growth of the global supply chain for batteries and minerals. Specifically, in our compliance modeling we imposed an upper limit on Gigawatt-hours (GWh) of gross battery energy capacity that can be produced and made available for production of BEVs that enter the new U.S. vehicle market in a given year of the analysis. The development of this constraint used by the OMEGA model is discussed in Chapter 3.1.3.2 of the DRIA.

EPA requests comment on the GWh constraint described in that DRIA chapter, and on alternative methods for representing constraints on future PEV production that may result from limitations on the supply chain for batteries and the critical minerals and other components that are used in their manufacture.

### iii. Mineral Security

As stated at the beginning of this section, it is our assessment that increased automotive electrification in the U.S. does not constitute a vulnerability to national security, for several reasons supported by the discussion in this Section IV.C.6 and in DRIA 3.1.3.2.

A domestic supply chain for battery and cell manufacturing is rapidly forming by the actions of stakeholders including automakers and suppliers who wish to take advantage of the business opportunities that this need presents, and by automakers who recognize the need to remain competitive in a global market that is shifting to electrification. It is, therefore, already a goal of the U.S. manufacturing industry to create a robust supply chain for these products, in order to supply not only the domestic vehicle market, but also all of the other applications for these products in global markets as the world decarbonizes.

Further, the Inflation Reduction Act and the Bipartisan Infrastructure Law are proving to be a highly effective means by which Congress and the Administration have provided support for the building of a robust supply chain, and to accelerate this activity to ensure that it forms as rapidly as possible. An example is the work of Li-Bridge, a public-private alliance committed to accelerating the development of a robust and secure domestic supply chain for lithium-based batteries. It has set forth a goal that by 2030 the United States should capture 60 percent of the economic value associated with the U.S. domestic demand for lithium batteries. Achieving this target would double the economic value expected in the U.S. under ''business as usual'' growth.[718] More evidence of recent growth in the supply chain is found in a February 2023 report by Pacific Northwest National Laboratory (PNNL), which documents robust growth in the North American lithium battery industry.[719]

Finally, it is important to note that utilization of critical minerals is different from the utilization of foreign oil, in that oil is consumed as a fuel while minerals become a constituent of manufactured vehicles. That is, mineral security is not a perfect analogy to energy security. Supply disruptions and fluctuating prices are relevant to critical minerals as well, but the impacts of such disruptions are felt differently and by different parties. Disruptions in oil supply or gasoline price has an immediate impact on consumers through higher fuel prices, and thus constrains the ability to travel. In contrast, supply disruptions or price fluctuations of minerals affect only the production and price of new vehicles. In practice, short-term price fluctuations do not always translate to higher production cost as most manufacturers purchase minerals via long-term contracts that insulate them to a degree from changes in spot prices. Moreover, critical minerals are not a single commodity but a number of distinct commodities, each having its own supply and demand dynamics, and some being capable of substitution by other minerals. Importantly, while oil is consumed as a fuel and thus requires continuous supply, minerals become part of the vehicle and have the potential to be recovered and recycled. Thus, even when minerals are imported from other countries, their acquisition adds to the domestic mineral stock that is available for domestic recycling in the future.

Over the long term, battery recycling will be a critical component of the PEV supply chain and will contribute to mineral security and sustainability, effectively acting as a domestically produced mineral source that reduces overall reliance on foreign-sourced products. While growth in the return of end-of-life PEV batteries will lag the market penetration of PEVs, it is important to consider the development of a battery recycling supply chain during the time frame of the rule and beyond.

By 2050, battery recycling could be capable of meeting 25 to 50 percent of total lithium demand for battery

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[712] In DRIA 3.1.3.3 we discuss the outlook for alternatives to lithium in battery chemistries that are under development.

[713] Sun et al., ''Surging lithium price will not impede the electric vehicle boom,'' *Joule,* doi:10.1016/j.joule. 2022.06.028 (*https://dx.doi.org/10.1016/j.joule.2022.06.028*).

[714] Green Car Congress, ''Tsinghua researchers conclude surging lithium price will not impede EV boom,'' July 29, 2022.

[715] Wood Mackenzie, ''Battery & raw materials—Investment horizon outlook to 2032,'' September 2022 (filename: brms–q3–2022–iho.pdf). Available to subscribers.

[716] Wood Mackenzie, ''Battery & raw materials—Investment horizon outlook to 2032,'' accompanying data set, September 2022 (filename: brms–data–q3–2022.xlsx). Available to subscribers.

[717] Bloomberg New Energy Finance, ''Lithium-ion Battery Pack Prices Rise for First Time to an Average of $151/kWh,'' December 6, 2022. Accessed on December 6, 2022 at: *https://about.bnef.com/blog/lithium-ion-battery-pack-prices-rise-for-first-time-to-an-average-of-151-kwh/.*

[718] Department of Energy, Li-Bridge, ''Building a Robust and Resilient U.S. Lithium Battery Supply Chain,'' February 2023.

[719] Pacific Northwest National Laboratory, ''North American Lithium Battery Materials V 1.2,'' February 2023. Available at *https://www.pnnl.gov/projects/north-american-lithium-battery-materials-industry-report.*

production.[720] [721] To this end, battery recycling is a very active area of research. The Department of Energy coordinates much research in this area through the ReCell Center, described as ''a national collaboration of industry, academia and national laboratories working together to advance recycling technologies along the entire battery life-cycle for current and future battery chemistries.'' [722] Funding is also being disbursed as directed by the Bipartisan Infrastructure Law.[723] A growing number of private companies are entering the battery recycling market as the rate of recyclable material becoming available from battery production facilities and salvaged vehicles has grown, and manufacturers are already reaching agreements to use these recycled materials for domestic battery manufacturing. For example, Panasonic has contracted with Redwood Materials Inc. to supply domestically processed cathode material, much of which will be sourced from recycled batteries.[724] Ford and Volvo have also partnered with Redwood to collect end-of-life batteries for recycling and promote a circular, closed-loop supply chain utilizing recycled materials.[725] Redwood has also announced a battery active materials plant in South Carolina with capacity to supply materials for 100 GWh per year of battery production, and is likely to provide these materials to many of the ''battery belt'' factories that are developing in a corridor between Michigan and Georgia.[726] General Motors and LG Energy Solution have also partnered with Li-Cycle to provide recycling of GM's Ultium cells.[727]

Recycling infrastructure is one of the targets of several provisions of the BIL. It includes a Battery Processing and Manufacturing program, which grants significant funds to promote U.S. processing and manufacturing of batteries for automotive and electric grid use, by awarding grants for demonstration projects, new construction, retooling and retrofitting, and facility expansion. It will provide a total of $3 billion for battery material processing, $3 billion for battery manufacturing and recycling, $10 million for a lithium-ion battery recycling prize competition, $60 million for research and development activities in battery recycling, an additional $50 million for state and local programs, and $15 million to develop a collection system for used batteries. In addition, the Electric Drive Vehicle Battery Recycling and Second-Life Application Program will provide $200 million in funds for research, development, and demonstration of battery recycling and second-life applications.[728]

The efforts to fund and build a mid-chain processing supply chain for active materials and related products will also be important to reclaiming minerals through domestic recycling. While domestic recycling can recover minerals and other materials needed for battery cell production, they commonly are recovered in elemental forms that require further midstream processing into precursor substances and active material powders that can be used in cell production. The DOE ReCell Center coordinates extensive research on development of a domestic lithium-ion recycling supply chain, including direct recycling, in which materials can be recycled for direct use in cell production without destroying their chemical structure, and advanced resource recovery, which uses chemical conversion to recover raw minerals for processing into new constituents.[729]

Currently, pilot-scale battery recycling research projects and private recycling startups have access to only limited amounts of recycling stock that originate from sources such as manufacturer waste, crashed vehicles, and occasional manufacturer recall/repair events. As PEVs are currently only a small portion of the U.S. vehicle stock, some time will pass before vehicle scrappage can provide a steady supply of end-of-life batteries to support large-scale battery recycling. During this time, we expect that the midchain processing portion of the supply chain will continue to develop and will be able to capture much of the resources made available by the recycling of used batteries coming in from the fleet.

### *D. Projected Compliance Costs and Technology Penetrations*

#### 1. $CO_2$ Targets and Compliance Levels

#### i. Light-Duty Vehicle Targets and Compliance Levels

The proposed footprint standards curve coefficients for light-duty vehicles were presented in Section III.B.2.iv. Here we present the projected industry average fleet targets for both the Proposal and the No Action case for reference. These average targets (for the proposed standards and the No Action case,[730] respectively) are presented for both the car and truck regulatory classes in Table 66 and Table 67, and then for three different modeled body styles: Sedans, crossovers and SUVs, and pickup trucks,[731] in Table 68 and Table 69. The projected targets for each are based on the industry sales weighted average of vehicle models (and their respective footprints) within the regulatory class or body style.[732]

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[720] Sun et al., ''Surging lithium price will not impede the electric vehicle boom,'' *Joule,* doi:10.1016/j.joule. 2022.06.028 (*https://dx.doi.org/10.1016/j.joule.2022.06.028*).

[721] Ziemann et al., ''Modeling the potential impact of lithium recycling from EV batteries on lithium demand: a dynamic MFA approach,'' Resour. Conserv. Recycl. 133, pp. 76–85. *https://doi.org/10.1016/j.resconrec.* 2018.01.031.

[722] *https://recellcenter.org/about/.*

[723] Department of Energy, ''Biden-Harris Administration Announces Nearly $74 Million To Advance Domestic Battery Recycling And Reuse, Strengthen Nation's Battery Supply Chain,'' Press Release, November 16, 2022.

[724] Randall, T., ''The Battery Supply Chain Is Finally Coming to America,'' Bloomberg, November 15, 2022.

[725] Automotive News Europe, ''Ford, Volvo join Redwood in EV battery recycling push in California,'' February 17, 2022. *https://europe.autonews.com/automakers/ford-volvo-join-redwood-ev-battery-recycling-push-california.*

[726] Wards Auto, ''Battery Recycler Redwood Plans $3.5 Billion South Carolina Plant,'' December 27, 2022. *https://www.wardsauto.com/industry-news/battery-recycler-redwood-plans-35-billion-south-carolinaplant.*

[727] General Motors, ''Ultium Cells LLC and Li-Cycle Collaborate to Expand Recycling in North America,'' Press Release, May 11, 2021. *https://news.gm.com/newsroom.detail.html/Pages/news/us/en/2021/may/0511-ultium.html.*

[728] Environmental Defense Fund and ERM, ''Electric Vehicle Market Update: Manufacturer Commitments and Public Policy Initiatives Supporting Electric Mobility in the U.S. and Worldwide,'' September 2022.

[729] Department of Energy, ''The ReCell Center for Advanced Battery Recycling FY22 Q4 Report,'' October 20, 2022. Available at: *https://recellcenter.org/2022/12/15/recell-advanced-battery-recycling-center-fourth-quarter-progress-report-2022/.*

[730] The No-Action case continues MY 2026 flexibilities for the off-cycle and A/C credits available to OEMs as defined in the 2021 Final Rule.

[731] All sedans are of the car regulatory class; crossovers and SUVs include both cars and trucks; and all pickups are of the truck regulatory class.

[732] Note that these targets are projected based on both projected future sales in applicable MYs and our proposed standards; after the standards are finalized the targets will change depending on each manufacturer's actual sales.

TABLE 66—PROJECTED TARGETS FOR PROPOSED LDV STANDARDS, BY REGULATORY CLASS

[$CO_2$ grams/mile]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| Cars | 134 | 116 | 99 | 91 | 82 | 73 |
| Trucks | 163 | 142 | 120 | 110 | 100 | 89 |
| Total | 152 | 131 | 111 | 102 | 93 | 82 |

TABLE 67—PROJECTED TARGETS FOR LDV NO-ACTION CASE, BY REGULATORY CLASS

[$CO_2$ grams/mile]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| Cars | 131 | 132 | 132 | 132 | 131 | 131 |
| Trucks | 183 | 182 | 183 | 183 | 183 | 183 |
| Total | 162 | 162 | 163 | 162 | 162 | 161 |

TABLE 68—PROJECTED TARGETS FOR PROPOSED LDV STANDARDS, BY BODY STYLE

[$CO_2$ grams/mile]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| Sedans | 134 | 117 | 99 | 91 | 82 | 73 |
| Crossovers/SUVs | 149 | 130 | 110 | 101 | 92 | 81 |
| Pickups | 195 | 166 | 141 | 129 | 118 | 105 |
| Total | 152 | 131 | 111 | 102 | 93 | 82 |

TABLE 69—PROJECTED TARGETS FOR LDV NO-ACTION CASE, BY BODY STYLE

[$CO_2$ grams/mile]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| Sedans | 132 | 132 | 133 | 132 | 132 | 131 |
| Crossovers/SUVs | 161 | 161 | 162 | 161 | 161 | 161 |
| Pickups | 222 | 219 | 220 | 222 | 222 | 223 |
| Total | 162 | 162 | 163 | 162 | 162 | 161 |

The modeled achieved $CO_2$ levels for the proposed standards and the No Action case are shown for both the car and truck regulatory class in Table 70 and Table 71 and then by body style in Table 72 and Table 73, respectively. These values were produced by the modeling analysis and represent the projected certification emissions values for possible compliance approaches with the proposed standards, grouped by body style. These achieved values, shown as sales weighted averages over the respective sedan, crossover/SUV, and pickup truck body styles, include the 2-cycle tailpipe emissions based on the modeled application of emissions-reduction technologies minus the modeled application of off-cycle credit technologies and A/C efficiency credits.

TABLE 70—PROPOSED LDV STANDARDS—ACHIEVED LEVELS BY REGULATORY CLASS

[$CO_2$ grams/mile]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| Cars | 115 | 100 | 84 | 72 | 68 | 60 |
| Trucks | 176 | 149 | 123 | 113 | 106 | 95 |
| Total | 151 | 129 | 107 | 97 | 91 | 81 |

TABLE 71—LDV NO-ACTION CASE—ACHIEVED LEVELS BY REGULATORY CLASS

[$CO_2$ grams/mile]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| Cars | 117 | 111 | 104 | 102 | 109 | 113 |
| Trucks | 183 | 169 | 155 | 153 | 158 | 160 |

TABLE 71—LDV NO-ACTION CASE—ACHIEVED LEVELS BY REGULATORY CLASS—Continued

[$CO_2$ grams/mile]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| Total | 157 | 146 | 135 | 132 | 138 | 141 |

TABLE 72—PROPOSED LDV STANDARDS—ACHIEVED LEVELS BY BODY STYLE

[$CO_2$ grams/mile]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| Sedans | 108 | 93 | 78 | 63 | 57 | 47 |
| Crossovers/SUVs | 140 | 123 | 102 | 97 | 97 | 95 |
| Pickups | 276 | 220 | 181 | 160 | 131 | 91 |
| Total | 151 | 129 | 107 | 97 | 91 | 81 |

TABLE 73—LDV NO ACTION CASE—ACHIEVED LEVELS BY BODY STYLE

[$CO_2$ grams/mile]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| Sedans | 106 | 101 | 96 | 95 | 103 | 108 |
| Crossovers/SUVs | 149 | 139 | 129 | 130 | 139 | 141 |
| Pickups | 279 | 251 | 227 | 211 | 204 | 203 |
| Total | 157 | 146 | 135 | 132 | 138 | 141 |

Comparing the target and achieved values it can be seen that the achieved values are over target (higher emissions) for the average pickup truck, and under target (lower emissions) for the average sedan. This is a feature of the unlimited credit transfer provision, which results in a compliance determination that is based on the combined car and truck fleet credits for each manufacturer, rather than a separate determination of each fleet's compliance. The application of technologies is influenced by the relative cost-effectiveness of technologies among each manufacturer's vehicles. For the combined fleet, the achieved values are typically close to or slightly under the target values, which would represent the banking of credits that can be carried over into other model years. This indicates that overall, the modeled fleet tracks the standards very closely from year-to-year. Note that an achieved value for a manufacturer's combined fleet that is above the target in a given model year does not indicate a likely failure to comply with the standards, since the model includes the GHG program credit banking provisions that allow credits from one year to be carried into another year.

The modeling predicts that the industry will over comply against the MY 2027–2032 standards in the No Action scenario, driven by the projected significant increase in BEVs. This is in part due to the economic opportunities provided for BEVs to both manufacturers and consumers by the IRA. Figure 37 shows a plot of industry average achieved tailpipe g/mi compared to the projected targets for both the No Action case and the proposed standards. The modeling shows that the industry as a whole should be able to achieve the proposed standards over the MY 2027–2032 time frame.

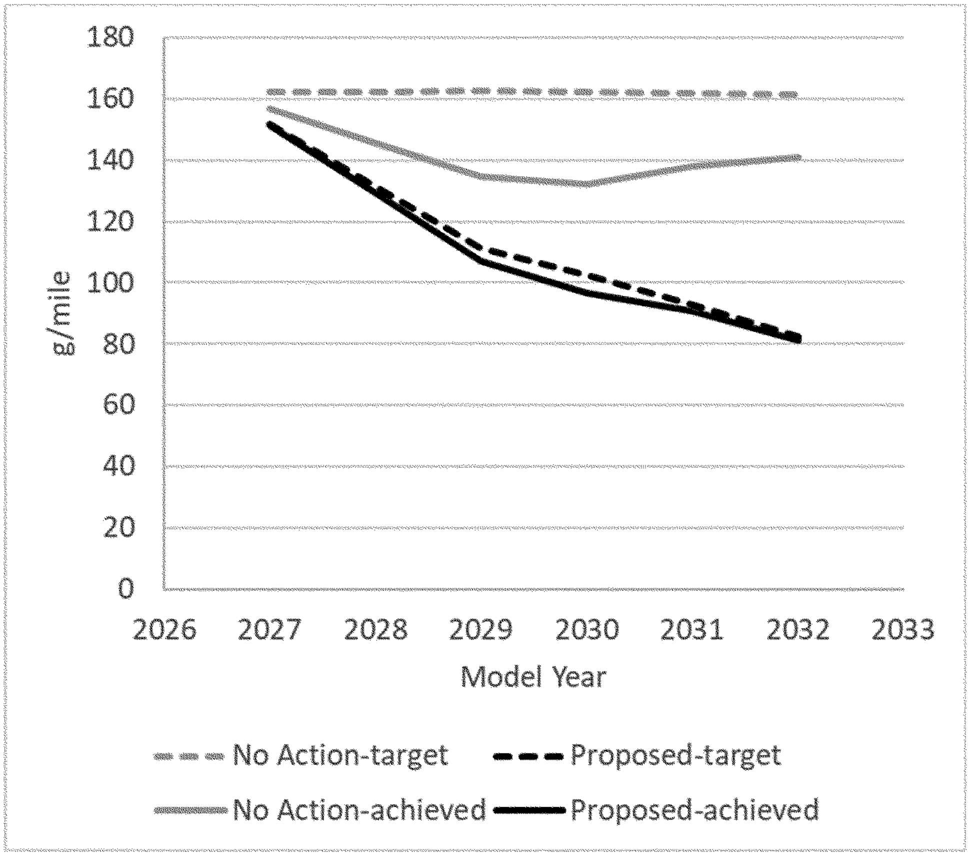

Figure 37. Achieved vs. target GHG g/mi for No Action case and proposed standards.

### ii. Medium-Duty Vehicle Targets and Compliance Levels

Based on the proposed work-factor based standards curve coefficients described in Section III.B.3, we present the projected industry average medium-duty vehicle fleet targets for both the proposed standards and the No Action case in Table 74 and Table 75. These average targets are shown for two different modeled body styles: Vans and pickup trucks. The projected targets for each case are based on the industry sales weighted average of vehicle models (and their respective work factors) within each body style.[733]

TABLE 74—PROJECTED TARGETS FOR PROPOSED MDV STANDARDS, BY BODY STYLE

[$CO_2$ grams/mile]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| Vans | 393 | 379 | 345 | 309 | 276 | 243 |
| Pickups | 462 | 452 | 413 | 374 | 331 | 292 |
| Total | 438 | 427 | 389 | 352 | 312 | 275 |

TABLE 75—PROJECTED TARGETS FOR MD VEHICLES, NO-ACTION CASE, BY BODY STYLE

[$CO_2$ grams/mile]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| Vans | 410 | 410 | 410 | 410 | 410 | 410 |
| Pickups | 517 | 517 | 517 | 518 | 518 | 518 |
| Total | 480 | 480 | 480 | 481 | 481 | 481 |

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[733] Note that these targets are projected based on both projected future sales in applicable MYs and our proposed standards; the targets will change each MY depending on each manufacturer's actual sales.

The modeled achieved $CO_2$ levels for the proposed standards are shown for both vans and pickups in Table 76. These values were produced by the modeling analysis and represent the projected certification emissions values for possible compliance approaches with the proposed standards, grouped by body style.

TABLE 76—PROPOSED STANDARDS FOR MD VEHICLES—PROJECTED ACHIEVED LEVELS BY BODY STYLE

[$CO_2$ grams/mile]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| Vans | 292 | 202 | 119 | 36 | 12 | 10 |
| Pickups | 515 | 546 | 534 | 512 | 466 | 410 |
| Total | 437 | 426 | 390 | 347 | 310 | 272 |

2. Compliance Costs per Vehicle for the Proposed Standards

i. Light-Duty Projected Compliance Costs

EPA has performed an assessment of the estimated per-vehicle costs for manufacturers to meet the proposed MY 2027–2032 GHG and criteria air pollutant standards. The fleet average costs per vehicle, again grouped by both regulatory class and body style, are shown in Table 77 and Table 78. As shown, the combined cost for cars and trucks increases gradually from MY 2027 through MY 2032. Incremental costs for pickups (shown in Table 78) decrease slightly in MY 2029 and 2030 before increasing again as the incentives in the IRA begin to phase out.

TABLE 77—AVERAGE INCREMENTAL VEHICLE COST BY REGULATORY CLASS, RELATIVE TO THE NO ACTION SCENARIO

[2020 dollars]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| Cars | $249 | $102 | $32 | $100 | $527 | $844 |
| Trucks | 891 | 767 | 653 | 821 | 1,100 | 1,385 |
| Total | 633 | 497 | 401 | 526 | 866 | 1,164 |

TABLE 78—AVERAGE INCREMENTAL VEHICLE COST BY BODY STYLE, RELATIVE TO THE NO ACTION SCENARIO

[2020 dollars]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| Sedans | $181 | $79 | $51 | $194 | $625 | $1,015 |
| Crossovers/SUVs | 657 | 448 | 332 | 487 | 804 | 962 |
| Pickups | 1,374 | 1,478 | 1,333 | 1,324 | 1,574 | 2,266 |
| Total | 633 | 497 | 401 | 526 | 866 | 1,164 |

Overall, EPA estimates the average costs of today's proposal at approximately $1,200 per vehicle in MY 2032 relative to meeting the No Action scenario in MY 2032. However, these estimates represent the incremental costs to manufacturers; for consumers, these costs are offset by savings in the reduced fuel costs, maintenance and repair costs, as discussed in Section VIII. Additionally, consumers may also benefit from IRA purchase incentives for PEVs.

ii. Medium-Duty Projected Compliance Costs

EPA's assessment of the estimated per-vehicle costs for manufacturers to meet the proposed MY 2027–2032 GHG and criteria air pollutant standards for medium-duty vehicles is presented here. The fleet average costs per vehicle, grouped by body style, are shown in Table 79. As shown, the combined cost for vans and pickups generally increases from MY 2027 through MY 2032.

TABLE 79—AVERAGE INCREMENTAL VEHICLE COST BY BODY STYLE, MEDIUM-DUTY VEHICLES

[2020 dollars]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| Vans | $322 | $658 | $711 | $1,184 | $1,592 | $1,932 |
| Pickups | 386 | 31 | 67 | 374 | 603 | 1,706 |
| Total | 364 | 249 | 290 | 654 | 944 | 1,784 |

Overall, EPA estimates the average costs of today's proposal at approximately $1,800 per medium-duty vehicle in MY 2032 relative to meeting the No Action scenario in MY 2032. Similar to our light-duty costs, these estimates represent the incremental costs to manufacturers; for consumers, these costs are offset by savings in the reduced fuel costs, maintenance and repair costs, as discussed in Section VIII. Additionally, consumers may also benefit from IRA purchase incentives for PEVs.

3. Technology Penetration Rates

i. Light-Duty Technology Penetrations

In this section, we discuss the projected new sales technology penetration rates from EPA's analysis for the proposed standards. Table 80 and Table 81 show the EPA projected penetration rates of BEV technology under the proposed standards and No Action case, respectively, by body style. It is important to note that this is a projection and represents one out of many possible compliance pathways for the industry. The proposed standards are performance-based and do not mandate any specific technology for any manufacturer or any vehicle type. Each manufacturer is free to choose its own set of technologies with which it will demonstrate compliance with the standards. In our projection, as the proposed standards become more stringent over MYs 2027 to 2032, the penetration of BEVs increases by almost 30 percentage points over this 6-year period, from 36 percent in MY 2027 up to 67 percent of overall vehicle production in MY 2032.

It is important to note that EPA's current analysis does not include PHEVs, though we recognize that many manufacturers' product plans include PHEVs. EPA recognizes that the inclusion of PHEVs could potentially increase the combined ZEV share projection beyond the BEV penetration levels shown in Table 81. EPA plans to incorporate PHEVs into our analysis for the final rule. In DRIA Chapter 2.6.4, we present information on the potential costs for PHEVs. We seek comment on this information and on any other data and information we should consider in developing the technical approach to incorporating PHEVs as a compliance technology option in our assessment for the final rule.

TABLE 80—FLEET BEV PENETRATION RATES, BY BODY STYLE, UNDER THE PROPOSED STANDARDS

| | 2027 (%) | 2028 (%) | 2029 (%) | 2030 (%) | 2031 (%) | 2032 (%) |
|---|---|---|---|---|---|---|
| Sedans | 45 | 53 | 61 | 69 | 73 | 78 |
| Crossovers/SUVs | 38 | 46 | 56 | 59 | 61 | 62 |
| Pickups | 11 | 23 | 37 | 45 | 55 | 68 |
| Total | 36 | 45 | 55 | 60 | 63 | 67 |

TABLE 81—FLEET BEV PENETRATION RATES, BY BODY STYLE, UNDER THE NO ACTION CASE

| | 2027 (%) | 2028 (%) | 2029 (%) | 2030 (%) | 2031 (%) | 2032 (%) |
|---|---|---|---|---|---|---|
| Sedans | 39 | 41 | 45 | 46 | 44 | 43 |
| Crossovers/SUVs | 26 | 32 | 37 | 40 | 39 | 39 |
| Pickups | 7 | 16 | 24 | 29 | 31 | 33 |
| Total | 27 | 32 | 37 | 40 | 40 | 39 |

Table 82 and Table 83 show the projected market penetrations for strong HEVs in the proposed standards and the No Action case. While a relatively small percentage of HEVs is projected in the early years of the proposed standards, HEVs were generally not projected in the compliance modeling for the No Action case. While manufacturers may in fact choose HEVs, the modeling indicates they are less cost effective than the BEVs which have been subsidized by the IRA and emit 0 g/mi tailpipe $CO_2$. Moreover, in the No Action case, the modeling indicates that the industry is already overachieving the standards, resulting in less need for HEVs. In the proposed standards case, the steady decline in projected HEVs is primarily a result of continued projected reductions in battery costs which make BEVs increasingly more cost effective relative to HEVs.

TABLE 82—FLEET STRONG HEV PENETRATION RATES UNDER THE PROPOSED STANDARDS

| | 2027 (%) | 2028 (%) | 2029 (%) | 2030 (%) | 2031 (%) | 2032 (%) |
|---|---|---|---|---|---|---|
| Sedans | 4 | 3 | 2 | 2 | 1 | 0 |
| Crossovers/SUVs | 2 | 2 | 2 | 1 | 1 | 0 |
| Pickups | 6 | 2 | 1 | 1 | 1 | 0 |
| Total | 3 | 2 | 2 | 1 | 1 | 0 |

TABLE 83—FLEET STRONG HEV PENETRATIONS RATES UNDER THE NO ACTION CASE

| | 2027 (%) | 2028 (%) | 2029 (%) | 2030 (%) | 2031 (%) | 2032 (%) |
|---|---|---|---|---|---|---|
| Sedans | 6 | 6 | 4 | 4 | 0 | 0 |
| Crossovers/SUVs | 3 | 3 | 3 | 1 | 0 | 0 |
| Pickups | 4 | 0 | 0 | 0 | 0 | 0 |

TABLE 83—FLEET STRONG HEV PENETRATIONS RATES UNDER THE NO ACTION CASE—Continued

| | 2027 (%) | 2028 (%) | 2029 (%) | 2030 (%) | 2031 (%) | 2032 (%) |
|---|---|---|---|---|---|---|
| Total | 4 | 3 | 3 | 2 | 0 | 0 |

Consistent with past rulemakings, EPA has evaluated a range of advanced technologies for ICE vehicles. Two of these technologies were noteworthy in the modeling results: Advanced turbocharged downsized engines (TURB12) and advanced Atkinson (ATK) engines.[734] Further details on EPA's modeling of engine technologies can be found in DRIA Chapters 2.4.5.1 and 3.5.1. Turbocharged engines and Atkinson engines are some of the most cost-effective ICE technologies for GHG compliance, however, like HEVs, are still not as cost-effective as BEVs subsidized by the IRA. Similar to the trends in projected HEV penetration, the advanced ICE technologies are projected to decline as BEVs become more cost effective over the period of the proposed standards; however, for the No Action case, penetrations of TURB12 and ATK increase. Table 84 and Table 85 show the projected market penetrations for downsized turbocharged engines in the proposed standards and the No Action case, while Table 86 and Table 87 show the projections for Atkinson engines.

TABLE 84—TURB12 PENETRATION RATES UNDER THE PROPOSED STANDARDS

| | 2027 (%) | 2028 (%) | 2029 (%) | 2030 (%) | 2031 (%) | 2032 (%) |
|---|---|---|---|---|---|---|
| Sedans | 22 | 20 | 17 | 16 | 18 | 14 |
| Crossovers/SUVs | 3 | 3 | 5 | 6 | 8 | 8 |
| Pickups | 6 | 0 | 0 | 0 | 0 | 0 |
| Total | 8 | 7 | 7 | 8 | 10 | 9 |

TABLE 85—TURB12 PENETRATIONS RATES UNDER THE NO ACTION CASE

| | 2027 (%) | 2028 (%) | 2029 (%) | 2030 (%) | 2031 (%) | 2032 (%) |
|---|---|---|---|---|---|---|
| Sedans | 28 | 29 | 29 | 31 | 39 | 40 |
| Crossovers/SUVs | 3 | 3 | 5 | 9 | 13 | 13 |
| Pickups | 6 | 0 | 0 | 0 | 0 | 0 |
| Total | 10 | 9 | 11 | 14 | 18 | 19 |

TABLE 86—ATK PENETRATION RATES UNDER THE PROPOSED STANDARDS

| | 2027 (%) | 2028 (%) | 2029 (%) | 2030 (%) | 2031 (%) | 2032 (%) |
|---|---|---|---|---|---|---|
| Sedans | 28 | 23 | 19 | 13 | 8 | 7 |
| Crossovers/SUVs | 55 | 49 | 37 | 34 | 30 | 29 |
| Pickups | 35 | 75 | 61 | 54 | 44 | 31 |
| Total | 45 | 46 | 36 | 31 | 26 | 23 |

TABLE 87—ATK PENETRATIONS RATES UNDER THE NO ACTION CASE

| | 2027 (%) | 2028 (%) | 2029 (%) | 2030 (%) | 2031 (%) | 2032 (%) |
|---|---|---|---|---|---|---|
| Sedans | 25 | 24 | 21 | 18 | 16 | 17 |
| Crossovers/SUVs | 68 | 63 | 54 | 49 | 48 | 48 |
| Pickups | 42 | 84 | 76 | 71 | 68 | 66 |
| Total | 53 | 55 | 49 | 44 | 42 | 42 |

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[734] As summarized in Table 86 and Table 87, the Atkinson engines also include a turbocharged variant (Miller cycle), however this is a very small portion of the technology penetrations shown.

### ii. Medium-Duty Technology Penetrations

In this section we discuss the projected new MDV[735] sales technology penetration rates from EPA's analysis for the proposed standards. Table 88 shows the EPA projected penetration rates of BEV technology under the proposed standards by body style. It is important to note that this is a projection and represents one out of many possible compliance pathways for the industry. The proposed standards are performance-based and do not mandate any specific technology for any manufacturer or any vehicle type. Each manufacturer is free to choose its own set of technologies with which it will demonstrate compliance with the standards. As the proposed standards become more stringent over MYs 2027 to 2032, the projected penetration of BEVs (driven mostly by electrification of vans) increases from 17 percent in MY 2027 up to 46 percent of overall vehicle production in MY 2032.

TABLE 88—FLEET BEV PENETRATION RATES, BY BODY STYLE, UNDER THE PROPOSED STANDARDS FOR MDVs

| | 2027 (%) | 2028 (%) | 2029 (%) | 2030 (%) | 2031 (%) | 2032 (%) |
|---|---|---|---|---|---|---|
| Vans | 35 | 55 | 73 | 92 | 97 | 98 |
| Pickups | 7 | 1 | 3 | 4 | 15 | 19 |
| Total | 17 | 20 | 28 | 34 | 43 | 46 |

### 4. Alternative Light-Duty GHG Standards: Projected $CO_2$ Fleet Targets, Costs and Technology Penetrations

In Section III.E, we describe three alternative sets of standards that we considered in developing the level of stringency of the proposed program—Alternative 1 (more stringent than the proposed program), Alternative 2 (less stringent), and Alternative 3 (a slower phase-in of the 2032 MY stringency level in the proposed standards). All four potential programs would incorporate fairly linear year-over-year increases in GHG stringency from MY 2027 through MY 2032, with stringencies that vary by (on average) 10 g/mi between the alternatives and the proposed standards. The alternatives are projected to result in reductions in average GHG emissions targets ranging from 51 percent to 67 percent from the MY 2026 standards, compared to a projected 56 percent reduction for the proposed standards.

Alternative 1 projected fleet-wide $CO_2$ targets are 10 g/mi lower on average than the proposed targets; Alternative 2 projected fleet-wide $CO_2$ targets averaged 10 g/mi higher than the proposed targets.[736] Alternative 3 projected targets in MY 2032 match those of the proposed standards. Table 89, Table 90 and Table 91 show the projected sales weighted averaged targets (MY 2027–2032) for cars, trucks, and the fleet total for the three alternatives. Similarly, Table 92, Table 93, and Table 94 show targets for sedans, crossovers/SUVs and pickups for the three alternatives. Table 95 provides a comparison for the projected industry-wide targets for the alternatives compared to the proposed standards.

TABLE 89—PROJECTED TARGETS BY REGULATORY CLASS [$CO_2$ grams/mile]—ALTERNATIVE 1

[$CO_2$ grams/mile]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| Cars | 124 | 106 | 89 | 81 | 72 | 63 |
| Trucks | 153 | 131 | 110 | 100 | 90 | 78 |
| Total | 141 | 121 | 101 | 92 | 83 | 72 |

TABLE 90—PROJECTED TARGETS BY REGULATORY CLASS [$CO_2$ grams/mile]—ALTERNATIVE 2

[$CO_2$ grams/mile]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| Cars | 144 | 126 | 108 | 100 | 92 | 83 |
| Trucks | 173 | 152 | 130 | 121 | 111 | 99 |
| Total | 162 | 141 | 122 | 112 | 103 | 92 |

TABLE 91—PROJECTED TARGETS BY REGULATORY CLASS [$CO_2$ grams/mile]—ALTERNATIVE 3

[$CO_2$ grams/mile]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| Cars | 139 | 126 | 112 | 99 | 86 | 73 |

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[735] MDVs were not broken down into separate Class 2b and Class 3 categories in the analysis for the proposal. The proposed GHG and criteria pollutant emissions standards regulate Class 2b and Class 3 as a single MDV class. The analysis did include a breakdown between MDV vans and MDV pickups due to differences in use-case and applicable technologies between MDV vans and MDV pickups.

[736] For reference, the targets at a footprint of 50 square feet were exactly 10 g/mi lower and greater for the alternatives.

### TABLE 91—PROJECTED TARGETS BY REGULATORY CLASS [$CO_2$ grams/mile]—ALTERNATIVE 3—Continued

[$CO_2$ grams/mile]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| Trucks | 183 | 163 | 144 | 126 | 107 | 89 |
| Total | 165 | 148 | 132 | 115 | 99 | 82 |

### TABLE 92—PROJECTED TARGETS BY BODY STYLE—ALTERNATIVE 1

[$CO_2$ grams/mile]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| Sedans | 124 | 107 | 89 | 81 | 73 | 63 |
| Crossovers/SUVs | 139 | 120 | 100 | 91 | 82 | 71 |
| Pickups | 182 | 154 | 129 | 117 | 105 | 91 |
| Total | 141 | 121 | 101 | 92 | 83 | 72 |

### TABLE 93—PROJECTED TARGETS BY BODY STYLE—ALTERNATIVE 2

[$CO_2$ grams/mile]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| Sedans | 144 | 126 | 108 | 101 | 92 | 83 |
| Crossovers/SUVs | 158 | 139 | 120 | 111 | 101 | 91 |
| Pickups | 207 | 179 | 153 | 142 | 130 | 116 |
| Total | 162 | 141 | 122 | 112 | 103 | 92 |

### TABLE 94—PROJECTED TARGETS BY BODY STYLE—ALTERNATIVE 3

[$CO_2$ grams/mile]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| Sedans | 139 | 126 | 112 | 99 | 87 | 73 |
| Crossovers/SUVs | 165 | 148 | 131 | 115 | 98 | 81 |
| Pickups | 216 | 190 | 169 | 148 | 126 | 104 |
| Total | 165 | 148 | 132 | 115 | 99 | 82 |

### TABLE 95—COMPARISON OF PROPOSED COMBINED FLEET TARGETS TO ALTERNATIVES

[$CO_2$ grams/mile]

| Model year | Proposed stds | Alternative 1 | Alternative 2 | Alternative 3 |
|---|---|---|---|---|
| 2026 adjusted | 186 | 186 | 186 | 186 |
| 2027 | 152 | 141 | 162 | 165 |
| 2028 | 131 | 121 | 141 | 148 |
| 2029 | 111 | 101 | 122 | 132 |
| 2030 | 102 | 92 | 112 | 115 |
| 2031 | 93 | 83 | 103 | 99 |
| 2032 and later | 82 | 72 | 92 | 82 |

Table 96, Table 97 and Table 98 provide the modeled fleet BEV penetration rates, by body style, for MY 2027–2032 for the three alternatives. Table 98 compares the projected BEV penetration rates for the alternatives compared to the proposed standards.

### TABLE 96—FLEET BEV PENETRATION RATES, BY BODY STYLE, UNDER ALTERNATIVE 1

| | 2027 (%) | 2028 (%) | 2029 (%) | 2030 (%) | 2031 (%) | 2032 (%) |
|---|---|---|---|---|---|---|
| Sedans | 46 | 52 | 59 | 68 | 75 | 75 |
| Crossovers/SUVs | 39 | 49 | 57 | 65 | 65 | 71 |
| Pickups | 12 | 27 | 38 | 47 | 45 | 52 |

TABLE 96—FLEET BEV PENETRATION RATES, BY BODY STYLE, UNDER ALTERNATIVE 1—Continued

| | 2027 (%) | 2028 (%) | 2029 (%) | 2030 (%) | 2031 (%) | 2032 (%) |
|---|---|---|---|---|---|---|
| Total | 37 | 46 | 54 | 63 | 65 | 69 |

TABLE 97—FLEET BEV PENETRATION RATES, BY BODY STYLE, UNDER ALTERNATIVE 2

| | 2027 (%) | 2028 (%) | 2029 (%) | 2030 (%) | 2031 (%) | 2032 (%) |
|---|---|---|---|---|---|---|
| Sedans | 44 | 49 | 60 | 62 | 69 | 72 |
| Crossovers/SUVs | 34 | 41 | 53 | 54 | 56 | 63 |
| Pickups | 12 | 21 | 33 | 45 | 53 | 52 |
| Total | 33 | 40 | 52 | 55 | 59 | 64 |

TABLE 98—FLEET BEV PENETRATION RATES, BY BODY STYLE, UNDER ALTERNATIVE 3

| | 2027 (%) | 2028 (%) | 2029 (%) | 2030 (%) | 2031 (%) | 2032 (%) |
|---|---|---|---|---|---|---|
| Sedans | 43 | 49 | 52 | 60 | 69 | 75 |
| Crossovers/SUVs | 33 | 40 | 47 | 53 | 59 | 64 |
| Pickups | 10 | 20 | 32 | 43 | 55 | 68 |
| Total | 32 | 39 | 46 | 54 | 62 | 68 |

TABLE 99—COMPARISON OF PROJECTED BEV PENETRATIONS FOR ALTERNATIVES VS PROPOSED STANDARDS

[$CO_2$ grams/mile]

| Model year (%) | Proposed stds (%) | Alternative 1 (%) | Alternative 2 (%) | Alternative 3 (%) |
|---|---|---|---|---|
| 2027 | 36 | 37 | 33 | 32 |
| 2028 | 45 | 46 | 40 | 39 |
| 2029 | 55 | 54 | 52 | 46 |
| 2030 | 60 | 63 | 55 | 54 |
| 2031 | 63 | 65 | 59 | 62 |
| 2032 | 67 | 69 | 64 | 68 |

As shown in Table 100 for Alternative 1, Table 101 for Alternative 2, and Table 102 for Alternative 3, the 2032 MY industry average vehicle cost increase (compared to the No Action case) ranges from approximately $1,000 to $1,800 per vehicle for the alternatives, compared to $1,200 per vehicle for the proposed standards.

TABLE 100—FLEET AVERAGE COST PER VEHICLE RELATIVE TO THE NO ACTION SCENARIO [2020 dollars]—ALTERNATIVE 1

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| Sedans | $204 | $276 | $480 | $601 | $1,143 | $1,301 |
| Crossovers/SUVs | 704 | 740 | 1,228 | 1,422 | 1,788 | 2,056 |
| Pickups | 1,382 | 2,033 | 1,871 | 1,866 | 1,469 | 1,544 |
| Total | 668 | 804 | 1,120 | 1,262 | 1,565 | 1,775 |

TABLE 101—FLEET AVERAGE COST PER VEHICLE RELATIVE TO THE NO ACTION SCENARIO [2020 dollars]—ALTERNATIVE 2

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| Sedans | $106 | −$74 | $16 | $8 | $556 | $827 |
| Crossovers/SUVs | 391 | 233 | 263 | 250 | 599 | 1,029 |
| Pickups | 1,406 | 1,656 | 1,353 | 1,328 | 1,511 | 1,503 |
| Total | 462 | 355 | 353 | 337 | 718 | 1,041 |

TABLE 102—FLEET AVERAGE COST PER VEHICLE RELATIVE TO THE NO ACTION SCENARIO [2020 dollars]—ALTERNATIVE 3

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| Sedans | −$21 | −$28 | −$208 | −$65 | $562 | $1,030 |
| Crossovers/SUVs | 251 | 122 | 58 | 288 | 786 | 1,142 |
| Pickups | 320 | 421 | 467 | 698 | 1,311 | 2,148 |
| Total | 189 | 125 | 45 | 250 | 800 | 1,256 |

TABLE 103—COMPARISON OF PROJECTED INCREMENTAL COSTS RELATIVE TO THE NO ACTION SCENARIO

[$CO_2$ grams/mile)] [2020 Dollars]

| Model year | Proposed stds | Alternative 1 | Alternative 2 | Alternative 3 |
|---|---|---|---|---|
| 2027 | $633 | $668 | $462 | $189 |
| 2028 | 497 | 804 | 355 | 125 |
| 2029 | 401 | 1,120 | 353 | 45 |
| 2030 | 526 | 1,262 | 337 | 250 |
| 2031 | 866 | 1,565 | 718 | 800 |
| 2032 | 1,164 | 1,775 | 1,041 | 1,256 |

### *E. Sensitivities—LD GHG Compliance Modeling*

EPA often conducts sensitivity analyses to help assess key areas of uncertainty in both underlying data and modeling assumptions, consistent with OMB Circular No. A–94 which establishes guidelines for conducting benefit-cost analysis of Federal programs. In the analysis for this proposal, EPA has evaluated the feasibility and appropriateness of the proposed standards using the central case assumptions for technology, market acceptance, and various other assumptions described throughout this Preamble and DRIA. For a select number of these key assumptions, we have conducted sensitivity analyses for the proposed and alternative policies using alternative sets of assumptions. We believe that together with the central case assumptions, these sensitivities span ranges of values that reasonably cover the uncertainty in the critical areas of battery costs and the market for BEVs.

#### 1. State-Level ZEV Policies (ACC II)

We have provided an analysis that accounts for state-level zero-emissions vehicle (ZEV) policies as described by California's ACC II program and other participating states under CAA Section 177. At the time this analysis was conducted, California had not yet submitted to EPA a request for a waiver for its ACC II program and EPA is not prejudging the outcome of any waiver process or whether or not certain states are able to adopt California's regulations under the criteria of section 177.[737] Nevertheless, it is an important question to analyze what the potential effect of state adoption of ZEV policies might be in the context of the No Action case, particularly since manufacturers may be adjusting product plans to account for ACC II, and thus we are providing this sensitivity analysis to explore this question. As shown in Table 104, state adoption of ACC II is projected to amount to about 30 percent of total U.S. light-duty sales in 2027 and beyond. Within the states adopting ACC II, manufacturers are required to sell a certain portion of vehicles that meet the ZEV definition, which includes BEVs, FCEVs, and a limited number of PHEVs that satisfy a minimum requirement for charge depleting range. The required ZEV shares increase by model year, reaching 100 percent in 2035 as shown in Table 105.

TABLE 104—SALES SHARE OF U.S. NEW LIGHT-DUTY VEHICLES IN STATES ADOPTING ACC II, BY MODEL YEAR

| Model years | Portion of U.S. new light-duty sales (%) | States adopting ACC II |
|---|---|---|
| 2018 to 2025 | 12.6 | CA. |
| 2026 | 22.6 | CA, MA, NY, OR, VT, WA. |
| 2027 and later | 30.4 | CA, CO, CT, MA, MD, ME, NJ, NY, OR, RI, VT, WA. |

TABLE 105—ZEV PERCENTAGE SALES REQUIREMENTS WITHIN STATES ADOPTING ACC II, BY MODEL YEAR

| 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14.5 | 17.0 | 19.5 | 22.0 | 35.0 | 43.0 | 51.0 | 59.0 | 68.0 | 76.0 | 82.0 | 88.0 | 94.0 | 100.0 |

EPA's analysis of state-level ZEV mandates was conducted by separating the base year fleet into two regions. We applied a minimum BEV sales share constraint to the portion of new vehicles in the ACC II-adopting states, using the

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[737] If California were to submit a waiver request for the ACC II program and EPA were to subsequently grant the waiver, then it may be appropriate to update the No Action case in the final rulemaking to reflect the ACC II program.

values in Table 105. For the remainder of new vehicles, a minimum BEV sales share value of zero was specified. In both ZEV and non-ZEV regions, the OMEGA modeling allowed manufacturers to exceed the minimum BEV shares if it resulted in lower producer generalized cost, while still meeting other modeling constraints including compliance with the National GHG standards for the particular policy case and satisfying the consumer demand for BEVs. The results of the analysis for this state-level ZEV mandate sensitivity are summarized in Table 106 through Table 109.

Table 106—Projected Targets With ACC II, for No Action Case, Proposed and Alternatives—Cars and Trucks Combined

[$CO_2$ grams/mile]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| No Action | 164 | 164 | 165 | 165 | 164 | 164 |
| Proposed | 151 | 131 | 111 | 102 | 93 | 82 |
| Alternative 1 | 141 | 121 | 102 | 92 | 83 | 72 |
| Alternative 2 | 161 | 141 | 121 | 112 | 103 | 92 |
| Alternative 3 | 166 | 149 | 132 | 115 | 99 | 82 |

Table 107—Projected Achieved Levels With ACC II, for No Action Case, Proposed and Alternatives—Cars and Trucks Combined

[$CO_2$ grams/mile]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| No Action | 146 | 123 | 104 | 100 | 103 | 99 |
| Proposed | 149 | 129 | 107 | 96 | 90 | 81 |
| Alternative 1 | 145 | 122 | 99 | 83 | 73 | 66 |
| Alternative 2 | 153 | 132 | 119 | 110 | 100 | 90 |
| Alternative 3 | 154 | 133 | 122 | 113 | 96 | 81 |

Table 108—BEV Penetrations With ACC II, for No Action Case, Proposed and Alternatives—Cars and Trucks Combined

| | 2027 (%) | 2028 (%) | 2029 (%) | 2030 (%) | 2031 (%) | 2032 (%) |
|---|---|---|---|---|---|---|
| No Action | 32 | 42 | 49 | 52 | 52 | 54 |
| Proposed | 37 | 45 | 55 | 61 | 64 | 68 |
| Alternative 1 | 38 | 47 | 55 | 63 | 68 | 72 |
| Alternative 2 | 37 | 46 | 51 | 57 | 61 | 65 |
| Alternative 3 | 36 | 45 | 50 | 55 | 62 | 68 |

Table 109—Average Incremental Vehicle Cost vs. No Action Case With ACC II, Proposed and Alternatives—Cars and Trucks Combined

[2020 Dollars]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 6-yr avg |
|---|---|---|---|---|---|---|---|
| Proposed | $172 | $56 | $11 | $57 | $268 | $423 | $164 |
| Alternative 1 | 454 | 639 | 1,130 | 1,050 | 1,212 | 1,186 | 945 |
| Alternative 2 | 106 | −$29 | −$184 | −$188 | 73 | 235 | 2 |
| Alternative 3 | 85 | −43 | −221 | −182 | 214 | 483 | 56 |

### 2. Battery Costs

We have included sensitivities for battery pack costs that are (a) 25 percent higher and (b) 15 percent lower (on a $/kWh basis) than the battery pack costs in the central case. The high and low sensitivities were selected so as to bound what EPA considered to be a reasonable envelope for future nominal battery pack cost per kWh, as informed by the full range of forecasts in the literature (see the discussion of battery cost forecasts we considered in Preamble Section IV.C.2 and DRIA Chapter 2.5.2.1.3).

#### i. Low Battery Costs

Table 110—Projected Targets With Low Battery Costs for No Action Case, Proposed and Alternatives—Cars and Trucks Combined

[CO$_2$ grams/mile]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| No Action | 162 | 162 | 164 | 164 | 164 | 163 |
| Proposed | 152 | 132 | 111 | 102 | 93 | 82 |
| Alternative 1 | 141 | 122 | 102 | 93 | 83 | 72 |
| Alternative 2 | 161 | 141 | 121 | 113 | 103 | 92 |
| Alternative 3 | 165 | 148 | 131 | 115 | 99 | 82 |

Table 111—Projected Achieved Levels With Low Battery Costs, for No Action Case, Proposed and Alternatives—Cars and Trucks Combined

[CO$_2$ grams/mile]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| No Action | 152 | 138 | 108 | 106 | 99 | 111 |
| Proposed | 154 | 130 | 110 | 100 | 83 | 80 |
| Alternative 1 | 154 | 125 | 102 | 83 | 70 | 65 |
| Alternative 2 | 157 | 136 | 119 | 96 | 98 | 90 |
| Alternative 3 | 161 | 141 | 124 | 109 | 95 | 80 |

Table 112—BEV Penetrations With Low Battery Costs, for No Action Case, Proposed and Alternatives—Cars and Trucks Combined

| | 2027 (%) | 2028 (%) | 2029 (%) | 2030 (%) | 2031 (%) | 2032 (%) |
|---|---|---|---|---|---|---|
| No Action | 34 | 39 | 51 | 52 | 55 | 51 |
| Proposed | 38 | 46 | 54 | 59 | 66 | 68 |
| Alternative 1 | 38 | 46 | 54 | 63 | 68 | 71 |
| Alternative 2 | 37 | 46 | 53 | 63 | 62 | 66 |
| Alternative 3 | 36 | 44 | 51 | 58 | 63 | 69 |

Table 113—Average Incremental Vehicle Cost vs. No Action Case for Low Battery Costs, Proposed and Alternatives—Cars and Trucks Combined

[2020 Dollars]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 6-yr avg |
|---|---|---|---|---|---|---|---|
| Proposed | $623 | $553 | $303 | $313 | $365 | $490 | $441 |
| Alternative 1 | 623 | 1,441 | 1,690 | 1,568 | 1,392 | 1,443 | 1,360 |
| Alternative 2 | 319 | 213 | −13 | 112 | 7 | 286 | 154 |
| Alternative 3 | 161 | 128 | −81 | −22 | 64 | 446 | 116 |

### ii. High Battery Costs

Table 114—Projected Targets With High Battery Costs for No Action Case, Proposed and Alternatives—Cars and Trucks Combined

[CO$_2$ grams/mile]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| No Action | 166 | 165 | 164 | 163 | 161 | 161 |
| Proposed | 153 | 132 | 112 | 102 | 93 | 82 |
| Alternative 1 | 143 | 122 | 102 | 92 | 83 | 72 |
| Alternative 2 | 163 | 142 | 122 | 112 | 103 | 92 |
| Alternative 3 | 167 | 150 | 133 | 116 | 99 | 82 |

### TABLE 115—PROJECTED ACHIEVED LEVELS WITH HIGH BATTERY COSTS, FOR NO ACTION CASE, PROPOSED AND ALTERNATIVES—CARS AND TRUCKS COMBINED

[$CO_2$ grams/mile]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| No Action | 162 | 153 | 152 | 155 | 160 | 159 |
| Proposed | 151 | 130 | 110 | 100 | 92 | 81 |
| Alternative 1 | 144 | 121 | 100 | 90 | 82 | 71 |
| Alternative 2 | 159 | 139 | 119 | 110 | 101 | 92 |
| Alternative 3 | 164 | 147 | 131 | 115 | 98 | 83 |

### TABLE 116—BEV PENETRATIONS WITH HIGH BATTERY COSTS, FOR NO ACTION CASE, PROPOSED AND ALTERNATIVES—CARS AND TRUCKS COMBINED

| | 2027 (%) | 2028 (%) | 2029 (%) | 2030 (%) | 2031 (%) | 2032 (%) |
|---|---|---|---|---|---|---|
| No Action | 21 | 26 | 28 | 29 | 29 | 29 |
| Proposed | 33 | 41 | 51 | 55 | 60 | 65 |
| Alternative 1 | 36 | 44 | 54 | 60 | 63 | 69 |
| Alternative 2 | 29 | 36 | 47 | 52 | 56 | 60 |
| Alternative 3 | 27 | 33 | 42 | 50 | 58 | 64 |

### TABLE 117—AVERAGE INCREMENTAL VEHICLE COST VS. NO ACTION CASE FOR HIGH BATTERY COSTS, PROPOSED AND ALTERNATIVES—CARS AND TRUCKS COMBINED

[2020 Dollars]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 6-yr avg |
|---|---|---|---|---|---|---|---|
| Proposed | $1,246 | $1,057 | $1,329 | $1,553 | $2,103 | $2,505 | $1,632 |
| Alternative 1 | 1,884 | 1,676 | 1,768 | 1,885 | 2,430 | 2,750 | 2,066 |
| Alternative 2 | 888 | 874 | 1,227 | 1,347 | 1,938 | 2,340 | 1,436 |
| Alternative 3 | 820 | 785 | 1,138 | 1,484 | 2,242 | 2,803 | 1,545 |

3. Consumer Acceptance

We have included sensitivities on the rate of BEV acceptance as well. Given the prevalence of automaker announcements in the media, we estimate results assuming a faster rate of BEV acceptance for all body styles. We also acknowledge that, though unlikely given available data and current trends, BEV acceptance may be slower than we estimate in our central case, possibly due to use cases such as towing or populations in remote locations. For information on what these BEV acceptance rates are, refer to DRIA Chapter 4.1.3. Results assuming a faster rate of BEV acceptance are provided in Table 118 through Table 121. Results assuming a slower rate of BEV acceptance are shown in Table 122 through Table 125.

i. Faster BEV Acceptance

### TABLE 118—PROJECTED TARGETS WITH FASTER BEV ACCEPTANCE FOR NO ACTION CASE, PROPOSED AND ALTERNATIVES—CARS AND TRUCKS COMBINED

[$CO_2$ grams/mile]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| No Action | 163 | 163 | 164 | 165 | 165 | 166 |
| Proposed | 151 | 132 | 112 | 103 | 93 | 83 |
| Alternative 1 | 141 | 122 | 102 | 93 | 83 | 72 |
| Alternative 2 | 161 | 141 | 121 | 113 | 103 | 93 |
| Alternative 3 | 165 | 148 | 132 | 116 | 99 | 82 |

### TABLE 119—PROJECTED ACHIEVED LEVELS WITH FASTER BEV ACCEPTANCE, FOR NO ACTION CASE, PROPOSED AND ALTERNATIVES—CARS AND TRUCKS COMBINED

[$CO_2$ grams/mile]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| No Action | 147 | 131 | 100 | 76 | 79 | 71 |
| Proposed | 157 | 129 | 107 | 86 | 73 | 59 |
| Alternative 1 | 156 | 128 | 104 | 80 | 66 | 53 |
| Alternative 2 | 157 | 136 | 116 | 100 | 80 | 71 |
| Alternative 3 | 159 | 140 | 118 | 96 | 90 | 76 |

TABLE 120—BEV PENETRATIONS WITH FASTER BEV ACCEPTANCE, FOR NO ACTION CASE, PROPOSED AND ALTERNATIVES—CARS AND TRUCKS COMBINED

| | 2027 (%) | 2028 (%) | 2029 (%) | 2030 (%) | 2031 (%) | 2032 (%) |
|---|---|---|---|---|---|---|
| No Action | 36 | 42 | 54 | 63 | 63 | 66 |
| Proposed | 38 | 46 | 55 | 63 | 69 | 75 |
| Alternative 1 | 38 | 46 | 55 | 63 | 69 | 76 |
| Alternative 2 | 38 | 46 | 54 | 61 | 69 | 73 |
| Alternative 3 | 38 | 46 | 54 | 63 | 66 | 71 |

TABLE 121—AVERAGE INCREMENTAL VEHICLE COST VS. NO ACTION CASE FOR FASTER BEV ACCEPTANCE, PROPOSED AND ALTERNATIVES—CARS AND TRUCKS COMBINED

[2020 Dollars]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 6-yr avg |
|---|---|---|---|---|---|---|---|
| Proposed | $287 | $982 | $809 | $602 | $746 | $712 | $690 |
| Alternative 1 | 317 | 1,001 | 1,209 | 1,533 | 1,675 | 1,445 | 1,196 |
| Alternative 2 | 212 | 214 | −34 | −194 | 179 | 163 | 90 |
| Alternative 3 | 54 | 33 | −176 | −235 | −66 | 53 | −56 |

### ii. Slower BEV Acceptance

TABLE 122—PROJECTED TARGETS WITH SLOWER BEV ACCEPTANCE FOR NO ACTION CASE, PROPOSED AND ALTERNATIVES—CARS AND TRUCKS COMBINED

[CO$_2$ grams/mile]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| No Action | 164 | 162 | 162 | 161 | 161 | 160 |
| Proposed | 153 | 133 | 112 | 103 | 93 | 82 |
| Alternative 1 | 143 | 122 | 102 | 92 | 83 | 72 |
| Alternative 2 | 163 | 142 | 122 | 112 | 103 | 92 |
| Alternative 3 | 167 | 149 | 132 | 115 | 99 | 82 |

TABLE 123—PROJECTED ACHIEVED LEVELS WITH SLOWER BEV ACCEPTANCE, FOR NO ACTION CASE, PROPOSED AND ALTERNATIVES—CARS AND TRUCKS COMBINED

[CO$_2$ grams/mile]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| No Action | 161 | 160 | 154 | 159 | 152 | 158 |
| Proposed | 150 | 131 | 110 | 101 | 92 | 82 |
| Alternative 1 | 144 | 118 | 99 | 90 | 81 | 74 |
| Alternative 2 | 160 | 140 | 119 | 111 | 101 | 90 |
| Alternative 3 | 164 | 148 | 128 | 113 | 97 | 80 |

TABLE 124—BEV PENETRATIONS WITH SLOWER BEV ACCEPTANCE, FOR NO ACTION CASE, PROPOSED AND ALTERNATIVES—CARS AND TRUCKS COMBINED

| | 2027 (%) | 2028 (%) | 2029 (%) | 2030 (%) | 2031 (%) | 2032 (%) |
|---|---|---|---|---|---|---|
| No Action | 22 | 23 | 28 | 27 | 33 | 31 |
| Proposed | 34 | 42 | 53 | 59 | 63 | 68 |
| Alternative 1 | 36 | 47 | 55 | 61 | 66 | 69 |
| Alternative 2 | 29 | 39 | 50 | 55 | 59 | 64 |
| Alternative 3 | 28 | 35 | 45 | 53 | 61 | 68 |

TABLE 125—AVERAGE INCREMENTAL VEHICLE COST VS. NO ACTION CASE FOR SLOWER BEV ACCEPTANCE, PROPOSED AND ALTERNATIVES—CARS AND TRUCKS COMBINED

[2020 Dollars]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 6-yr avg |
|---|---|---|---|---|---|---|---|
| Proposed | $877 | $1,135 | $755 | $898 | $995 | $1,498 | $1,026 |

TABLE 125—AVERAGE INCREMENTAL VEHICLE COST VS. NO ACTION CASE FOR SLOWER BEV ACCEPTANCE, PROPOSED AND ALTERNATIVES—CARS AND TRUCKS COMBINED—Continued

[2020 Dollars]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 6-yr avg |
|---|---|---|---|---|---|---|---|
| Alternative 1 | 1,336 | 1,470 | 1,143 | 1,244 | 1,393 | 1,731 | 1,386 |
| Alternative 2 | 695 | 853 | 560 | 689 | 888 | 1,344 | 838 |
| Alternative 3 | 508 | 734 | 473 | 702 | 1,005 | 1,621 | 841 |

### 4. Impact of Sensitivities on Proposed LD GHG Standards

The following is a summary of the sensitivities conducted and a comparison on resulting BEV penetrations and incremental technology costs for the proposed standards compared to the respective No Action case.

As can be seen, the projected targets for the proposed standards are not affected by the range of sensitivities discussed in this section. It is important to note that manufacturers are able to meet the targets for the proposed standards in every year for the range of sensitivities analyzed here. However, the achieved levels do vary in each sensitivity: in some cases, there is greater level of overcompliance (most notably in the High BEV acceptance case).

Table 126 and Table 127 give a comparison for the projected targets and achieved levels for the proposed standards, based on the various identified sensitivities. While BEV penetrations projected to meet the proposed standards (shown in Table 128) do not vary much across the sensitivity cases, BEV penetrations in the No Action case do vary significantly: projected MY 2032 BEV penetrations range from 31 percent to 61 percent based on different input assumptions which affect either required BEV share (in the case of the State-level Policies scenario) or consumer demand for electric vehicles. The range of BEV penetrations in the No Action case is provided in Table 129.

Of the metrics considered, the range of sensitivities have the greatest impact on incremental vehicle cost compared to the No Action case. Compared to a 6-year average incremental costs of about $1100 for the Central Case, these sensitivities result in a range of 6-year average incremental costs from $200 per vehicle to about $1600. The two sensitivity cases which result in less BEV penetrations in the No Action case—High Battery Costs and the Slower BEV Acceptance cases—result in the highest incremental costs, while the lower incremental costs are for the three sensitivity cases that result in more BEVs in the No Action case: The Low Battery Costs, Faster BEV Acceptance, and the State-Level Policies scenario.

TABLE 126—RANGE OF TARGETS FOR PROPOSED STANDARDS—CARS AND TRUCKS COMBINED

[$CO_2$ grams/mile]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| Central Case | 152 | 131 | 111 | 102 | 93 | 82 |
| State-level Policies | 151 | 131 | 111 | 102 | 93 | 82 |
| Low Battery Costs | 152 | 132 | 111 | 102 | 93 | 82 |
| High Battery Costs | 153 | 132 | 112 | 102 | 93 | 82 |
| Faster BEV Acceptance | 151 | 132 | 112 | 103 | 93 | 83 |
| Slower BEV Acceptance | 153 | 133 | 112 | 103 | 93 | 82 |

TABLE 127—RANGE OF ACHIEVED LEVELS FOR PROPOSED STANDARDS—CARS AND TRUCKS COMBINED

[$CO_2$ grams/mile]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| Central Case | 151 | 129 | 107 | 97 | 91 | 81 |
| State-level Policies | 149 | 129 | 107 | 96 | 90 | 81 |
| Low Battery Costs | 154 | 130 | 110 | 100 | 83 | 80 |
| High Battery Costs | 151 | 130 | 110 | 100 | 92 | 81 |
| Faster BEV Acceptance | 157 | 129 | 107 | 86 | 73 | 59 |
| Slower BEV Acceptance | 150 | 131 | 110 | 101 | 92 | 82 |

TABLE 128—RANGE OF BEV PENETRATIONS FOR PROPOSED STANDARDS—CARS AND TRUCKS COMBINED

| | 2027 (%) | 2028 (%) | 2029 (%) | 2030 (%) | 2031 (%) | 2032 (%) |
|---|---|---|---|---|---|---|
| Central Case | 36 | 45 | 55 | 60 | 63 | 67 |
| State-level Policies | 38 | 46 | 54 | 59 | 66 | 68 |
| Low Battery Costs | 38 | 46 | 54 | 59 | 66 | 68 |
| High Battery Costs | 33 | 41 | 51 | 55 | 60 | 65 |
| Faster BEV Acceptance | 38 | 46 | 55 | 63 | 69 | 75 |
| Slower BEV Acceptance | 34 | 42 | 53 | 59 | 63 | 68 |

TABLE 129—RANGE OF BEV PENETRATIONS FOR NO ACTION CASE—CARS AND TRUCKS COMBINED

| | 2027 (%) | 2028 (%) | 2029 (%) | 2030 (%) | 2031 (%) | 2032 (%) |
|---|---|---|---|---|---|---|
| Central Case | 27 | 32 | 37 | 40 | 40 | 39 |
| State-level Policies | 32 | 42 | 49 | 52 | 52 | 54 |
| Low Battery Costs | 34 | 39 | 51 | 52 | 55 | 51 |
| High Battery Costs | 21 | 26 | 28 | 29 | 29 | 29 |
| Faster BEV Acceptance | 36 | 42 | 54 | 63 | 63 | 66 |
| Slower BEV Acceptance | 22 | 23 | 28 | 27 | 33 | 31 |

TABLE 130—RANGE OF INCREMENTAL VEHICLE COST VS. NO ACTION CASE FOR PROPOSED STANDARDS—CARS AND TRUCKS COMBINED

[2020 Dollars]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 6-yr avg |
|---|---|---|---|---|---|---|---|
| Central Case | $633 | $497 | $401 | $526 | $866 | $1,164 | $681 |
| State-level Policies | 172 | 56 | 11 | 57 | 268 | 423 | 164 |
| Low Battery Costs | 623 | 553 | 303 | 313 | 365 | 490 | 441 |
| High Battery Costs | 1,246 | 1,057 | 1,329 | 1,553 | 2,103 | 2,505 | 1,632 |
| Faster BEV Acceptance | 287 | 982 | 809 | 602 | 746 | 712 | 690 |
| Slower BEV Acceptance | 877 | 1,135 | 755 | 898 | 995 | 1,498 | 1,026 |

### *F. Sensitivities—MD GHG Compliance Modeling*

#### 1. Battery Costs (Low and High)

For medium duty vehicles, we have carried over the high and low battery pack cost sensitivities, similar to those conducted for the light-duty GHG analysis (for more information refer to Section IV.E.2). The low and high battery pack cost sensitivities have been combined into the summary tables in this section.

Table 131 and Table 132 gives a comparison for the targets and the projected achieved levels for the proposed standards, based on battery costs assumed for the central case and the low and high cost sensitivity cases.

The range of BEV penetrations for the proposed MD standards are provided in Table 133.

Battery costs have the greatest impact on incremental vehicle cost compared to the No Action case. Compared to a 6-year average incremental costs of about $700 for the Central Case, these sensitivities result in a range of incremental costs from $300 per vehicle to about $1500. Incremental vehicle costs for the proposed standards for the three sensitivities are provided in Table 134.

TABLE 131—PROJECTED TARGETS FOR PROPOSED STANDARDS: CENTRAL CASE, LOW AND HIGH BATTERY SENSITIVITIES—MEDIUM DUTY VEHICLES

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| Central Case | 438 | 427 | 389 | 352 | 312 | 275 |
| Low Battery Costs | 437 | 423 | 386 | 349 | 312 | 275 |
| High Battery Costs | 439 | 428 | 390 | 355 | 316 | 276 |

TABLE 132—PROJECTED ACHIEVED LEVELS FOR PROPOSED STANDARDS: CENTRAL CASE, LOW AND HIGH BATTERY SENSITIVITIES—MEDIUM DUTY VEHICLES

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|
| Central Case | 437 | 426 | 390 | 347 | 310 | 272 |
| Low Battery Costs | 436 | 423 | 385 | 350 | 307 | 273 |
| High Battery Costs | 439 | 428 | 389 | 352 | 313 | 273 |

TABLE 133—BEV PENETRATIONS FOR PROPOSED STANDARDS: CENTRAL CASE, LOW AND HIGH BATTERY SENSITIVITIES—MEDIUM DUTY VEHICLES

| | 2027 (%) | 2028 (%) | 2029 (%) | 2030 (%) | 2031 (%) | 2032 (%) |
|---|---|---|---|---|---|---|
| Central Case | 17 | 20 | 28 | 34 | 43 | 46 |
| Low Battery Costs | 17 | 18 | 26 | 33 | 38 | 44 |
| High Battery Costs | 14 | 17 | 25 | 27 | 36 | 43 |

TABLE 134—AVERAGE INCREMENTAL VEHICLE COST VS. NO ACTION CASE FOR PROPOSED STANDARDS: CENTRAL CASE, LOW AND HIGH BATTERY SENSITIVITIES—MEDIUM DUTY VEHICLES

[2020 dollars]

| | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 6-yr avg |
|---|---|---|---|---|---|---|---|
| Central Case | $364 | $249 | $290 | $654 | $944 | $1,784 | $714 |
| Low Battery Costs | 118 | 4 | −142 | 5 | 564 | 1,094 | 274 |
| High Battery Costs | 810 | 640 | 919 | 1,648 | 2,191 | 3,072 | 1,547 |

## V. EPA's Basis That the Proposed Standards Are Feasible and Appropriate Under the Clean Air Act

### *A. Overview*

As discussed in Section II of this preamble, there is a critical need for further criteria pollutant and GHG reductions to address the adverse impacts of air pollution from light and medium duty vehicles on public health and welfare. With continued advances in internal combustion emissions controls and vehicle electrification technologies coming into the mainstream as primary vehicle emissions controls, EPA believes substantial further emissions reductions are feasible and appropriate under the Clean Air Act.

The Clean Air Act authorizes EPA to establish emissions standards for motor vehicles to regulate emissions of air pollutants that contribute to air pollution which, in the Administrator's judgment, may reasonably be anticipated to endanger public health or welfare. As discussed in Section II, emissions from motor vehicles contribute to ambient levels of pollutants for which EPA has established health-based NAAQS. These pollutants are linked with respiratory and/or cardiovascular problems and other adverse health impacts leading to increased medication use, hospital admissions, emergency department visits, and premature mortality.

In addition, light and medium-duty vehicles are significant contributors to the U.S. GHG emissions inventories, and additional reductions in GHGs from vehicles are needed to avoid the worst consequences of climate change as discussed in Section II.

This proposed rule also considers the large potential impact that the Inflation Reduction Act (IRA) will have on facilitating production and adoption of PEV technology, which is highly effective technology for controlling tailpipe emissions of criteria pollutants and GHGs. Prior to the passage of the IRA, EPA received input from auto manufacturers that increasing the market share of PEVs is now technologically feasible but that it is important to address consumer issues such as charging infrastructure and the cost to purchase a PEV, as well as manufacturing issues such as battery supply and manufacturing costs. The IRA provides powerful incentives in all of these areas that will help facilitate increased market penetration of PEV technology in the time frame considered in this rulemaking. Thus, it is an important element of EPA's cost and feasibility assessment, and EPA has considered the impacts of the IRA in our assessment of the appropriate proposed standards.[738]

### *B. Consideration of Technological Feasibility, Compliance Costs and Lead Time*

The technological readiness of the auto industry to meet the proposed standards for model years 2027–2032 is best understood in the context of over a decade of light-duty vehicle emissions reduction programs in which the auto industry has introduced emissions-reducing technologies in a wide lineup of ever more cost effective, efficient, and high-volume vehicle applications . Among the range of technologies that have been demonstrated over the past decade, electrification technologies have seen particularly rapid development and lower costs, and as a result the number of PEVs projected across all the policy alternatives considered here is much higher than in any of EPA's prior rulemaking analyses. In particular, BEVs have zero tailpipe emissions and so are capable of supporting rates of annual stringency increases that are much greater than were typical in earlier rulemakings.

In this rulemaking, unlike some prior vehicle emissions standards, the technology necessary to achieve significantly more stringent standards has already been developed and demonstrated in production vehicles. PEVs are now being produced in large numbers in every segment and size of the current light-duty fleet, ranging from small cars such as GM's Bolt EV to light trucks such as Ford's F150 Lightning, and their production for the U.S. market is roughly doubling every year.[739] Large fleet owners have also begun fulfilling fleet electrification commitments by taking delivery of rapidly growing numbers of BEV medium-duty delivery vans.[740] In setting standards, EPA considers the extent of further deployment that is warranted in light of the benefits to public health and welfare, and potential constraints, such as costs, raw material availability, component supplies, redesign cycles, infrastructure, and consumer acceptance. The extent of these potential constraints has diminished significantly, even since the 2021 rule, in light of increased investment by automakers, increased acceptance by consumers, and significant support from Congress to address such areas as upfront purchase price, charging infrastructure, critical mineral supplies, and domestic supply chain manufacturing.

At the same time, in response to the increased stringency of the proposed standards, automakers would be expected to adopt advanced technologies at an increasing pace across more of their vehicle fleets. EPA has carefully considered potential constraints on further deployment of these advanced technologies. For example, in addition to considering the breadth of current product offerings, EPA has also considered vehicle redesign cycles. Based on previous public comments and industry trends, manufacturers generally require about five years to design, develop, and produce a new vehicle model.[741] EPA's technical assessment for this proposal

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[738] It is important to note that, although E.O. 14037 identified a goal for 50 percent of U.S. new vehicle sales to be zero-emission vehicles by 2030, the E.O. only directed EPA to consider beginning work on a new rulemaking and to do so consistent with applicable law. EPA exercised its technical judgment based on the record before it in developing this proposal consistent with the authority of section 202 of the Clean Air Act.

[739] Estimated at 8.4 percent of production in MY 2022, up from 4.4 percent in MY 2021 and 2.2 percent in MY 2020. See also the discussion of U.S. PEV penetration in I.A.2.ii.

[740] See the discussion of fleet electrification commitments in I.A.2.ii.

[741] For example, in its comments on the 2012 rule, Ford stated that manufacturers typically begin to firm up their product plans roughly five years in advance of actual production. (Docket OAR–2009–0472–7082.1, p. 10.)

accounts for these redesign limits.[742] Within the modeling that EPA conducted to support this proposal, we have assumed limits to the rate at which a manufacturer can choose to ramp in the transition from an ICE vehicle to a BEV. We have also applied limits to the ramp up of battery production, considering the time needed to increase the availability of raw materials and construct or expand battery production facilities. Constraints for redesign and battery production in our compliance modeling are described in more detail in Chapter 2.6 of the DRIA. Our modeling also incorporates constraints related to consumer acceptance. Under our central case analysis assumptions, the model anticipates that consumers will in the near term tend to favor ICE vehicles over PEVs when two vehicles are comparable in cost and capability.[743] Taking into account individual consumer preferences, we anticipate that PEV acceptance and adoption will continue to accelerate as consumer familiarity with PEVs grows, as demonstrated in the scientific literature on PEV acceptance and consistent with typical diffusion of innovation. Adoption of PEVs is expected to be further supported by expansion of key enablers of PEV acceptance, namely increasing market presence of PEV, more model choices, expanding infrastructure, and decreasing costs to consumers.[744] See also Preamble Section IV.C.5 and DRIA Chapter 4. Overall, given the number and breadth of current low- or zero-emission vehicles and the assumptions we have made to limit the rate at which new vehicle technologies are adopted, our assessment shows that there is sufficient lead time for the industry to more broadly deploy existing technologies and successfully comply with the proposed standards.

Our analysis projects that for the industry overall, 65 percent of new vehicles in MY 2032 would be BEVs. EPA believes that this is an achievable level based on our technical assessment for this proposal that includes consideration of the feasibility and lead time required for BEVs and acceptance of BEVs in the market. Our assessment of the appropriateness of the level of BEVs in our analysis is also informed by public announcements by manufacturers about their plans to transition fleets to electrified vehicles, as described in Section I.A.2 of this Preamble and further developed in DRIA 3.1.3.1. More detail about our technical assessment, and the assumptions for the production feasibility and consumer acceptance of BEVs is provided in Section IV of this Preamble, and Chapters 2, 3, 4, and 6 of the DRIA.

At the same time, we note that the proposed standards are performance-based and do not mandate any specific technology for any manufacturer or any vehicle. Moreover, the overall industry does not necessarily need to reach this level of BEVs in order to comply—the projection in our analysis is one of many possible compliance pathways that manufacturers could choose to take under the performance-based standards. For example, manufacturers that choose to increase their sales of HEV and PHEV technologies or apply more advanced technology to non-hybrid ICE vehicles would require a smaller number of BEVs than we have projected in our assessment to comply with the proposed standards.

In considering feasibility of the proposed standards, EPA also considers the impact of available compliance flexibilities on automakers' compliance options.[745] The advanced technologies that automakers are continuing to incorporate in vehicle models today directly contribute to each company's compliance plan (*i.e.,* these vehicle models have lower criteria pollutant and GHG emissions), and manufacturers can choose to comply with the proposed standards outright through their choice of emissions reducing technologies. In addition, automakers typically have widely utilized the program's established averaging, banking, and trading (ABT) provisions which provide a variety of flexible paths to plan compliance. We have discussed this dynamic at length in past rules, and we anticipate that this same dynamic will support compliance with this rulemaking. Although the ABT program for GHG and criteria pollutants have some differences (as discussed in detail in Sections III.B.4 and III.C.9), they fundamentally operate in a similar fashion. The credit program was designed to recognize that automakers typically have compliance opportunities and strategies that differ across their fleet, as well a multi-year redesign cycle, so not every vehicle will be redesigned every year to add emissions-reducing technology. Moreover, when technology is added, it will generally not achieve emissions reductions corresponding exactly to a single year-over-year change in stringency of the standards. Instead, in any given model year, some vehicles will be ''credit generators,'' over-performing compared to their criteria pollutant standards or footprint-based $CO_2$ emissions targets in that model year, while other vehicles will be ''debit generators'' and under-performing against their standards or targets. As the proposed standards reach increasingly lower numerical emissions levels, some vehicle designs that had generated credits in earlier model years may instead generate debits in later model years. In MY 2032 when the proposed standards reach the lowest level, it is possible that only BEVs and PHEVs are generating positive credits, and all ICE vehicles generate varying levels of deficits. Even in this case, the application of ICE technologies can remain an important part of a manufacturer's compliance strategy by reducing the amount of debits generated by these vehicles. A greater application of ICE technologies (*e.g.,* strong hybrids) can enable compliance with fewer BEVs than if less ICE technology was adopted, and therefore enable the tailoring of a compliance strategy to the manufacturer's specific market and product offerings. Together, an automaker's mix of credit-generating and debit-generating vehicles determine its compliance with both criteria pollutant and GHG standards for that year.

Moreover, the trading provisions of the program allow manufacturers to design a compliance strategy relying not only on overcompliance and undercompliance by different vehicles or in different years, but even by different manufacturers. Credit trading is a compliance flexibility provision that allows one vehicle manufacturer to purchase credits from another, accommodating the ability of manufacturers to make strategic choices in planning for and reacting to normal fluctuations in an automotive business cycle. When credits are available for less

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[742] In our compliance modeling, we have limited vehicle redesign opportunities through MY 2029 in our compliance modeling to every 7 years for light- and medium-duty pickup trucks and medium-duty vans, and 5 years for all other vehicles. We are assuming that manufacturers have sufficient lead team to adjust product redesign years after MY 2029, so we do not continue to apply redesign constraints for MYs 2030 and beyond.

[743] EPA's compliance modeling estimates the consumer demand for BEV and ICE vehicles using a consumer ''generalized cost'' that includes elements of the purchase cost (including any purchase incentives), vehicle maintenance and repair costs, and fuel operating costs as described in DRIA Chapter 4.1.

[744] Jackman, D K, K S Fujita, H C Yang, and M Taylor. 2023. Literature Review of U.S. Consumer Acceptance of New Personally Owned Light Duty Plug-in Electric Vehicles. Washington, DC: U.S. Environmental Protection Agency.

[745] While EPA is considering these compliance flexibilities in assessing the feasibility of the proposed standards, EPA is not reopening such flexibilities, except to the extent that we are proposing or soliciting comment on a specific flexibility as in Section III of this preamble. Specifically, EPA is not reopening ABT.

than the marginal cost of compliance, EPA would anticipate that an automaker might choose to adopt a compliance strategy relying on purchasing credits.

The proposed performance-based standards with ABT provisions give manufacturers a degree of flexibility in the design of specific vehicles and their fleet offerings, while allowing industry overall to meet the standards and thus achieve the health and environmental benefits projected for this rulemaking at a lower cost. EPA has considered ABT in the feasibility assessments for many previous rulemakings since EPA first began incorporating ABT credits provisions in mobile source rulemakings in the 1980s (see Section III.B.4 for further information on the history of ABT) and continues that practice here. First, by fully averaging across vehicles in the car and truck regulatory classes and by allowing for credit banking across years, manufacturers have the flexibility to adopt emissions-reducing technologies in the manner that best suits their particular market and business circumstances. Similarly, with the opportunity to trade credits with other firms, each manufacturer can, in effect, average credits among a pool of vehicles that extends beyond their own fleet. EPA's annual Automotive Trends Report illustrates how different automakers have chosen to make use of the GHG program's various credit features.[746] It is clear that manufacturers are widely utilizing the various credit programs available, and we have every expectation that manufacturers will continue to take advantage of the compliance flexibilities and crediting programs to their fullest extent, thereby providing them with additional tools in finding the lowest cost compliance solutions in light of the proposed revised standards.

While the potential value of credit trading as a means of reducing costs to automakers was always clear, there is increasing evidence that automakers have successfully adopted credit trading as an important compliance strategy that reduces costs. The market for trading credits is now well established. As shown in the most recent EPA Trends Report, 19 vehicle firms collectively have participated in nearly 100 credit trading transactions totaling 169 Tg of credits since the inception of the EPA program through Model Year 2021. These firms include many of the largest automotive firms.[747] Several of these manufacturers have publicly acknowledged the importance of considering credit purchase or sales as part of their business plans to improve their competitive position.[748] [749] For firms with new vehicle production made up entirely or primarily of credit-generating vehicles, the revenue generated from credit sales can help to fund the development of GHG-reducing technologies and offset production costs. Other firms have the option of purchasing credits if they choose to make a fleet that is overall deficit-generating. This can be a cost-effective compliance strategy, especially for companies that make lower-volume vehicles where the incremental development costs for GHG-reducing technologies would be higher on a per-vehicle basis than for another company. The opportunity to purchase credits can also enable a company to continue specializing in vehicle applications where the application of advanced GHG-reducing technologies may be more costly than purchasing credits. For example, manufacturers of light- and medium-duty pickups might choose to purchase credits rather than apply BEV technology to some of those vehicles used frequently for long distance towing applications, at least in the shorter term when higher capacity batteries might be used to accommodate the existing charging infrastructure.

In light of the evidence of increased adoption of trading as a compliance strategy, EPA has included the ability of manufacturers to trade credits as part of our central case compliance modeling for this proposal, rather than as a sensitivity analysis as we did in the modeling for the 2021 rule. We anticipate that the economic efficiencies of credit trading will generally be attractive to automakers, and thus we consider it appropriate to take trading into account in estimating the costs of the standards. However, trading is an optional compliance flexibility, and we recognize that automakers may choose to use it in their compliance strategies to varying degrees. If a manufacturer chooses not to participate in credit trading for whatever reason, additional compliance strategies can be used to supplement the adoption of emissions-reducing technologies. For example, such manufacturers also could elect to shift market segments and sales volumes as a strategy for increasing the proportion of credit-generating vehicles relative to debit-generating vehicles. Thus, reduced use of credit trading may result in somewhat higher costs for the program, but we do not believe it would alter our conclusion that the standards are feasible.

As part of its assessment of technological feasibility and lead time, EPA has considered the cost for the auto industry to comply with the proposed revised standards. See Section VI.B and Chapter 10 of the DRIA for our analysis of compliance costs.

The estimated average costs to manufacturers to meet the proposed standards are approximately $1,200 (2020 dollars) per vehicle in MY 2032, which is within the range of costs projected in prior rules, which EPA estimated at about $1,800 (2010 dollars) and $1,000 (2018 dollars) per vehicle for the 2012 and 2021 rules respectively. Across the range of sensitivities, the projected costs are approximately $200 to $1,600 per vehicle in MY 2032, which is a range EPA believes is reasonable and within the range of cost estimates in prior rules. The estimated MY 2032 costs of $1,200 represent under 3 percent of the average cost of a new vehicle today (about $46,000 in 2022).[750]

As also discussed in Section I.A.2.ii of this Preamble, EPA has observed a shift toward electrification both in vehicle sales and across the automotive industry at large, and that these changes are being driven to a large degree by the technological innovation of the automotive industry and the significant funds, estimated at $1.2 trillion by at

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[746] "The 2022 EPA Automotive Trends Report, Greenhouse Gas Emissions, Fuel Economy, and Technology since 1975," EPA–420–R–22–029 December 2022.

[747] EPA 2020 Trends Report, page 110 and Figure 5.15.

[748] "FCA historically pursued compliance with fuel economy and greenhouse gas regulations in the markets where it operated through the most cost effective combination of developing, manufacturing and selling vehicles with better fuel economy and lower GHG emissions, purchasing compliance credits, and, as allowed by the U.S. federal Corporate Average Fuel Economy ("CAFE") program, paying regulatory penalties." Stellantis N.V. (2020). "Annual Report and Form 20–F for the year ended December 31, 2020."

[749] "We have several options to comply with existing and potential new global regulations. Such options include increasing production and sale of certain vehicles, such as EVs, and curtailing production of less fuel efficient ICE vehicles; technology changes, including fuel consumption efficiency and engine upgrades; payment of penalties; and/or purchase of credits from third parties. We regularly evaluate our current and future product plans and strategies for compliance with fuel economy and GHG regulations" General Motors Company (2022). "Annual Report and Form 10–K for the fiscal year ended December 31, 2021."

[750] Note that these values are averages across all body styles, powertrains, makes, models, and trims, and there will be differences for each individual vehicle. Also note that, as discussed in DRIA Chapter 4.2, the price of a new vehicle has been increasing over time due to factors not associated with our rules. If the average price of a MY 2032 vehicle is higher than that of a MY 2022 vehicle, this estimated increase in cost could well be smaller than 3 percent compared to the cost of a new MY 2032 vehicle.

least one analysis,[751] [752] those firms intend to spend by 2030 on developing and deploying electrification technologies. EPA believes its standards will support this very significant investment and, particularly in light of the available compliance flexibilities and multiple paths for compliance, are feasible and will not cause economic disruption in the automotive industry. We do not believe the estimated increase in marginal vehicle cost will lead to detrimental effects to automakers for multiple reasons, including the fact that macroeconomic effects are a much larger factor in OEM revenues (for example, the chip shortage), and that automakers regularly adjust product plans and choose the mix of vehicles they produce to maximize profits. We also note that through the third quarter of 2022, domestic automakers reported their highest profits since 2016, even though domestic vehicle sales fell from the previous year. In addition, the significant investments by industry and Congress (*e.g.,* BIL and IRA) in supporting technology which eliminates both criteria and GHG tailpipe emissions, presents an opportunity for a significant step forward in achieving the goals of the Clean Air Act. The compliance costs per vehicle in this proposal are reasonable and consistent with those in past GHG rules while the standards would achieve substantially greater emissions reductions of GHGs and substantial emissions reductions for criteria pollutants as well.

For this proposal, EPA finds that the expected compliance costs for automakers are reasonable in light of the emissions reductions in air pollutants and the resulting benefits for public health and welfare.

### *C. Consideration of Emissions of GHGs and Criteria Air Pollutants*

An essential factor that EPA considered in determining the appropriate level of the proposed standards is the reductions in air pollutant emissions that would result from the program, including emissions of GHGs, criteria pollutants and air toxics and associated public health and welfare impacts.

The cumulative GHG emissions reductions through 2055 are projected to be 7,400 MMT of $CO_2$, 0.12 MMT of $CH_4$ and 0.13 MMT of $N_2O$, as the fleet turns over year-by-year to new vehicles that meet the proposed light- and medium-duty standards. This represents a 26 percent reduction in $CO_2$ over that time period relative to the no-action case. See Section VI and Chapter 9 of the DRIA. We also project, in calendar year 2055, 35 percent to 40 percent reductions in $PM_{2.5}$, $NO_X$, and $SO_X$ emissions. Further, we project over 40 percent reduction in VOC emissions in the year 2055. See Section VII and Chapter 9 of the DRIA. EPA finds that the additional emissions reductions that would be achieved under these proposed standards are important in reducing the public health and welfare impacts of air pollution.

As discussed in Section VIII, we monetize benefits of the proposed standards and evaluate other costs in part to enable a comparison of costs and benefits pursuant to E.O. 12866, but we recognize there are benefits that we are currently unable to fully quantify. EPA's practice has been to set standards to achieve improved air quality consistent with CAA section 202, and not to rely on cost-benefit calculations, with their uncertainties and limitations, as identifying the appropriate standards. Nonetheless, our conclusion that the estimated benefits considerably exceed the estimated costs of the proposed program reinforces our view that the proposed standards are appropriate under section 202(a).

The present value of climate benefits attributable to the proposed standards are estimated at $83 billion to $1.0 trillion across a range of discount rates and values for the social cost of carbon (present values in 2027 for GHG reductions through 2055). See Section VIII and Chapter 10 of the DRIA for a full discussion of the SC–GHG estimates used to monetize climate benefits and the data and modeling limitations that naturally restrain the ability of SC–GHG estimates to include all the important physical, ecological, and economic impacts of climate change, such that the estimates are a partial accounting of climate change impacts and will therefore, tend to be underestimates of the marginal benefits of abatement. The present value of $PM_{2.5}$-related health benefits attributable to the proposed standards through 2055 are estimated to total $64 billion to $290 billion (assuming a 7 percent and 3 percent discount rate, respectively, as well as different long-term PM-related mortality risk studies; see Section VIII.E).[753]

### *D. Consideration of Impacts on Consumers, Energy, Safety and Other Factors*

EPA also considered the impact of the proposed light- and medium-duty standards on consumers as well as on energy and safety. EPA concludes that the proposed standards would be beneficial for consumers because the lower operating costs would offset increases in vehicle technology costs, irrespective of BEV purchase incentives in the IRA. Vehicle technology cost increases for light-and medium-duty vehicles through 2055 are estimated at $260 billion to $380 billion (7 and 3 percent discount rates.) Total fuel savings, net of reduced liquid fuel and increased electricity, for consumers through 2055 are estimated at $560 billion to $1.1 trillion (7 percent and 3 percent discount rates.) Reduced maintenance and repair costs through 2055 are estimated at $280 billion to $580 billion (7 percent and 3 percent discount rates) (See Sections VIII.B and VIII.F and Chapter 10 of the DRIA). Thus, the proposal would result in significant savings for consumers.

EPA also carefully considered the consumer impacts of these proposed standards. We recognize that increases in upfront purchase costs are likely to be of particular concern to low-income households, but we anticipate that automakers will continue to offer a variety of models at different price points (see Chapter 4 of the DRIA). Moreover, because lower-income households spend more of their income on fuel than other households, the effects of reduced fuel costs may be especially important for these households. Similarly, low-income households are more likely to buy used vehicles and own older vehicles, and thus would benefit from significant savings in repair and maintenance costs if they purchase electric vehicles. Furthermore, for used BEVs, there is evidence that the original purchase incentive is passed on to the next buyer (*i.e.,* reduces the used price of BEVs). In addition, BEV purchase incentives for used vehicles are provided for the first time ever through the IRA.

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[751] Reuters, ''A Reuters analysis of 37 global automakers found that they plan to invest nearly $1.2 trillion in electric vehicles and batteries through 2030,'' October 21, 2022. Accessed on November 4, 2022 at *https://graphics.reuters.com/AUTOS-INVESTMENT/ELECTRIC/akpeqgzqypr/.*

[752] Reuters, ''Exclusive: Automakers to double spending on EVs, batteries to $1.2 trillion by 2030,'' October 25, 2022. Accessed on November 4, 2022 at *https://www.reuters.com/technology/exclusive-automakers-double-spending-evs-batteries-12-trillion-by-2030-2022-10-21/.*

[753] The criteria pollutant benefits associated with the standards presented here do not include the full complement of health and environmental benefits that, if quantified and monetized, would increase the total monetized benefits (such as the benefits associated with reductions in human exposure to ambient concentrations of ozone). See Section VIII.E and DRIA Chapter 7 for more information about benefits we are not currently able to fully quantify.

EPA also evaluated the impacts of the proposed light- and medium-duty standards on energy, in terms of fuel consumption and energy security. This proposal is projected to reduce U.S. gasoline consumption by 950 billion gallons through 2055 (see DRIA Chapter 9). EPA considered the impacts of this projected reduction in fuel consumption on energy security, specifically the avoided costs of macroeconomic disruption (See Section VIII.G). A reduction of U.S. net petroleum imports reduces both financial and strategic risks caused by potential sudden disruptions in the supply of petroleum to the U.S., thus increasing U.S. energy security. We estimate the energy security benefits of the proposal through 2055 at $21 billion to $42 billion (7 percent and 3 percent discount rate, see Chapter 10 of the DRIA). EPA considers this proposal to be beneficial from an energy security perspective.

Section 202(a)(4)(A) of the CAA specifically prohibits the use of an emission control device, system or element of design that will cause or contribute to an unreasonable risk to public health, welfare, or safety. EPA has a long history of considering the safety implications of its emission standards,[754] up to and including the more recent light-duty GHG regulations: The 2010 rule which established the MY 2012–2016 light-duty vehicle GHG standards, the 2012 rule which first established MY 2017–2025 light-duty vehicle GHG standards, and the 2020 and 2021 rules. The relationship between GHG emissions standards and safety is multi-faceted, and can be influenced not only by control technologies, but also by consumer decisions about vehicle ownership and use. EPA has estimated the impacts of this proposal on safety by accounting for changes in new vehicle purchase, fleet turnover and VMT, changes in vehicle footprint, and vehicle weight changes that are in some cases lower (as an emissions control strategy) and in other cases higher (with the additional weight often associated with electrified vehicles). EPA finds that under this proposal, there is no statistically significant change in the estimated risk of fatalities per distance traveled. EPA is presenting non-statistically significant values here in part to enable comparison with prior rules. We have found virtually no change in fatality risk as a result of the proposed standards, with an estimated increase of 0.2 percent per distance traveled (see Section VIII.F). However, as the costs of driving decline due to the improvement in fuel economy, consumers overall will choose to drive more miles (this is the ''VMT rebound'' effect). As a result of this personal decision by consumers to drive more due to the reduced cost of driving, EPA projects this will result in an increase in accidents, injuries, and fatalities (*i.e.,* although the rate of injury per mile stays virtually unchanged, an increase in miles driven results in an increase in total number of injuries). EPA's goal in setting motor vehicle standards is to protect public health and welfare while recognizing the importance of the mobility choices of Americans. Because the only statistically significant projected increase in accidents, injuries, and fatalities would be the result of consumers' voluntary choices to drive more when operating costs are reduced, EPA believes it Is appropriate to place emphasis on the level of risk of injury per mile traveled, and to consider the projected change in injuries in that context.

The increase in fatalities per distance traveled is not statistically significant, and the only statistically significant increase in fatalities is due to consumers' voluntary choices to drive more. As with the 2021 rule, EPA considers safety impacts in the context of all projected health impacts from the rule including public health benefits from the projected reductions in air pollution. In considering these estimates in the context of anticipated public health benefits, EPA notes that the estimated present value of monetized benefits of reduced $PM_{2.5}$ through 2055 is between $63 billion and $280 billion (depending on study and discount rate), and that the illustrative air quality modeling which, as discussed further in Chapter 8 of the DRIA assesses a regulatory scenario with lower rates of PEV penetration than EPA is projecting in this proposal, estimates that in 2055 such a scenario would prevent between 730 and 1,400 premature deaths associated with exposure to $PM_{2.5}$ and prevent between 15 and 330 premature deaths associated with exposure to ozone. We expect that the cumulative number of premature deaths avoided that would occur during the entire period of 2027–2055 as a result of the proposed rule would be much larger than the 2055 estimate.

### *E. Selection of Proposed Standards Under CAA 202(a)*

Under section 202(a) EPA has a statutory obligation to set standards to reduce air pollution from classes of motor vehicles that the Administrator has found contribute to air pollution that may be expected to endanger public health and welfare. Consistent with our longstanding approach to setting motor vehicle standards, the Administrator has considered a number of factors in proposing these vehicles standards. In setting such standards, the Administrator must provide adequate lead time for the development and application of technology to meet the standards, taking into consideration the cost of compliance. Furthermore, in setting standards for $NMOG+NO_X$, PM and CO for heavy duty vehicles (including MDVs and light trucks over 6,000 pounds GWVR), standards shall reflect the greatest degree of emissions reduction that the Administrator determines is achievable for the model year, giving appropriate consideration to cost, energy and safety factors. EPA's proposed standards properly implement these statutory provisions. As discussed in Sections II, VI, and VII, the proposed standards will achieve significant and important reductions in emissions of a wide range of air pollutants that endanger public health and welfare. Furthermore, as discussed throughout this preamble, the emission reduction technologies needed to meet the proposed standards have already been developed and are feasible and available for manufacturers to utilize in their fleets at reasonable cost in the timeframe of these proposed standards, even after considering key constraints including battery manufacturing capacity, critical materials availability, and vehicle redesign cadence.

Moreover, the flexibilities already available under EPA's existing regulations, including fleet average standards and the ABT program—in effect enabling manufacturers to spread the compliance requirement for any particular model year across multiple model years—support EPA's conclusion that the proposed standards provide sufficient time for the development and application of technology, giving appropriate consideration to cost.

Section 202(a)(3) is explicit that, for certain pollutants for certain vehicles, the Administrator shall establish standards that achieve the greatest degree of emissions reduction achievable, although the provision identifies other factors to consider and requires the Administrator to exercise judgment in weighing those factors. Section 202(a)(1)–(2) provides greater discretion to the Administrator to weigh various factors but, as with the 2021 rule, the Administrator notes that the purpose of adopting standards under that provision of the Clean Air Act is to

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[754] See, *e.g.,* 45 FR 14496, 14503 (1980) (''EPA would not require a particulate control technology that was known to involve serious safety problems.'').

address air pollution that may reasonably be anticipated to endanger public health and welfare and that reducing air pollution has traditionally been the focus of such standards. Thus, for this proposal the agency's focus in identifying proposed standards, and a range of alternative standards, is on achieving significant emissions reductions, within the constraints identified by CAA section 202.

There have been very significant developments in the adoption of PEVs since EPA promulgated the 2021 rule. While at the time of the 2021 rule, estimates of financial commitments to electric vehicles by the automotive industry were in the range of $500–600 billion, more recent estimates are $1.2 trillion, approximately twice that of only two years ago.[755] [756] The European Union has given preliminary approval to a requirement to end tailpipe GHG emissions by 2035 (with a 55% reduction for cars by 2030), to complement other countries' decisions to phase out ICE engines. In the United States, sales of PEVs have continued to follow an accelerated rate of growth, reaching 8.4 percent of U.S. light-duty vehicle production in 2022, up from 4.4 percent in MY 2021 and 2.2 percent in MY 2020.[757] In 2022, BEVs alone accounted for about 807,000 U.S. new car sales, or about 5.8 percent of the new light-duty passenger vehicle market, up from 3.2 percent BEVs the year before.[758] The year-over-year growth in U.S. BEV sales suggests that an increasing share of new vehicle buyers are concluding that a PEV is the best vehicle to meet their needs. Waiting lists for BEVs, as well as recent published studies, indicate that consumer demand for PEVs is strong, and that limited availability is likely a greater constraint than consumer acceptance.[759]

One of the most significant developments for U.S. automakers and consumers is Congressional passage of the IRA, which takes a comprehensive approach to addressing many of the potential barriers to wider adoption of PEVs in the United States. The IRA provides tens of billions of dollars in tax credits and direct Federal funding to reduce the upfront cost to consumers of purchasing PEVs, to increase the number of charging stations across the country, to reduce the cost of manufacturing batteries, and to promote domestic sources of critical minerals and other important elements of the PEV supply chain. By addressing all of these potential obstacles to wider PEV adoption in a coordinated, well-financed, strategy, Congress significantly advanced the potential for PEV adoption in the near term.

In developing this proposal, EPA has recognized that these significant developments in automaker investment, PEV market growth, and Congressional support through the BIL and IRA represent a significant opportunity to ensure that the emissions reductions these developments make possible will be realized as fully as possible and at a reasonable cost over the time frame of the rule. It is clear that these prior developments have already led to PEVs being increasingly employed across the fleet in both light-duty and medium-duty applications, largely independent of EPA's prior standards. Although the 2021 rule projected a PEV penetration rate of 17 percent for 2026, our updated modeling of the No Action case for this rule suggests a PEV penetration rate for 2027 of 27 percent, even with no change in the standards. This projection is consistent with, if not more conservative than, the projections of third-party analysts.[760] [761] This proposal seeks to build on the trends that these developments and projections indicate, and accelerate the continued deployment of these technologies to achieve further emissions reductions in 2027 and beyond.

In developing our PEV penetration estimates, EPA considered a variety of constraints which have to date limited PEV adoption and/or could limit it in the future, including: Cost to manufacturers and consumers; refresh and redesign cycles for manufacturers; availability of raw materials, batteries, and other necessary supply chain elements; adequate electricity supply and distribution; and barriers to consumer acceptance such as adequate charging infrastructure and a wide range of vehicle model choices that meet a diverse set of consumer needs.[762] EPA has consulted with analysts from other agencies, including the Federal Energy Regulatory Commission, DOE, DOT, and the Joint Office for Energy and Transportation, extensively reviewed published literature and other data, and, as discussed thoroughly in this preamble and the accompanying DRIA, has incorporated limitations into our modeling to address these potential constraints, as appropriate.

We also developed further analyses, recognizing that there are uncertainties in our projections. For example, battery costs may turn out to be higher, or lower, than we project, and consumers may adopt PEVs faster or slower than we anticipate. Overall, we identified a range of potential costs and PEV penetrations which we view as representing a wider range of possible, and still feasible and reasonable, compliance pathways under the proposed standards.

Taking both the significant developments in the automotive market and all of these potential constraints and uncertainties into account, EPA's analyses found that it would be feasible to reduce net emissions (compared to the No Action case) by 46 percent for $CO_2$, 35 percent for $PM_{2.5}$, 40 percent for $NO_X$, and 47 percent for VOCs by the final year analyzed. EPA also analyzed a range of standards which are somewhat more stringent and somewhat less stringent than the proposed standards. EPA anticipates that the appropriate choice of final standards within this range will reflect the Administrator's judgments about the uncertainties in EPA's analyses as well

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[755] Reuters, ''A Reuters analysis of 37 global automakers found that they plan to invest nearly $1.2 trillion in electric vehicles and batteries through 2030,'' October 21, 2022. Accessed on November 4, 2022 at *https://graphics.reuters.com/AUTOS-INVESTMENT/ELECTRIC/akpeqgzqypr/*.

[756] Reuters, ''Exclusive: Automakers to double spending on EVs, batteries to $1.2 trillion by 2030,'' October 25, 2022. Accessed on November 4, 2022 at *https://www.reuters.com/technology/exclusive-automakers-double-spending-evs-batteries-12-trillion-by-2030-2022-10-21/*.

[757] Environmental Protection Agency, ''The 2022 EPA Automotive Trends Report: Greenhouse Gas Emissions, Fuel Economy, and Technology since 1975,'' (forthcoming).

[758] Colias, M., ''U.S. EV Sales Jolted Higher in 2022 as Newcomers Target Tesla,'' Wall Street Journal, January 6, 2023.

[759] Gillingham, K, A van Benthem, S Weber, D Saafi, and X He. 2023. ''Has Consumer Acceptance of Electric Vehicles Been Increasing: Evidence from Microdata on Every New Vehicle Sale in the United States.'' American Economics Association: Papers & Proceedings, forthcoming, Bartlett, Jeff. 2022. More Americans Would Buy and Electric Vehicle, and Some Consumers Would Use Low-Carbon Fuels, Survey Shows. Consumer Reports. July 7. Accessed March 2, 2023. *https://www.consumerreports.org/hybrids-evs/interest-in-electric-vehicles-and-low-carbon-fuels-survey-a8457332578/*.

[760] In 2021, IHS Markit projected 27.8 percent BEV, PHEV, and range-extended electric vehicle (REX) for 2027. ''US EPA Proposed Greenhouse Gas Emissions Standards for Model Years 2023–2026; What to Expect,'' August 9, 2021. Accessed on October 28, 2021 at *https://www.spglobal.com/mobility/en/research-analysis/us-epa-proposed-greenhouse-gas-emissions-standards-my2023-26.html*.

[761] In early 2023 ICCT projected 39 percent PEVs for 2027 under the moderate IRA impact scenario. See International Council on Clean Transportation, ''Analyzing the Impact of the Inflation Reduction Act on Electric Vehicle Uptake in the US,'' ICCT White Paper, January 2023. Available at *https://theicct.org/wp-content/uploads/2023/01/ira-impact-evs-us-jan23.pdf*.

[762] Although has considered consumer acceptance (including consumer costs) in exercising our discretion under the statute based on the record before us, to assess the feasibility and appropriateness of the proposed standards, we note that it is not a statutorily-enumerated factor under section 202(a)(1)–(3).

as consideration of public comment and updated information where available. However, EPA proposes to find that standards substantially more stringent than Alternative 1 would not be appropriate because of uncertainties concerning the cost and feasibility of such standards. EPA proposes to find that standards substantially less stringent than Alternative 2 or 3 would not be appropriate because they would forgo feasible emissions reductions that would improve the protection of public health and welfare.

Taking into consideration the importance of reducing criteria pollutant and GHG emissions and the primary purpose of CAA section 202 to reduce the threat posed to human health and the environment by air pollution, the Administrator finds it is appropriate and consistent with the text and purpose of section 202 to adopt standard that, when implemented, would result in significant reductions of light-duty vehicle emissions both in the near term and over the longer term, taking into consideration the cost of compliance within the available lead time. Likewise, the Administrator concludes that these standards are consistent with the text and purpose of section 202 for heavy-duty vehicles by achieving significant reductions of GHGs, taking into consideration the cost of compliance within the available lead time, and by achieving the greatest degree of emissions reduction achievable for certain other pollutants, taking into consideration cost, lead-time, energy and safety factors.

Finally, EPA notes that the estimated benefits of the proposed standards exceed the estimated costs, and estimates net benefits of this proposal through 2055 at $850 billion to $1.6 trillion (7 percent and 3 percent discount rates, with 3 percent SC–GHG) (see Section VIII and Chapter 10 of the DRIA). We recognize the uncertainties and limitations in these estimates (including unquantified benefits), and the Administrator has not relied on these estimates in identifying the appropriate standards under section 202. Nonetheless, our conclusion that the estimated benefits considerably exceed the estimated costs of the proposed program reinforces our view that the proposed standards are appropriate.

In summary, after consideration of the very significant reductions in criteria pollutant and GHG emissions, given the technical feasibility of the proposed standards and the moderate costs per vehicle in the available lead time, and taking into account a number of other factors such as the savings to consumers in operating costs over the lifetime of the vehicle, safety, the benefits for energy security, and the significantly greater quantified benefits compared to quantified costs, EPA believes that the proposed standards are appropriate under EPA's section 202(a) authority.

## VI. How would this proposal reduce GHG emissions and their associated effects?

### *A. Estimating Emission Inventories in OMEGA*

To estimate emission inventory effects due to a potential policy, OMEGA uses as inputs a set of vehicle, refinery and electricity generating unit (EGU) emission rates. In an iterative process, we first generate emission inventories using very detailed emissions models that estimate inventories from vehicles (EPA's MOVES model) and EGUs (EPA's Power Sector Modeling Platform, v.6.21[763] [764]). The generation of those inventories is described in Chapters 8 and 5, respectively, of the DRIA. However, upstream EGU inventories used a set of bounding runs that looked at two possible futures—one with a low level of fleet electrification and another with a higher level of electrification. These bounding runs represented our best estimate of these two possible futures—the continuation of the 2021 rule (lower) and our proposal (upper)—at the time that those model runs were conducted. With those bounded sets of inventories, and the associated electricity demands within them, we can calculate emission rates for the two ends of these bounds. Using those rates, we can interpolate, using the given OMEGA policy scenario's fuel demands, to generate a unique set of emission rates for that OMEGA policy scenario. Using those unique rates, OMEGA then generates emission inventories for any future OMEGA policy scenario depending on the liquid fuel and electricity demands of that specific policy. This is explained in greater detail in Chapter 9 of the DRIA.

For vehicle criteria pollutant emissions (which are discussed further in Preamble Section VII), $CH_4$ and $N_2O$ emissions, EPA used two sets of MOVES emission inventory runs—one assuming no future use of gasoline particulate filters and one assuming such use. Using the miles traveled (for tailpipe, tire wear, and brake wear emissions) and liquid fuel consumed (for evaporative and fuel spillage emissions), we can then generate sets of emission rates for use in OMEGA. Using those rates, which are specific to fuel types and vehicle types (car vs. truck, etc.), we can then generate unique emission inventories for the given OMEGA policy scenario. This is important given the changing nature of the transportation fleet (BEV vs ICE, car vs CUV vs pickup) and the way those change for any possible policy scenario and the many factors within OMEGA that impact the future fleet composition and the very different vehicle emission rates for BEVs vs ICE vehicles. This is especially true given the consumer choice elements within OMEGA and the wide variety of input parameters that can have significant impacts on the projected future fleet. This is explained in greater detail in Chapter 9 of the DRIA. Note that OMEGA estimates $CO_2$ emissions based on the policy scenario.

Regarding refinery emissions, EPA did not have GHG refinery emissions from which to generate GHG emission rates associated with refineries. We did estimate refinery emissions in OMEGA for some criteria air pollutants and describe that in Section VII.

### *B. Impact on GHG Emissions*

Using OMEGA as described in Section VI.A, we estimated annual GHG emissions impacts (accounting for vehicles and EGUs) associated with the proposed program for the calendar years 2027 through 2055, as shown in Table 135. The table shows that the proposed program would result in significant net GHG reductions compared to the No Action scenario. The cumulative $CO_2$, $CH_4$ and $N_2O$ emissions reductions from the proposed program total 7,300 MMT, 0.12 MMT, and 0.13 MMT, respectively, through 2055. Table 136, Table 137 and Table 138 show the analogous results for alternatives 1, 2 and 3, respectively.

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[763] *https://www.epa.gov/power-sector-modeling.*

[764] *https://www.epa.gov/power-sector-modeling/epas-power-sector-modeling-platform-v6-using-ipm-summer-2021-reference-case.*

### TABLE 135—ESTIMATED GHG IMPACTS OF THE PROPOSED STANDARDS RELATIVE TO THE NO ACTION SCENARIO, LIGHT-DUTY AND MEDIUM-DUTY *

| Calendar year | Emission impacts relative to no action (million metric tons per year) | | | Percent change from no action | | |
|---|---|---|---|---|---|---|
| | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ |
| 2027 | −5.8 | −0.000025 | −0.00013 | −0.4 | −0.1 | −0.6 |
| 2028 | −15 | −0.000076 | −0.00029 | −1.2 | −0.2 | −1.3 |
| 2029 | −27 | −0.00017 | −0.00052 | −2.3 | −0.4 | −2.4 |
| 2030 | −42 | −0.00028 | −0.00078 | −3.6 | −0.8 | −3.8 |
| 2031 | −60 | −0.00043 | −0.0011 | −5.4 | −1.2 | −5.7 |
| 2032 | −82 | −0.00062 | −0.0015 | −7.6 | −1.9 | −7.9 |
| 2033 | −110 | −0.00087 | −0.002 | −10.1 | −2.9 | −10.4 |
| 2034 | −130 | −0.0012 | −0.0024 | −13 | −4.1 | −13 |
| 2035 | −150 | −0.0015 | −0.0028 | −16 | −5.6 | −16 |
| 2036 | −170 | −0.0018 | −0.0032 | −18 | −7.1 | −18 |
| 2037 | −200 | −0.0022 | −0.0036 | −21 | −9.0 | −20 |
| 2038 | −220 | −0.0027 | −0.004 | −24 | −11 | −23 |
| 2039 | −240 | −0.0031 | −0.0044 | −26 | −14 | −25 |
| 2040 | −260 | −0.0036 | −0.0048 | −29 | −16 | −27 |
| 2041 | −280 | −0.0041 | −0.0052 | −31 | −19 | −29 |
| 2042 | −300 | −0.0045 | −0.0055 | −34 | −21 | −31 |
| 2043 | −320 | −0.005 | −0.0058 | −36 | −24 | −33 |
| 2044 | −330 | −0.0054 | −0.006 | −38 | −27 | −34 |
| 2045 | −350 | −0.0059 | −0.0063 | −39 | −30 | −35 |
| 2046 | −360 | −0.0063 | −0.0065 | −41 | −32 | −37 |
| 2047 | −370 | −0.0067 | −0.0067 | −42 | −35 | −38 |
| 2048 | −390 | −0.0072 | −0.0069 | −44 | −38 | −39 |
| 2049 | −400 | −0.0076 | −0.0071 | −45 | −40 | −39 |
| 2050 | −410 | −0.008 | −0.0073 | −46 | −43 | −40 |
| 2051 | −410 | −0.0081 | −0.0074 | −46 | −44 | −40 |
| 2052 | −420 | −0.0082 | −0.0075 | −47 | −44 | −41 |
| 2053 | −420 | −0.0083 | −0.0076 | −47 | −45 | −41 |
| 2054 | −420 | −0.0084 | −0.0077 | −47 | −45 | −41 |
| 2055 | −420 | −0.0084 | −0.0077 | −47 | −45 | −41 |
| Sum | −7,300 | −0.12 | −0.13 | −26 | −17 | −25 |

* GHG emission rates were not available for calculating GHG inventories from refineries.

### TABLE 136—ESTIMATED GHG IMPACTS OF ALTERNATIVE 1 RELATIVE TO THE NO ACTION SCENARIO, LIGHT-DUTY AND MEDIUM-DUTY *

| Calendar year | Emission impacts relative to no action (million metric tons per year) | | | Percent change from no action | | |
|---|---|---|---|---|---|---|
| | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ |
| 2027 | −6.1 | −0.000027 | −0.00014 | −0.5 | −0.1 | −0.6 |
| 2028 | −17 | −0.000073 | −0.00031 | −1.3 | −0.2 | −1.4 |
| 2029 | −31 | −0.00015 | −0.00053 | −2.5 | −0.4 | −2.5 |
| 2030 | −49 | −0.00026 | −0.00084 | −4.2 | −0.7 | −4.1 |
| 2031 | −69 | −0.00042 | −0.0012 | −6.2 | −1.2 | −6.0 |
| 2032 | −93 | −0.00062 | −0.0016 | −8.6 | −1.9 | −8.3 |
| 2033 | −120 | −0.00089 | −0.0021 | −11.5 | −2.9 | −11.0 |
| 2034 | −150 | −0.0012 | −0.0026 | −14 | −4.2 | −14 |
| 2035 | −170 | −0.0016 | −0.003 | −17 | −5.8 | −17 |
| 2036 | −200 | −0.002 | −0.0034 | −20 | −7.5 | −19 |
| 2037 | −220 | −0.0024 | −0.0039 | −23 | −9.6 | −22 |
| 2038 | −250 | −0.0028 | −0.0043 | −26 | −12 | −24 |
| 2039 | −270 | −0.0033 | −0.0048 | −29 | −14 | −27 |
| 2040 | −290 | −0.0038 | −0.0052 | −32 | −17 | −29 |
| 2041 | −320 | −0.0043 | −0.0056 | −35 | −20 | −32 |
| 2042 | −330 | −0.0048 | −0.0059 | −37 | −23 | −33 |
| 2043 | −360 | −0.0054 | −0.0062 | −40 | −26 | −35 |
| 2044 | −370 | −0.0059 | −0.0065 | −42 | −29 | −37 |
| 2045 | −390 | −0.0064 | −0.0068 | −43 | −32 | −38 |
| 2046 | −400 | −0.0069 | −0.0071 | −45 | −35 | −40 |
| 2047 | −410 | −0.0073 | −0.0073 | −47 | −38 | −41 |
| 2048 | −430 | −0.0078 | −0.0075 | −48 | −41 | −42 |
| 2049 | −440 | −0.0083 | −0.0077 | −50 | −44 | −43 |
| 2050 | −450 | −0.0088 | −0.0079 | −51 | −47 | −43 |
| 2051 | −450 | −0.0089 | −0.008 | −51 | −48 | −44 |
| 2052 | −460 | −0.009 | −0.0081 | −51 | −48 | −44 |
| 2053 | −460 | −0.0091 | −0.0082 | −52 | −49 | −44 |

### TABLE 136—ESTIMATED GHG IMPACTS OF ALTERNATIVE 1 RELATIVE TO THE NO ACTION SCENARIO, LIGHT-DUTY AND MEDIUM-DUTY *—Continued

| Calendar year | Emission impacts relative to no action (million metric tons per year) | | | Percent change from no action | | |
|---|---|---|---|---|---|---|
| | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ |
| 2054 | −460 | −0.0091 | −0.0083 | −52 | −49 | −44 |
| 2055 | −460 | −0.0092 | −0.0083 | −52 | −49 | −44 |
| Sum | −8,100 | −0.13 | −0.14 | −29 | −18 | −27 |

*GHG emission rates were not available for calculating GHG inventories from refineries.

### TABLE 137—ESTIMATED GHG IMPACTS OF ALTERNATIVE 2 RELATIVE TO THE NO ACTION SCENARIO, LIGHT-DUTY AND MEDIUM-DUTY *

| Calendar year | Emission impacts relative to no action (million metric tons per year) | | | Percent change from no action | | |
|---|---|---|---|---|---|---|
| | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ |
| 2027 | −4.2 | −0.000021 | −0.0001 | −0.3 | 0.0 | −0.4 |
| 2028 | −11 | −0.000058 | −0.00021 | −0.9 | −0.1 | −1.0 |
| 2029 | −22 | −0.00014 | −0.00042 | −1.8 | −0.4 | −2.0 |
| 2030 | −34 | −0.00023 | −0.00064 | −2.9 | −0.6 | −3.1 |
| 2031 | −49 | −0.00036 | −0.00094 | −4.4 | −1.0 | −4.8 |
| 2032 | −69 | −0.00054 | −0.0013 | −6.4 | −1.7 | −6.8 |
| 2033 | −92 | −0.00077 | −0.0017 | −8.8 | −2.5 | −9.2 |
| 2034 | −120 | −0.0011 | −0.0022 | −11 | −3.7 | −12 |
| 2035 | −140 | −0.0014 | −0.0026 | −14 | −5.0 | −14 |
| 2036 | −150 | −0.0017 | −0.0029 | −16 | −6.4 | −16 |
| 2037 | −180 | −0.002 | −0.0033 | −19 | −8.2 | −19 |
| 2038 | −200 | −0.0024 | −0.0037 | −21 | −10 | −21 |
| 2039 | −220 | −0.0028 | −0.0041 | −24 | −12 | −23 |
| 2040 | −240 | −0.0033 | −0.0044 | −26 | −15 | −25 |
| 2041 | −260 | −0.0037 | −0.0048 | −28 | −17 | −27 |
| 2042 | −270 | −0.0041 | −0.0051 | −30 | −20 | −29 |
| 2043 | −290 | −0.0046 | −0.0054 | −32 | −22 | −31 |
| 2044 | −300 | −0.005 | −0.0056 | −34 | −25 | −32 |
| 2045 | −310 | −0.0054 | −0.0058 | −35 | −27 | −33 |
| 2046 | −330 | −0.0059 | −0.0061 | −37 | −30 | −34 |
| 2047 | −340 | −0.0063 | −0.0063 | −38 | −32 | −35 |
| 2048 | −350 | −0.0067 | −0.0065 | −40 | −35 | −36 |
| 2049 | −360 | −0.0071 | −0.0066 | −41 | −38 | −37 |
| 2050 | −370 | −0.0075 | −0.0068 | −42 | −40 | −37 |
| 2051 | −370 | −0.0076 | −0.0069 | −42 | −40 | −38 |
| 2052 | −380 | −0.0076 | −0.007 | −42 | −41 | −38 |
| 2053 | −380 | −0.0077 | −0.0071 | −42 | −41 | −38 |
| 2054 | −380 | −0.0077 | −0.0071 | −43 | −41 | −38 |
| 2055 | −380 | −0.0078 | −0.0072 | −43 | −42 | −38 |
| Sum | −6,600 | −0.11 | −0.12 | −23 | −15 | −23 |

*GHG emission rates were not available for calculating GHG inventories from refineries.

### TABLE 138—ESTIMATED GHG IMPACTS OF ALTERNATIVE 3 RELATIVE TO THE NO ACTION SCENARIO, LIGHT-DUTY AND MEDIUM-DUTY *

| Calendar year | Emission impacts relative to no action (million metric tons per year) | | | Percent change from no action | | |
|---|---|---|---|---|---|---|
| | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ |
| 2027 | −3.4 | −0.000023 | −0.00009 | −0.3 | −0.1 | −0.4 |
| 2028 | −8.9 | −0.000062 | −0.00019 | −0.7 | −0.1 | −0.9 |
| 2029 | −16 | −0.00012 | −0.00033 | −1.3 | −0.3 | −1.6 |
| 2030 | −27 | −0.0002 | −0.00054 | −2.3 | −0.5 | −2.6 |
| 2031 | −44 | −0.00033 | −0.00088 | −4.0 | −1.0 | −4.4 |
| 2032 | −66 | −0.00051 | −0.0013 | −6.2 | −1.6 | −6.7 |
| 2033 | −91 | −0.00075 | −0.0017 | −8.7 | −2.5 | −9.2 |
| 2034 | −120 | −0.001 | −0.0022 | −11 | −3.7 | −12 |
| 2035 | −140 | −0.0014 | −0.0027 | −14 | −5.1 | −15 |
| 2036 | −160 | −0.0017 | −0.003 | −17 | −6.6 | −17 |
| 2037 | −190 | −0.0021 | −0.0035 | −20 | −8.5 | −19 |
| 2038 | −210 | −0.0026 | −0.0039 | −22 | −11 | −22 |
| 2039 | −230 | −0.003 | −0.0043 | −25 | −13 | −24 |

TABLE 138—ESTIMATED GHG IMPACTS OF ALTERNATIVE 3 RELATIVE TO THE NO ACTION SCENARIO, LIGHT-DUTY AND MEDIUM-DUTY *—Continued

| Calendar year | Emission impacts relative to no action (million metric tons per year) | | | Percent change from no action | | |
|---|---|---|---|---|---|---|
| | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ |
| 2040 | −250 | −0.0035 | −0.0047 | −28 | −15 | −27 |
| 2041 | −280 | −0.0039 | −0.0051 | −31 | −18 | −29 |
| 2042 | −290 | −0.0044 | −0.0054 | −33 | −21 | −31 |
| 2043 | −310 | −0.0049 | −0.0057 | −35 | −24 | −32 |
| 2044 | −330 | −0.0053 | −0.006 | −37 | −26 | −34 |
| 2045 | −340 | −0.0058 | −0.0062 | −39 | −29 | −35 |
| 2046 | −360 | −0.0063 | −0.0065 | −41 | −32 | −37 |
| 2047 | −370 | −0.0067 | −0.0067 | −42 | −35 | −38 |
| 2048 | −390 | −0.0072 | −0.0069 | −43 | −38 | −39 |
| 2049 | −400 | −0.0076 | −0.0071 | −45 | −40 | −39 |
| 2050 | −410 | −0.0081 | −0.0073 | −46 | −43 | −40 |
| 2051 | −410 | −0.0082 | −0.0074 | −46 | −44 | −41 |
| 2052 | −420 | −0.0083 | −0.0075 | −47 | −44 | −41 |
| 2053 | −420 | −0.0083 | −0.0076 | −47 | −45 | −41 |
| 2054 | −420 | −0.0084 | −0.0077 | −47 | −45 | −41 |
| 2055 | −420 | −0.0084 | −0.0077 | −47 | −45 | −41 |
| Sum | −7,100 | −0.12 | −0.13 | −25 | −16 | −24 |

*GHG emission rates were not available for calculating GHG inventories from refineries.

### *C. Global Climate Impacts Associated With the Proposal's GHG Emissions Reductions*

The transportation sector is the largest U.S. source of GHG emissions, representing 27.2 percent of total GHG emissions.[765] Within the transportation sector, light-duty vehicles are the largest contributor, at 57.1 percent, and thus comprise 15.5 percent of total U.S. GHG emissions,[766] even before considering the contribution of medium-duty Class 2b and 3 vehicles which are also included under this rule. Reducing GHG emissions, including the three GHGs ($CO_2$, $CH_4$, and $N_2O$) affected by this program, will contribute toward the goal of holding the increase in the global average temperature to well below 2 °C above pre-industrial levels, and subsequently reducing the probability of severe climate change related impacts including heat waves, drought, sea level rise, extreme climate and weather events, coastal flooding, and wildfires. While EPA did not conduct modeling to specifically quantify changes in climate impacts resulting from this rule in terms of avoided temperature change or sea-level rise, we did quantify the climate benefits by monetizing the emission reductions through the application of the social cost of greenhouse gases (SC–GHGs), as described in Section VIII.D of this preamble.

## **VII. How would the proposal impact criteria and air toxics emissions and their associated effects?**

As described in Section VI.A (and in more detail in Chapter 9 of the DRIA), EPA has used OMEGA to estimate criteria air pollutant and air toxic emission inventories associated with the proposed standards and with Alternatives 1 and 2. These estimates are presented in Section VII.A. OMEGA's emissions estimates include emissions from vehicles (using MOVES), electricity generation (using IPM, as described in Section IV.B.3), and refineries.[767]

Section VII.B discusses the air quality impacts of these emissions changes.

### *A. Impact on Emissions of Criteria and Air Toxics Pollutants*

Table 139 through Table 142 present changes in emissions of criteria air pollutants from vehicles for the light-duty proposal and each of the light-duty alternatives. Each of these tables also includes changes in emissions of criteria air pollutants from vehicles due to the medium-duty proposal.

Table 143 through Table 146 present changes in emissions from EGUs and refineries for the light-duty proposal and each of the light-duty alternatives. Each of these tables also includes changes in emissions from EGUs and refineries due to the medium-duty proposal.

Table 147 through Table 150 present net changes in emissions of criteria air pollutants from vehicles, EGUs and refineries due to the light-duty proposal and each of the light-duty alternatives. Each of these tables also include changes due to the medium-duty proposal.

Table 151 presents net changes in emissions of criteria air pollutants from vehicles and EGUs without any impacts associated with refinery emissions. This table shows results for the proposal and includes changes due to the medium-duty proposal. We present these results as a sensitivity given the uncertainty surrounding how changes in domestic demand for liquid fuel may or may not impact domestic refining of liquid fuel.

Table 152 through Table 155 present changes in emissions of air toxic pollutants from vehicles due to the light-duty proposal and each of the light-duty alternatives. Each of these tables also includes changes in air toxic emissions from vehicles due to the medium-duty proposal.

The vehicle reductions in $PM_{2.5}$, $NO_X$, NMOG, and CO emissions shown in Table 139 through Table 142 are related to the proposed standards for these pollutants and the technologies we project that manufacturers will choose to use to comply with them, including both BEV technologies and, for gasoline-powered vehicles, gasoline particulate filters. Vehicle $SO_X$ emissions are a function of the sulfur content of gasoline and diesel fuel. Therefore, the reductions in $SO_X$ emissions from vehicles result from the decrease in

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[765] *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2020* (EPA–430–R–22–003, published April 2022).

[766] *Ibid.*

[767] Illustrative Air Quality Analysis for the Light and Medium Duty Vehicle Multipollutant Proposed Rule Technical Support Document (TSD) contained in the docket.

gasoline and diesel fuel consumption associated with the GHG standards.

### Table 139—OMEGA Estimated Vehicle Criteria Emission Impacts of the Proposed Standards Relative to the No Action Scenario, Light-duty and Medium-Duty

[U.S. tons per year]

| Calendar year | PM$_{2.5}$ | NO$_X$ | NMOG | SO$_X$ | CO |
|---|---|---|---|---|---|
| 2027 | −68 | −720 | −1,100 | −50 | −24,000 |
| 2028 | −170 | −1,700 | −3,400 | −130 | −61,000 |
| 2029 | −310 | −3,200 | −7,200 | −230 | −110,000 |
| 2030 | −790 | −4,800 | −12,000 | −350 | −180,000 |
| 2031 | −1,300 | −6,800 | −18,000 | −490 | −250,000 |
| 2032 | −1,800 | −9,100 | −25,000 | −650 | −330,000 |
| 2033 | −2,300 | −12,000 | −33,000 | −830 | −430,000 |
| 2034 | −2,900 | −14,000 | −42,000 | −1,000 | −530,000 |
| 2035 | −3,400 | −17,000 | −52,000 | −1,200 | −640,000 |
| 2036 | −4,000 | −19,000 | −62,000 | −1,300 | −720,000 |
| 2037 | −4,500 | −21,000 | −73,000 | −1,500 | −820,000 |
| 2038 | −5,100 | −24,000 | −85,000 | −1,600 | −930,000 |
| 2039 | −5,600 | −26,000 | −96,000 | −1,800 | −1,000,000 |
| 2040 | −6,100 | −28,000 | −110,000 | −1,900 | −1,100,000 |
| 2041 | −6,600 | −30,000 | −120,000 | −2,000 | −1,200,000 |
| 2042 | −7,000 | −32,000 | −130,000 | −2,100 | −1,300,000 |
| 2043 | −7,500 | −33,000 | −140,000 | −2,300 | −1,400,000 |
| 2044 | −7,900 | −35,000 | −150,000 | −2,300 | −1,400,000 |
| 2045 | −8,200 | −36,000 | −160,000 | −2,400 | −1,500,000 |
| 2046 | −8,500 | −37,000 | −170,000 | −2,500 | −1,600,000 |
| 2047 | −8,800 | −38,000 | −180,000 | −2,500 | −1,600,000 |
| 2048 | −9,000 | −39,000 | −180,000 | −2,600 | −1,700,000 |
| 2049 | −9,200 | −40,000 | −190,000 | −2,600 | −1,700,000 |
| 2050 | −9,400 | −41,000 | −190,000 | −2,700 | −1,700,000 |
| 2051 | −9,500 | −42,000 | −200,000 | −2,700 | −1,800,000 |
| 2052 | −9,600 | −43,000 | −200,000 | −2,700 | −1,800,000 |
| 2053 | −9,700 | −43,000 | −200,000 | −2,700 | −1,800,000 |
| 2054 | −9,800 | −44,000 | −200,000 | −2,800 | −1,800,000 |
| 2055 | −9,800 | −44,000 | −200,000 | −2,800 | −1,800,000 |

### Table 140—OMEGA Estimated Vehicle Criteria Emission Impacts of the Proposed Standards Relative to the No Action Scenario, Light-Duty and Medium-Duty

[U.S. tons per year]

| Calendar year | PM$_{2.5}$ | NO$_X$ | NMOG | SO$_X$ | CO |
|---|---|---|---|---|---|
| 2027 | −70 | −750 | −1,200 | −53 | −25,000 |
| 2028 | −180 | −1,800 | −3,600 | −140 | −65,000 |
| 2029 | −320 | −3,100 | −7,200 | −250 | −110,000 |
| 2030 | −790 | −4,900 | −12,000 | −400 | −180,000 |
| 2031 | −1,300 | −6,900 | −19,000 | −550 | −260,000 |
| 2032 | −1,800 | −9,300 | −26,000 | −730 | −350,000 |
| 2033 | −2,300 | −12,000 | −35,000 | −940 | −450,000 |
| 2034 | −2,900 | −15,000 | −46,000 | −1,100 | −570,000 |
| 2035 | −3,400 | −18,000 | −57,000 | −1,300 | −680,000 |
| 2036 | −4,000 | −20,000 | −69,000 | −1,500 | −780,000 |
| 2037 | −4,500 | −23,000 | −81,000 | −1,700 | −900,000 |
| 2038 | −5,100 | −25,000 | −94,000 | −1,800 | −1,000,000 |
| 2039 | −5,600 | −27,000 | −110,000 | −2,000 | −1,100,000 |
| 2040 | −6,100 | −30,000 | −120,000 | −2,100 | −1,200,000 |
| 2041 | −6,600 | −32,000 | −130,000 | −2,300 | −1,300,000 |
| 2042 | −7,100 | −34,000 | −140,000 | −2,400 | −1,400,000 |
| 2043 | −7,500 | −36,000 | −160,000 | −2,500 | −1,500,000 |
| 2044 | −7,900 | −37,000 | −170,000 | −2,600 | −1,600,000 |
| 2045 | −8,200 | −39,000 | −180,000 | −2,700 | −1,700,000 |
| 2046 | −8,600 | −40,000 | −190,000 | −2,800 | −1,700,000 |
| 2047 | −8,800 | −41,000 | −190,000 | −2,800 | −1,800,000 |
| 2048 | −9,100 | −42,000 | −200,000 | −2,900 | −1,800,000 |
| 2049 | −9,300 | −43,000 | −210,000 | −2,900 | −1,900,000 |
| 2050 | −9,500 | −44,000 | −210,000 | −3,000 | −1,900,000 |
| 2051 | −9,600 | −45,000 | −220,000 | −3,000 | −1,900,000 |
| 2052 | −9,700 | −46,000 | −220,000 | −3,000 | −2,000,000 |
| 2053 | −9,700 | −46,000 | −220,000 | −3,000 | −2,000,000 |
| 2054 | −9,800 | −47,000 | −220,000 | −3,000 | −2,000,000 |
| 2055 | −9,800 | −47,000 | −230,000 | −3,000 | −2,000,000 |

TABLE 141—OMEGA ESTIMATED VEHICLE CRITERIA EMISSION IMPACTS OF THE PROPOSED STANDARDS RELATIVE TO THE NO ACTION SCENARIO, LIGHT-DUTY AND MEDIUM-DUTY

[U.S. tons per year]

| Calendar year | PM$_{2.5}$ | NO$_X$ | NMOG | SO$_X$ | CO |
|---|---|---|---|---|---|
| 2027 | −49 | −570 | −810 | −36 | −17,000 |
| 2028 | −120 | −1,300 | −2,400 | −91 | −42,000 |
| 2029 | −250 | −2,600 | −5,600 | −180 | −88,000 |
| 2030 | −730 | −3,900 | −9,400 | −280 | −140,000 |
| 2031 | −1,200 | −5,800 | −14,000 | −400 | −200,000 |
| 2032 | −1,700 | −7,900 | −20,000 | −540 | −270,000 |
| 2033 | −2,300 | −10,000 | −28,000 | −720 | −360,000 |
| 2034 | −2,800 | −13,000 | −36,000 | −890 | −460,000 |
| 2035 | −3,400 | −15,000 | −45,000 | −1,000 | −560,000 |
| 2036 | −3,900 | −17,000 | −54,000 | −1,200 | −640,000 |
| 2037 | −4,500 | −20,000 | −64,000 | −1,300 | −730,000 |
| 2038 | −5,000 | −22,000 | −74,000 | −1,500 | −830,000 |
| 2039 | −5,500 | −24,000 | −85,000 | −1,600 | −920,000 |
| 2040 | −6,100 | −26,000 | −96,000 | −1,700 | −1,000,000 |
| 2041 | −6,500 | −28,000 | −110,000 | −1,800 | −1,100,000 |
| 2042 | −7,000 | −29,000 | −120,000 | −1,900 | −1,200,000 |
| 2043 | −7,400 | −31,000 | −130,000 | −2,000 | −1,300,000 |
| 2044 | −7,800 | −32,000 | −130,000 | −2,100 | −1,300,000 |
| 2045 | −8,200 | −34,000 | −140,000 | −2,200 | −1,400,000 |
| 2046 | −8,500 | −35,000 | −150,000 | −2,200 | −1,400,000 |
| 2047 | −8,800 | −36,000 | −160,000 | −2,300 | −1,500,000 |
| 2048 | −9,000 | −37,000 | −160,000 | −2,300 | −1,500,000 |
| 2049 | −9,200 | −38,000 | −170,000 | −2,400 | −1,600,000 |
| 2050 | −9,400 | −39,000 | −170,000 | −2,400 | −1,600,000 |
| 2051 | −9,500 | −39,000 | −180,000 | −2,500 | −1,600,000 |
| 2052 | −9,600 | −40,000 | −180,000 | −2,500 | −1,600,000 |
| 2053 | −9,700 | −40,000 | −180,000 | −2,500 | −1,600,000 |
| 2054 | −9,700 | −41,000 | −180,000 | −2,500 | −1,600,000 |
| 2055 | −9,800 | −41,000 | −190,000 | −2,500 | −1,600,000 |

TABLE 142—OMEGA ESTIMATED VEHICLE CRITERIA EMISSION IMPACTS OF THE PROPOSED STANDARDS RELATIVE TO THE NO ACTION SCENARIO, LIGHT-DUTY AND MEDIUM-DUTY

[U.S. tons per year]

| Calendar year | PM$_{2.5}$ | NO$_X$ | NMOG | SO$_X$ | CO |
|---|---|---|---|---|---|
| 2027 | −43 | −550 | −800 | −30 | −15,000 |
| 2028 | −110 | −1,200 | −2,300 | −75 | −39,000 |
| 2029 | −190 | −2,100 | −4,500 | −130 | −68,000 |
| 2030 | −670 | −3,400 | −7,800 | −220 | −110,000 |
| 2031 | −1,200 | −5,400 | −12,000 | −360 | −180,000 |
| 2032 | −1,600 | −7,700 | −19,000 | −530 | −260,000 |
| 2033 | −2,200 | −10,000 | −26,000 | −710 | −360,000 |
| 2034 | −2,800 | −13,000 | −35,000 | −910 | −470,000 |
| 2035 | −3,300 | −16,000 | −44,000 | −1,100 | −570,000 |
| 2036 | −3,800 | −18,000 | −54,000 | −1,200 | −660,000 |
| 2037 | −4,400 | −20,000 | −65,000 | −1,400 | −770,000 |
| 2038 | −5,000 | −23,000 | −76,000 | −1,600 | −870,000 |
| 2039 | −5,500 | −25,000 | −88,000 | −1,700 | −980,000 |
| 2040 | −6,000 | −27,000 | −100,000 | −1,900 | −1,100,000 |
| 2041 | −6,500 | −29,000 | −110,000 | −2,000 | −1,200,000 |
| 2042 | −7,000 | −31,000 | −120,000 | −2,100 | −1,300,000 |
| 2043 | −7,400 | −33,000 | −130,000 | −2,200 | −1,400,000 |
| 2044 | −7,800 | −34,000 | −140,000 | −2,300 | −1,400,000 |
| 2045 | −8,100 | −36,000 | −150,000 | −2,400 | −1,500,000 |
| 2046 | −8,500 | −37,000 | −160,000 | −2,500 | −1,600,000 |
| 2047 | −8,700 | −38,000 | −170,000 | −2,500 | −1,600,000 |
| 2048 | −9,000 | −39,000 | −180,000 | −2,600 | −1,700,000 |
| 2049 | −9,200 | −40,000 | −190,000 | −2,600 | −1,700,000 |
| 2050 | −9,400 | −41,000 | −190,000 | −2,700 | −1,700,000 |
| 2051 | −9,500 | −42,000 | −200,000 | −2,700 | −1,800,000 |
| 2052 | −9,600 | −43,000 | −200,000 | −2,700 | −1,800,000 |
| 2053 | −9,700 | −43,000 | −200,000 | −2,700 | −1,800,000 |
| 2054 | −9,800 | −44,000 | −200,000 | −2,800 | −1,800,000 |
| 2055 | −9,800 | −44,000 | −200,000 | −2,800 | −1,800,000 |

Table 143 through Table 146 show the ''upstream'' emissions impacts from EGUs and refineries. As explained in Section IV.B.3, our power sector modeling predicts that EGU emissions will decrease between 2028 and 2055 due to increasing use of renewables. As a result, the increase in EGU emissions associated with the proposal's increased electricity generation would peak in the late 2030's/early 2040's (depending on the pollutant) and then generally decrease or level off through 2055. Section VI.A provides more detail on the estimation of refinery emissions, which we predict would decrease as a result of the decreased demand for liquid fuel associated with the proposed GHG standards.

TABLE 143—OMEGA ESTIMATED UPSTREAM CRITERIA EMISSION IMPACTS OF THE PROPOSED STANDARDS RELATIVE TO THE NO ACTION SCENARIO, LIGHT-DUTY AND MEDIUM-DUTY

[U.S. tons per year]

| | EGU | | | | Refinery | | | |
|---|---|---|---|---|---|---|---|---|
| | $PM_{2.5}$ | $NO_X$ | NMOG | $SO_X$ | $PM_{2.5}$ | $NO_X$ | NMOG | $SO_X$ |
| 2027 | 140 | 800 | 68 | 660 | −130 | −510 | −440 | −200 |
| 2028 | 310 | 1,800 | 150 | 1,500 | −330 | −1,200 | −1,100 | −490 |
| 2029 | 540 | 3,100 | 260 | 2,500 | −590 | −2,300 | −1,900 | −890 |
| 2030 | 790 | 4,400 | 380 | 3,600 | −900 | −3,400 | −2,900 | −1,400 |
| 2031 | 1,100 | 5,900 | 510 | 4,800 | −1,300 | −4,800 | −4,100 | −1,900 |
| 2032 | 1,300 | 7,500 | 660 | 6,000 | −1,700 | −6,400 | −5,500 | −2,600 |
| 2033 | 1,600 | 9,000 | 800 | 7,100 | −2,100 | −8,100 | −7,000 | −3,300 |
| 2034 | 1,900 | 10,000 | 940 | 8,100 | −2,600 | −9,900 | −8,500 | −4,000 |
| 2035 | 2,100 | 11,000 | 1,100 | 8,800 | −3,100 | −12,000 | −9,900 | −4,700 |
| 2036 | 2,300 | 12,000 | 1,100 | 9,000 | −3,400 | −13,000 | −11,000 | −5,200 |
| 2037 | 2,400 | 12,000 | 1,200 | 9,300 | −3,800 | −14,000 | −12,000 | −5,800 |
| 2038 | 2,500 | 13,000 | 1,300 | 9,300 | −4,200 | −16,000 | −13,000 | −6,400 |
| 2039 | 2,600 | 13,000 | 1,300 | 9,100 | −4,500 | −17,000 | −14,000 | −6,900 |
| 2040 | 2,600 | 13,000 | 1,400 | 8,700 | −4,900 | −18,000 | −16,000 | −7,400 |
| 2041 | 2,600 | 12,000 | 1,400 | 8,100 | −5,200 | −19,000 | −16,000 | −7,900 |
| 2042 | 2,600 | 12,000 | 1,400 | 7,300 | −5,500 | −20,000 | −17,000 | −8,300 |
| 2043 | 2,600 | 11,000 | 1,400 | 6,500 | −5,700 | −21,000 | −18,000 | −8,700 |
| 2044 | 2,400 | 10,000 | 1,400 | 5,400 | −5,900 | −22,000 | −19,000 | −9,000 |
| 2045 | 2,300 | 9,200 | 1,300 | 4,200 | −6,100 | −22,000 | −19,000 | −9,300 |
| 2046 | 2,200 | 8,100 | 1,300 | 2,900 | −6,300 | −23,000 | −20,000 | −9,600 |
| 2047 | 2,000 | 6,700 | 1,200 | 1,500 | −6,400 | −23,000 | −20,000 | −9,700 |
| 2048 | 1,900 | 5,400 | 1,100 | 1,500 | −6,500 | −24,000 | −20,000 | −10,000 |
| 2049 | 1,700 | 4,000 | 1,100 | 1,600 | −6,600 | −24,000 | −21,000 | −10,000 |
| 2050 | 1,500 | 2,500 | 1,000 | 1,600 | −6,700 | −24,000 | −21,000 | −10,000 |
| 2051 | 1,500 | 2,500 | 1,000 | 1,600 | −6,800 | −25,000 | −21,000 | −10,000 |
| 2052 | 1,500 | 2,500 | 1,000 | 1,600 | −6,800 | −25,000 | −21,000 | −10,000 |
| 2053 | 1,500 | 2,600 | 1,000 | 1,600 | −6,900 | −25,000 | −21,000 | −10,000 |
| 2054 | 1,500 | 2,600 | 1,000 | 1,600 | −6,900 | −25,000 | −21,000 | −11,000 |
| 2055 | 1,500 | 2,600 | 1,000 | 1,600 | −6,900 | −25,000 | −21,000 | −11,000 |

* CO emission rates were not available for calculating CO inventories from EGUs or refineries.

TABLE 144—OMEGA ESTIMATED UPSTREAM CRITERIA EMISSION IMPACTS OF THE PROPOSED STANDARDS RELATIVE TO THE NO ACTION SCENARIO, LIGHT-DUTY AND MEDIUM-DUTY

[U.S. tons per year]

| | EGU | | | | Refinery | | | |
|---|---|---|---|---|---|---|---|---|
| | $PM_{2.5}$ | $NO_X$ | NMOG | $SO_X$ | $PM_{2.5}$ | $NO_X$ | NMOG | $SO_X$ |
| 2027 | 140 | 830 | 71 | 680 | −140 | −530 | −450 | −210 |
| 2028 | 350 | 2,000 | 170 | 1,600 | −370 | −1,400 | −1,200 | −560 |
| 2029 | 570 | 3,300 | 280 | 2,700 | −660 | −2,500 | −2,200 | −990 |
| 2030 | 860 | 4,900 | 420 | 4,000 | −1,000 | −3,900 | −3,400 | −1,600 |
| 2031 | 1,100 | 6,300 | 550 | 5,100 | −1,400 | −5,400 | −4,700 | −2,200 |
| 2032 | 1,400 | 7,900 | 700 | 6,300 | −1,900 | −7,200 | −6,200 | −2,900 |
| 2033 | 1,800 | 9,700 | 860 | 7,700 | −2,400 | −9,200 | −7,900 | −3,700 |
| 2034 | 2,100 | 11,000 | 1,000 | 8,800 | −2,900 | −11,000 | −9,500 | −4,500 |
| 2035 | 2,300 | 12,000 | 1,100 | 9,500 | −3,400 | −13,000 | −11,000 | −5,200 |
| 2036 | 2,500 | 13,000 | 1,200 | 9,900 | −3,800 | −14,000 | −12,000 | −5,800 |
| 2037 | 2,600 | 14,000 | 1,300 | 10,000 | −4,300 | −16,000 | −14,000 | −6,500 |
| 2038 | 2,800 | 14,000 | 1,400 | 10,000 | −4,700 | −17,000 | −15,000 | −7,100 |
| 2039 | 2,800 | 14,000 | 1,500 | 10,000 | −5,100 | −19,000 | −16,000 | −7,700 |
| 2040 | 2,900 | 14,000 | 1,500 | 9,600 | −5,400 | −20,000 | −17,000 | −8,300 |
| 2041 | 2,900 | 14,000 | 1,500 | 9,000 | −5,800 | −21,000 | −18,000 | −8,800 |
| 2042 | 2,900 | 13,000 | 1,500 | 8,100 | −6,100 | −22,000 | −19,000 | −9,200 |
| 2043 | 2,800 | 12,000 | 1,500 | 7,200 | −6,400 | −23,000 | −20,000 | −9,700 |
| 2044 | 2,700 | 11,000 | 1,500 | 6,000 | −6,600 | −24,000 | −21,000 | −10,000 |
| 2045 | 2,600 | 10,000 | 1,500 | 4,600 | −6,700 | −25,000 | −21,000 | −10,000 |

### TABLE 144—OMEGA ESTIMATED UPSTREAM CRITERIA EMISSION IMPACTS OF THE PROPOSED STANDARDS RELATIVE TO THE NO ACTION SCENARIO, LIGHT-DUTY AND MEDIUM-DUTY—Continued

[U.S. tons per year]

| | EGU | | | | Refinery | | | |
|---|---|---|---|---|---|---|---|---|
| | PM$_{2.5}$ | NO$_X$ | NMOG | SO$_X$ | PM$_{2.5}$ | NO$_X$ | NMOG | SO$_X$ |
| 2046 | 2,400 | 8,900 | 1,400 | 3,200 | −7,000 | −25,000 | −22,000 | −11,000 |
| 2047 | 2,200 | 7,500 | 1,300 | 1,700 | −7,100 | −26,000 | −22,000 | −11,000 |
| 2048 | 2,100 | 6,000 | 1,300 | 1,700 | −7,200 | −26,000 | −22,000 | −11,000 |
| 2049 | 1,900 | 4,400 | 1,200 | 1,800 | −7,300 | −27,000 | −23,000 | −11,000 |
| 2050 | 1,600 | 2,800 | 1,100 | 1,800 | −7,400 | −27,000 | −23,000 | −11,000 |
| 2051 | 1,700 | 2,800 | 1,100 | 1,800 | −7,500 | −27,000 | −23,000 | −11,000 |
| 2052 | 1,700 | 2,800 | 1,100 | 1,800 | −7,500 | −27,000 | −23,000 | −12,000 |
| 2053 | 1,700 | 2,800 | 1,100 | 1,800 | −7,500 | −27,000 | −23,000 | −12,000 |
| 2054 | 1,700 | 2,800 | 1,100 | 1,800 | −7,600 | −27,000 | −23,000 | −12,000 |
| 2055 | 1,700 | 2,800 | 1,100 | 1,900 | −7,600 | −27,000 | −23,000 | −12,000 |

* CO emission rates were not available for calculating CO inventories from EGUs or refineries.

### TABLE 145—OMEGA ESTIMATED UPSTREAM CRITERIA EMISSION IMPACTS OF THE PROPOSED STANDARDS RELATIVE TO THE NO ACTION SCENARIO, LIGHT-DUTY AND MEDIUM-DUTY

[U.S. tons per year]

| | EGU | | | | Refinery | | | |
|---|---|---|---|---|---|---|---|---|
| | PM$_{2.5}$ | NO$_X$ | NMOG | SO$_X$ | PM$_{2.5}$ | NO$_X$ | NMOG | SO$_X$ |
| 2027 | 100 | 580 | 49 | 470 | −96 | −370 | −320 | −150 |
| 2028 | 220 | 1,300 | 110 | 1,000 | −240 | −900 | −780 | −360 |
| 2029 | 420 | 2,400 | 210 | 2,000 | −470 | −1,800 | −1,500 | −710 |
| 2030 | 620 | 3,500 | 300 | 2,800 | −710 | −2,700 | −2,300 | −1,100 |
| 2031 | 860 | 4,800 | 420 | 3,900 | −1,000 | −3,900 | −3,400 | −1,600 |
| 2032 | 1,100 | 6,200 | 540 | 4,900 | −1,400 | −5,300 | −4,600 | −2,100 |
| 2033 | 1,400 | 7,800 | 700 | 6,100 | −1,900 | −7,100 | −6,100 | −2,800 |
| 2034 | 1,700 | 9,100 | 830 | 7,100 | −2,300 | −8,700 | −7,500 | −3,500 |
| 2035 | 1,900 | 10,000 | 940 | 7,800 | −2,700 | −10,000 | −8,700 | −4,100 |
| 2036 | 2,000 | 11,000 | 1,000 | 8,000 | −3,000 | −11,000 | −9,700 | −4,600 |
| 2037 | 2,200 | 11,000 | 1,100 | 8,400 | −3,400 | −13,000 | −11,000 | −5,200 |
| 2038 | 2,300 | 12,000 | 1,200 | 8,400 | −3,800 | −14,000 | −12,000 | −5,700 |
| 2039 | 2,400 | 12,000 | 1,200 | 8,300 | −4,100 | −15,000 | −13,000 | −6,200 |
| 2040 | 2,400 | 12,000 | 1,300 | 8,000 | −4,400 | −16,000 | −14,000 | −6,700 |
| 2041 | 2,400 | 12,000 | 1,300 | 7,500 | −4,700 | −17,000 | −15,000 | −7,200 |
| 2042 | 2,400 | 11,000 | 1,300 | 6,800 | −4,900 | −18,000 | −16,000 | −7,500 |
| 2043 | 2,400 | 10,000 | 1,300 | 6,000 | −5,200 | −19,000 | −16,000 | −7,900 |
| 2044 | 2,300 | 9,500 | 1,300 | 4,900 | −5,300 | −20,000 | −17,000 | −8,100 |
| 2045 | 2,100 | 8,500 | 1,200 | 3,800 | −5,500 | −20,000 | −17,000 | −8,400 |
| 2046 | 2,000 | 7,400 | 1,200 | 2,700 | −5,700 | −21,000 | −18,000 | −8,700 |
| 2047 | 1,900 | 6,200 | 1,100 | 1,400 | −5,800 | −21,000 | −18,000 | −8,800 |
| 2048 | 1,700 | 5,000 | 1,100 | 1,400 | −5,900 | −22,000 | −18,000 | −9,000 |
| 2049 | 1,500 | 3,700 | 1,000 | 1,400 | −6,000 | −22,000 | −19,000 | −9,200 |
| 2050 | 1,400 | 2,300 | 930 | 1,500 | −6,100 | −22,000 | −19,000 | −9,300 |
| 2051 | 1,400 | 2,300 | 940 | 1,500 | −6,200 | −22,000 | −19,000 | −9,400 |
| 2052 | 1,400 | 2,300 | 940 | 1,500 | −6,200 | −22,000 | −19,000 | −9,500 |
| 2053 | 1,400 | 2,300 | 950 | 1,500 | −6,200 | −22,000 | −19,000 | −9,500 |
| 2054 | 1,400 | 2,400 | 950 | 1,500 | −6,200 | −22,000 | −19,000 | −9,500 |
| 2055 | 1,400 | 2,400 | 950 | 1,500 | −6,200 | −22,000 | −19,000 | −9,500 |

* CO emission rates were not available for calculating CO inventories from EGUs or refineries.

### TABLE 146—OMEGA ESTIMATED UPSTREAM CRITERIA EMISSION IMPACTS OF THE PROPOSED STANDARDS RELATIVE TO THE NO ACTION SCENARIO, LIGHT-DUTY AND MEDIUM-DUTY

[U.S. tons per year]

| | EGU | | | | Refinery | | | |
|---|---|---|---|---|---|---|---|---|
| | PM$_{2.5}$ | NO$_X$ | NMOG | SO$_X$ | PM$_{2.5}$ | NO$_X$ | NMOG | SO$_X$ |
| 2027 | 84 | 490 | 42 | 400 | −78 | −300 | −260 | −120 |
| 2028 | 190 | 1,100 | 95 | 910 | −200 | −750 | −650 | −300 |
| 2029 | 320 | 1,800 | 160 | 1,500 | −350 | −1,300 | −1,100 | −520 |
| 2030 | 500 | 2,900 | 250 | 2,300 | −570 | −2,200 | −1,900 | −870 |
| 2031 | 780 | 4,400 | 380 | 3,500 | −930 | −3,500 | −3,000 | −1,400 |
| 2032 | 1,100 | 6,100 | 540 | 4,900 | −1,400 | −5,200 | −4,500 | −2,100 |

## TABLE 146—OMEGA ESTIMATED UPSTREAM CRITERIA EMISSION IMPACTS OF THE PROPOSED STANDARDS RELATIVE TO THE NO ACTION SCENARIO, LIGHT-DUTY AND MEDIUM-DUTY—Continued

[U.S. tons per year]

| | EGU | | | | Refinery | | | |
|---|---|---|---|---|---|---|---|---|
| | $PM_{2.5}$ | $NO_X$ | NMOG | $SO_X$ | $PM_{2.5}$ | $NO_X$ | NMOG | $SO_X$ |
| 2033 | 1,400 | 7,700 | 690 | 6,100 | −1,800 | −7,000 | −6,000 | −2,800 |
| 2034 | 1,700 | 9,300 | 850 | 7,300 | −2,400 | −8,900 | −7,600 | −3,600 |
| 2035 | 2,000 | 10,000 | 970 | 8,100 | −2,800 | −11,000 | −9,100 | −4,300 |
| 2036 | 2,100 | 11,000 | 1,100 | 8,400 | −3,200 | −12,000 | −10,000 | −4,800 |
| 2037 | 2,300 | 12,000 | 1,200 | 8,800 | −3,600 | −13,000 | −12,000 | −5,500 |
| 2038 | 2,400 | 12,000 | 1,200 | 8,900 | −4,000 | −15,000 | −13,000 | −6,100 |
| 2039 | 2,500 | 12,000 | 1,300 | 8,800 | −4,400 | −16,000 | −14,000 | −6,600 |
| 2040 | 2,600 | 12,000 | 1,300 | 8,500 | −4,700 | −18,000 | −15,000 | −7,200 |
| 2041 | 2,600 | 12,000 | 1,400 | 8,000 | −5,100 | −19,000 | −16,000 | −7,700 |
| 2042 | 2,600 | 12,000 | 1,400 | 7,200 | −5,300 | −20,000 | −17,000 | −8,100 |
| 2043 | 2,500 | 11,000 | 1,400 | 6,400 | −5,600 | −21,000 | −18,000 | −8,600 |
| 2044 | 2,400 | 10,000 | 1,300 | 5,300 | −5,800 | −21,000 | −18,000 | −8,900 |
| 2045 | 2,300 | 9,200 | 1,300 | 4,100 | −6,000 | −22,000 | −19,000 | −9,200 |
| 2046 | 2,200 | 8,100 | 1,300 | 2,900 | −6,200 | −23,000 | −19,000 | −9,500 |
| 2047 | 2,000 | 6,800 | 1,200 | 1,500 | −6,300 | −23,000 | −20,000 | −9,700 |
| 2048 | 1,900 | 5,400 | 1,200 | 1,600 | −6,500 | −24,000 | −20,000 | −9,900 |
| 2049 | 1,700 | 4,000 | 1,100 | 1,600 | −6,600 | −24,000 | −20,000 | −10,000 |
| 2050 | 1,500 | 2,500 | 1,000 | 1,600 | −6,700 | −24,000 | −21,000 | −10,000 |
| 2051 | 1,500 | 2,500 | 1,000 | 1,600 | −6,800 | −25,000 | −21,000 | −10,000 |
| 2052 | 1,500 | 2,600 | 1,000 | 1,600 | −6,800 | −25,000 | −21,000 | −10,000 |
| 2053 | 1,500 | 2,600 | 1,000 | 1,600 | −6,900 | −25,000 | −21,000 | −10,000 |
| 2054 | 1,500 | 2,600 | 1,000 | 1,700 | −6,900 | −25,000 | −21,000 | −11,000 |
| 2055 | 1,500 | 2,600 | 1,000 | 1,700 | −6,900 | −25,000 | −21,000 | −11,000 |

* CO emission rates were not available for calculating CO inventories from EGUs or refineries.

Table 147 through Table 150 show the net impact of the proposed standards and alternatives on emissions of criteria pollutants, accounting for vehicle, EGU, and refinery emissions. In 2055, when the fleet will be largely comprised of vehicle meeting the proposed standards, there would be a net decrease in emissions of $PM_{2.5}$, $NO_X$, and $SO_X$ (*i.e.,* all of the pollutants for which we have emissions estimates from all three source sectors). The proposal would result in net reductions of $PM_{2.5}$, $NO_X$, NMOG, and CO emissions for all years between 2028 and 2055. Net $SO_X$ emissions would be reduced beginning in 2040. Until then, the increased electricity generation associated with the proposed standards would result in net increases in $SO_X$ emissions, which would peak in the mid-2030's.

## TABLE 147—OMEGA ESTIMATED NET CRITERIA EMISSION IMPACTS OF THE PROPOSED STANDARDS RELATIVE TO THE NO ACTION SCENARIO, LIGHT-DUTY AND MEDIUM-DUTY VEHICLES, EGUS AND REFINERIES

[U.S. tons per year]

| Calendar year | Emission impacts relative to no action (thousand U.S. tons) | | | | | Percent change from no action | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $PM_{2.5}$ | $NO_X$ | NMOG | $SO_X$ | CO | $PM_{2.5}$ (%) | $NO_X$ (%) | NMOG (%) | $SO_X$ (%) | CO (%) |
| 2027 | −62 | −430 | −1,500 | 410 | −24,000 | −0.11 | −0.070 | −0.13 | 0.89 | −0.22 |
| 2028 | −180 | −1,100 | −4,300 | 860 | −61,000 | −0.33 | −0.21 | −0.42 | 1.9 | −0.60 |
| 2029 | −360 | −2,300 | −8,900 | 1,400 | −110,000 | −0.68 | −0.49 | −0.91 | 3.1 | −1.2 |
| 2030 | −900 | −3,700 | −15,000 | 1,900 | −180,000 | −1.8 | −0.9 | −1.6 | 4.2 | −2.0 |
| 2031 | −1,500 | −5,700 | −21,000 | 2,400 | −250,000 | −3.0 | −1.5 | −2.5 | 5.3 | −3.1 |
| 2032 | −2,100 | −8,100 | −30,000 | 2,800 | −330,000 | −4.4 | −2.4 | −3.6 | 6.3 | −4.5 |
| 2033 | −2,800 | −11,000 | −39,000 | 3,000 | −430,000 | −6.0 | −3.5 | −5.1 | 7.0 | −6.2 |
| 2034 | −3,600 | −14,000 | −50,000 | 3,100 | −530,000 | −7.7 | −4.9 | −6.9 | 7.3 | −8.3 |
| 2035 | −4,400 | −17,000 | −61,000 | 3,000 | −640,000 | −9.5 | −6.5 | −8.9 | 7.2 | −11 |
| 2036 | −5,100 | −20,000 | −72,000 | 2,600 | −720,000 | −11 | −8.2 | −11 | 6.3 | −13 |
| 2037 | −5,900 | −23,000 | −84,000 | 2,000 | −820,000 | −13 | −10 | −14 | 5.1 | −16 |
| 2038 | −6,700 | −26,000 | −97,000 | 1,300 | −930,000 | −15 | −13 | −17 | 3.4 | −19 |
| 2039 | −7,500 | −30,000 | −110,000 | 400 | −1,000,000 | −17 | −15 | −20 | 1.1 | −22 |
| 2040 | −8,400 | −33,000 | −120,000 | −650 | −1,100,000 | −19 | −17 | −23 | −1.8 | −25 |
| 2041 | −9,200 | −37,000 | −130,000 | −1,800 | −1,200,000 | −21 | −20 | −26 | −5.2 | −28 |
| 2042 | −9,900 | −40,000 | −150,000 | −3,100 | −1,300,000 | −23 | −22 | −29 | −9 | −31 |
| 2043 | −11,000 | −43,000 | −160,000 | −4,500 | −1,400,000 | −25 | −25 | −32 | −14 | −34 |
| 2044 | −11,000 | −46,000 | −170,000 | −6,000 | −1,400,000 | −26 | −27 | −35 | −19 | −37 |
| 2045 | −12,000 | −49,000 | −180,000 | −7,500 | −1,500,000 | −28 | −29 | −37 | −25 | −39 |
| 2046 | −13,000 | −52,000 | −190,000 | −9,200 | −1,600,000 | −30 | −31 | −40 | −32 | −41 |
| 2047 | −13,000 | −55,000 | −190,000 | −11,000 | −1,600,000 | −31 | −34 | −42 | −39 | −43 |
| 2048 | −14,000 | −58,000 | −200,000 | −11,000 | −1,700,000 | −32 | −36 | −44 | −40 | −44 |
| 2049 | −14,000 | −61,000 | −210,000 | −11,000 | −1,700,000 | −33 | −38 | −45 | −40 | −46 |

### TABLE 147—OMEGA ESTIMATED NET CRITERIA EMISSION IMPACTS OF THE PROPOSED STANDARDS RELATIVE TO THE NO ACTION SCENARIO, LIGHT-DUTY AND MEDIUM-DUTY VEHICLES, EGUs AND REFINERIES—Continued

[U.S. tons per year]

| Calendar year | Emission impacts relative to no action (thousand U.S. tons) | | | | | Percent change from no action | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | PM$_{2.5}$ | NO$_X$ | NMOG | SO$_X$ | CO | PM$_{2.5}$ (%) | NO$_X$ (%) | NMOG (%) | SO$_X$ (%) | CO (%) |
| 2050 | −15,000 | −63,000 | −210,000 | −11,000 | −1,700,000 | −34 | −40 | −46 | −41 | −47 |
| 2051 | −15,000 | −64,000 | −220,000 | −11,000 | −1,800,000 | −35 | −40 | −47 | −41 | −47 |
| 2052 | −15,000 | −65,000 | −220,000 | −12,000 | −1,800,000 | −35 | −40 | −48 | −41 | −48 |
| 2053 | −15,000 | −65,000 | −220,000 | −12,000 | −1,800,000 | −35 | −41 | −49 | −42 | −49 |
| 2054 | −15,000 | −66,000 | −220,000 | −12,000 | −1,800,000 | −35 | −41 | −49 | −42 | −49 |
| 2055 | −15,000 | −66,000 | −220,000 | −12,000 | −1,800,000 | −35 | −41 | −50 | −42 | −49 |

* CO emission rates were not available for calculating CO inventories from EGUs or refineries.

### TABLE 148—OMEGA ESTIMATED NET CRITERIA EMISSION IMPACTS OF THE ALTERNATIVE 1 STANDARDS RELATIVE TO THE NO ACTION SCENARIO, LIGHT-DUTY AND MEDIUM-DUTY VEHICLES, EGUs AND REFINERIES

[U.S. tons per year]

| Calendar year | Emission impacts relative to no action (thousand U.S. tons) | | | | | Percent change from no action | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | PM$_{2.5}$ | NO$_X$ | NMOG | SO$_X$ | CO | PM$_{2.5}$ (%) | NO$_X$ (%) | NMOG (%) | SO$_X$ (%) | CO (%) |
| 2027 | −65 | −440 | −1,500 | 420 | −25,000 | −0.11 | −0.072 | −0.14 | 0.92 | −0.23 |
| 2028 | −200 | −1,200 | −4,600 | 940 | −65,000 | −0.37 | −0.22 | −0.45 | 2.1 | −0.65 |
| 2029 | −400 | −2,400 | −9,000 | 1,400 | −110,000 | −0.76 | −0.49 | −0.93 | 3.1 | −1.2 |
| 2030 | −970 | −3,900 | −15,000 | 2,000 | −180,000 | −1.9 | −0.9 | −1.7 | 4.4 | −2.1 |
| 2031 | −1,600 | −6,000 | −23,000 | 2,400 | −260,000 | −3.2 | −1.6 | −2.6 | 5.3 | −3.2 |
| 2032 | −2,200 | −8,600 | −32,000 | 2,700 | −350,000 | −4.6 | −2.5 | −3.9 | 6.2 | −4.7 |
| 2033 | −3,000 | −12,000 | −42,000 | 3,100 | −450,000 | −6.2 | −3.8 | −5.5 | 7.0 | −6.6 |
| 2034 | −3,800 | −15,000 | −54,000 | 3,100 | −570,000 | −8.0 | −5.3 | −7.5 | 7.4 | −8.8 |
| 2035 | −4,500 | −18,000 | −67,000 | 3,000 | −680,000 | −9.9 | −7.0 | −9.8 | 7.2 | −11 |
| 2036 | −5,300 | −21,000 | −80,000 | 2,600 | −780,000 | −12 | −8.9 | −12 | 6.4 | −14 |
| 2037 | −6,100 | −25,000 | −93,000 | 2,100 | −900,000 | −14 | −11 | −15 | 5.2 | −17 |
| 2038 | −7,000 | −29,000 | −110,000 | 1,300 | −1,000,000 | −16 | −14 | −18 | 3.4 | −20 |
| 2039 | −7,800 | −32,000 | −120,000 | 340 | −1,100,000 | −18 | −16 | −22 | 0.9 | −24 |
| 2040 | −8,700 | −36,000 | −140,000 | −780 | −1,200,000 | −20 | −19 | −25 | −2.2 | −27 |
| 2041 | −9,500 | −40,000 | −150,000 | −2,100 | −1,300,000 | −22 | −21 | −29 | −5.9 | −31 |
| 2042 | −10,000 | −43,000 | −160,000 | −3,500 | −1,400,000 | −24 | −24 | −32 | −10 | −34 |
| 2043 | −11,000 | −47,000 | −180,000 | −5,000 | −1,500,000 | −26 | −27 | −35 | −15 | −37 |
| 2044 | −12,000 | −50,000 | −190,000 | −6,600 | −1,600,000 | −27 | −29 | −38 | −21 | −40 |
| 2045 | −12,000 | −53,000 | −200,000 | −8,300 | −1,700,000 | −29 | −32 | −41 | −28 | −43 |
| 2046 | −13,000 | −57,000 | −210,000 | −10,000 | −1,700,000 | −31 | −34 | −44 | −35 | −45 |
| 2047 | −14,000 | −59,000 | −210,000 | −12,000 | −1,800,000 | −32 | −36 | −46 | −43 | −47 |
| 2048 | −14,000 | −63,000 | −220,000 | −12,000 | −1,800,000 | −33 | −39 | −48 | −44 | −49 |
| 2049 | −15,000 | −66,000 | −230,000 | −12,000 | −1,900,000 | −35 | −41 | −50 | −45 | −50 |
| 2050 | −15,000 | −69,000 | −230,000 | −13,000 | −1,900,000 | −36 | −43 | −51 | −45 | −52 |
| 2051 | −15,000 | −69,000 | −240,000 | −13,000 | −1,900,000 | −36 | −43 | −52 | −45 | −52 |
| 2052 | −16,000 | −70,000 | −240,000 | −13,000 | −2,000,000 | −36 | −44 | −53 | −45 | −53 |
| 2053 | −16,000 | −71,000 | −240,000 | −13,000 | −2,000,000 | −37 | −44 | −54 | −46 | −54 |
| 2054 | −16,000 | −71,000 | −250,000 | −13,000 | −2,000,000 | −37 | −44 | −54 | −46 | −54 |
| 2055 | −16,000 | −71,000 | −250,000 | −13,000 | −2,000,000 | −37 | −44 | −55 | −46 | −55 |

* CO emission rates were not available for calculating CO inventories from EGUs or refineries.

### TABLE 149—OMEGA ESTIMATED NET CRITERIA EMISSION IMPACTS OF THE ALTERNATIVE 2 STANDARDS RELATIVE TO THE NO ACTION SCENARIO, LIGHT-DUTY AND MEDIUM-DUTY VEHICLES, EGUs AND REFINERIES

[U.S. tons per year]

| Calendar year | Emission impacts relative to no action (thousand U.S. tons) | | | | | Percent change from no action | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | PM$_{2.5}$ | NO$_X$ | NMOG | SO$_X$ | CO | PM$_{2.5}$ (%) | NO$_X$ (%) | NMOG (%) | SO$_X$ (%) | CO (%) |
| 2027 | −45 | −360 | −1,100 | 290 | −17,000 | −0.08 | −0.058 | −0.10 | 0.64 | −0.16 |
| 2028 | −130 | −910 | −3,100 | 600 | −42,000 | −0.25 | −0.17 | −0.30 | 1.3 | −0.42 |
| 2029 | −290 | −2,000 | −6,900 | 1,100 | −88,000 | −0.55 | −0.41 | −0.71 | 2.4 | −0.9 |
| 2030 | −820 | −3,100 | −11,000 | 1,500 | −140,000 | −1.6 | −0.7 | −1.2 | 3.3 | −1.6 |
| 2031 | −1,400 | −4,900 | −17,000 | 1,900 | −200,000 | −2.8 | −1.3 | −2.0 | 4.2 | −2.5 |
| 2032 | −2,000 | −7,000 | −24,000 | 2,200 | −270,000 | −4.1 | −2.1 | −3.0 | 5.1 | −3.7 |
| 2033 | −2,700 | −9,600 | −33,000 | 2,600 | −360,000 | −5.7 | −3.2 | −4.3 | 5.9 | −5.3 |

### TABLE 149—OMEGA ESTIMATED NET CRITERIA EMISSION IMPACTS OF THE ALTERNATIVE 2 STANDARDS RELATIVE TO THE NO ACTION SCENARIO, LIGHT-DUTY AND MEDIUM-DUTY VEHICLES, EGUS AND REFINERIES—Continued

[U.S. tons per year]

| Calendar year | Emission impacts relative to no action (thousand U.S. tons) | | | | | Percent change from no action | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $PM_{2.5}$ | $NO_X$ | NMOG | $SO_X$ | CO | $PM_{2.5}$ (%) | $NO_X$ (%) | NMOG (%) | $SO_X$ (%) | CO (%) |
| 2034 ..... | −3,400 | −12,000 | −43,000 | 2,700 | −460,000 | −7.4 | −4.5 | −5.9 | 6.3 | −7.2 |
| 2035 ..... | −4,200 | −15,000 | −53,000 | 2,600 | −560,000 | −9.1 | −5.9 | −7.7 | 6.3 | −9 |
| 2036 ..... | −4,900 | −18,000 | −63,000 | 2,300 | −640,000 | −11 | −7.5 | −10 | 5.6 | −11 |
| 2037 ..... | −5,700 | −21,000 | −74,000 | 1,900 | −730,000 | −13 | −9 | −12 | 4.8 | −14 |
| 2038 ..... | −6,500 | −24,000 | −85,000 | 1,300 | −830,000 | −15 | −11 | −15 | 3.3 | −17 |
| 2039 ..... | −7,300 | −27,000 | −97,000 | 500 | −920,000 | −17 | −14 | −17 | 1.3 | −20 |
| 2040 ..... | −8,000 | −31,000 | −110,000 | −430 | −1,000,000 | −18 | −16 | −20 | −1.2 | −23 |
| 2041 ..... | −8,800 | −34,000 | −120,000 | −1,500 | −1,100,000 | −20 | −18 | −23 | −4.3 | −25 |
| 2042 ..... | −9,500 | −37,000 | −130,000 | −2,700 | −1,200,000 | −22 | −21 | −26 | −8 | −28 |
| 2043 ..... | −10,000 | −40,000 | −140,000 | −4,000 | −1,300,000 | −24 | −23 | −29 | −12 | −31 |
| 2044 ..... | −11,000 | −43,000 | −150,000 | −5,300 | −1,300,000 | −25 | −25 | −31 | −17 | −33 |
| 2045 ..... | −12,000 | −45,000 | −160,000 | −6,700 | −1,400,000 | −27 | −27 | −33 | −22 | −35 |
| 2046 ..... | −12,000 | −48,000 | −170,000 | −8,300 | −1,400,000 | −28 | −29 | −36 | −29 | −37 |
| 2047 ..... | −13,000 | −51,000 | −170,000 | −9,700 | −1,500,000 | −30 | −31 | −38 | −35 | −39 |
| 2048 ..... | −13,000 | −54,000 | −180,000 | −10,000 | −1,500,000 | −31 | −33 | −39 | −36 | −40 |
| 2049 ..... | −14,000 | −56,000 | −190,000 | −10,000 | −1,600,000 | −32 | −35 | −41 | −37 | −42 |
| 2050 ..... | −14,000 | −59,000 | −190,000 | −10,000 | −1,600,000 | −33 | −37 | −42 | −37 | −43 |
| 2051 ..... | −14,000 | −59,000 | −200,000 | −10,000 | −1,600,000 | −34 | −37 | −43 | −37 | −43 |
| 2052 ..... | −14,000 | −60,000 | −200,000 | −10,000 | −1,600,000 | −34 | −37 | −44 | −38 | −44 |
| 2053 ..... | −15,000 | −60,000 | −200,000 | −11,000 | −1,600,000 | −34 | −38 | −44 | −38 | −44 |
| 2054 ..... | −15,000 | −61,000 | −200,000 | −11,000 | −1,600,000 | −34 | −38 | −45 | −38 | −45 |
| 2055 ..... | −15,000 | −61,000 | −200,000 | −11,000 | −1,600,000 | −34 | −38 | −45 | −38 | −45 |

*CO emission rates were not available for calculating CO inventories from EGUs or refineries.

### TABLE 150—OMEGA ESTIMATED NET CRITERIA EMISSION IMPACTS OF THE ALTERNATIVE 3 STANDARDS RELATIVE TO THE NO ACTION SCENARIO, LIGHT-DUTY AND MEDIUM-DUTY VEHICLES, EGUS AND REFINERIES

[U.S. tons per year]

| Calendar year | Emission impacts relative to no action (thousand U.S. tons) | | | | | Percent change from no action | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $PM_{2.5}$ | $NO_X$ | NMOG | $SO_X$ | CO | $PM_{2.5}$ (%) | $NO_X$ (%) | NMOG (%) | $SO_X$ (%) | CO (%) |
| 2027 ..... | −37 | −360 | −1,000 | 250 | −15,000 | −0.07 | −0.058 | −0.09 | 0.55 | −0.14 |
| 2028 ..... | −110 | −870 | −2,900 | 530 | −39,000 | −0.21 | −0.16 | −0.28 | 1.2 | −0.39 |
| 2029 ..... | −220 | −1,600 | −5,500 | 830 | −68,000 | −0.42 | −0.34 | −0.56 | 1.8 | −0.7 |
| 2030 ..... | −740 | −2,700 | −9,400 | 1,200 | −110,000 | −1.4 | −0.6 | −1.0 | 2.7 | −1.3 |
| 2031 ..... | −1,300 | −4,500 | −15,000 | 1,700 | −180,000 | −2.6 | −1.2 | −1.7 | 3.9 | −2.2 |
| 2032 ..... | −1,900 | −6,800 | −23,000 | 2,300 | −260,000 | −4.0 | −2.0 | −2.8 | 5.1 | −3.6 |
| 2033 ..... | −2,600 | −9,500 | −31,000 | 2,600 | −360,000 | −5.5 | −3.1 | −4.1 | 6.0 | −5.2 |
| 2034 ..... | −3,400 | −13,000 | −41,000 | 2,800 | −470,000 | −7.2 | −4.5 | −5.7 | 6.5 | −7.3 |
| 2035 ..... | −4,200 | −16,000 | −52,000 | 2,700 | −570,000 | −9.0 | −6.1 | −7.7 | 6.5 | −10 |
| 2036 ..... | −4,900 | −19,000 | −63,000 | 2,400 | −660,000 | −11 | −7.8 | −10 | 5.9 | −12 |
| 2037 ..... | −5,700 | −22,000 | −75,000 | 1,900 | −770,000 | −13 | −10 | −12 | 4.9 | −15 |
| 2038 ..... | −6,500 | −25,000 | −88,000 | 1,300 | −870,000 | −15 | −12 | −15 | 3.3 | −18 |
| 2039 ..... | −7,300 | −29,000 | −100,000 | 440 | −980,000 | −17 | −14 | −18 | 1.2 | −21 |
| 2040 ..... | −8,200 | −32,000 | −110,000 | −550 | −1,100,000 | −19 | −17 | −21 | −1.5 | −24 |
| 2041 ..... | −9,000 | −36,000 | −130,000 | −1,700 | −1,200,000 | −21 | −19 | −24 | −4.9 | −27 |
| 2042 ..... | −9,700 | −39,000 | −140,000 | −3,000 | −1,300,000 | −23 | −22 | −27 | −9 | −30 |
| 2043 ..... | −11,000 | −43,000 | −150,000 | −4,400 | −1,400,000 | −24 | −24 | −31 | −13 | −33 |
| 2044 ..... | −11,000 | −46,000 | −160,000 | −5,800 | −1,400,000 | −26 | −27 | −33 | −19 | −36 |
| 2045 ..... | −12,000 | −49,000 | −170,000 | −7,400 | −1,500,000 | −28 | −29 | −36 | −25 | −38 |
| 2046 ..... | −13,000 | −52,000 | −180,000 | −9,100 | −1,600,000 | −29 | −31 | −39 | −31 | −41 |
| 2047 ..... | −13,000 | −55,000 | −190,000 | −11,000 | −1,600,000 | −31 | −33 | −41 | −39 | −42 |
| 2048 ..... | −14,000 | −58,000 | −200,000 | −11,000 | −1,700,000 | −32 | −36 | −43 | −40 | −44 |
| 2049 ..... | −14,000 | −60,000 | −210,000 | −11,000 | −1,700,000 | −33 | −38 | −45 | −40 | −45 |
| 2050 ..... | −15,000 | −63,000 | −210,000 | −11,000 | −1,700,000 | −34 | −40 | −46 | −41 | −47 |
| 2051 ..... | −15,000 | −64,000 | −210,000 | −11,000 | −1,800,000 | −35 | −40 | −47 | −41 | −47 |
| 2052 ..... | −15,000 | −65,000 | −220,000 | −12,000 | −1,800,000 | −35 | −40 | −48 | −41 | −48 |
| 2053 ..... | −15,000 | −65,000 | −220,000 | −12,000 | −1,800,000 | −35 | −41 | −49 | −42 | −49 |
| 2054 ..... | −15,000 | −66,000 | −220,000 | −12,000 | −1,800,000 | −35 | −41 | −49 | −42 | −49 |
| 2055 ..... | −15,000 | −66,000 | −220,000 | −12,000 | −1,800,000 | −35 | −41 | −50 | −42 | −50 |

*CO emission rates were not available for calculating CO inventories from EGUs or refineries.

The estimated refinery emission impacts include consideration of the impact on reduced liquid fuel demand on domestic refining. Our central analysis estimates that impact at 93 percent. In other words, 93 percent of the reduced liquid fuel demand results in reduced domestic refining. There is the possibility that reduced domestic demand for liquid fuel would have no impact on domestic refining. In other words, excess domestic refined liquid fuel would be exported for use elsewhere. In that event, there would be no decrease in domestic refinery emissions and the net criteria air pollutant impacts for the proposed standards would be as shown in Table 151. We request comment on the correct portion of reduced liquid fuel demand that would result in reduced domestic refining.

TABLE 151—OMEGA ESTIMATED NET CRITERIA EMISSION IMPACTS OF THE PROPOSED STANDARDS RELATIVE TO THE NO ACTION SCENARIO, LIGHT-DUTY AND MEDIUM-DUTY VEHICLES AND EGUS AND NO IMPACTS FROM REFINERIES

[U.S. tons per year]

| Calendar year | Emission impacts relative to no action (thousand U.S. tons) | | | | | Percent change from no action | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $PM_{2.5}$ | $NO_X$ | NMOG | $SO_X$ | CO | $PM_{2.5}$ (%) | $NO_X$ (%) | NMOG (%) | $SO_X$ (%) | CO (%) |
| 2027 ..... | 70 | 79 | −1,000 | 610 | −24,000 | 0.20 | 0.015 | −0.1 | 4.5 | −0.22 |
| 2028 ..... | 150 | 100 | −3,300 | 1,400 | −61,000 | 0.43 | 0.02 | −0.34 | 9.3 | −0.6 |
| 2029 ..... | 230 | −61 | −6,900 | 2,300 | −110,000 | 0.70 | −0.02 | −0.76 | 15 | −1.2 |
| 2030 ..... | −8 | −320 | −12,000 | 3,300 | −180,000 | 0.0 | −0.1 | −1.3 | 19 | −2 |
| 2031 ..... | −230 | −900 | −17,000 | 4,300 | −250,000 | −0.7 | −0.3 | −2.1 | 24 | −3.1 |
| 2032 ..... | −430 | −1,700 | −24,000 | 5,300 | −330,000 | −1.4 | −0.6 | −3.2 | 29 | −4.5 |
| 2033 ..... | −680 | −2,600 | −32,000 | 6,300 | −430,000 | −2.2 | −1.1 | −4.5 | 34 | −6.2 |
| 2034 ..... | −960 | −3,800 | −41,000 | 7,100 | −530,000 | −3.1 | −1.7 | −6.1 | 39 | −8.3 |
| 2035 ..... | −1,300 | −5,200 | −51,000 | 7,600 | −640,000 | −4.2 | −2.6 | −8.1 | 42 | −11 |
| 2036 ..... | −1,700 | −6,900 | −61,000 | 7,700 | −720,000 | −6 | −3.8 | −10 | 43 | −13 |
| 2037 ..... | −2,100 | −8,700 | −72,000 | 7,800 | −820,000 | −7 | −5 | −13 | 45 | −16 |
| 2038 ..... | −2,500 | −11,000 | −83,000 | 7,700 | −930,000 | −9 | −7 | −16 | 47 | −19 |
| 2039 ..... | −3,000 | −13,000 | −95,000 | 7,300 | −1,000,000 | −10 | −9 | −19 | 47 | −22 |
| 2040 ..... | −3,500 | −15,000 | −110,000 | 6,800 | −1,100,000 | −12 | −11 | −22 | 47 | −25 |
| 2041 ..... | −4,000 | −17,000 | −120,000 | 6,100 | −1,200,000 | −13 | −13 | −25 | 45 | −28 |
| 2042 ..... | −4,400 | −20,000 | −130,000 | 5,200 | −1,300,000 | −15 | −15 | −28 | 42 | −31 |
| 2043 ..... | −4,900 | −22,000 | −140,000 | 4,200 | −1,400,000 | −17 | −18 | −31 | 37 | −34 |
| 2044 ..... | −5,400 | −24,000 | −150,000 | 3,000 | −1,400,000 | −19 | −20 | −34 | 30 | −37 |
| 2045 ..... | −5,900 | −27,000 | −160,000 | 1,800 | −1,500,000 | −20 | −23 | −37 | 19 | −39 |
| 2046 ..... | −6,400 | −29,000 | −170,000 | 410 | −1,600,000 | −22 | −25 | −39 | 5 | −41 |
| 2047 ..... | −6,800 | −31,000 | −170,000 | −1,000 | −1,600,000 | −23 | −28 | −41 | −16 | −43 |
| 2048 ..... | −7,200 | −34,000 | −180,000 | −1,000 | −1,700,000 | −25 | −30 | −43 | −16 | −44 |
| 2049 ..... | −7,600 | −36,000 | −190,000 | −1,100 | −1,700,000 | −26 | −33 | −45 | −16 | −46 |
| 2050 ..... | −8,000 | −39,000 | −190,000 | −1,100 | −1,700,000 | −28 | −35 | −46 | −16 | −47 |
| 2051 ..... | −8,000 | −39,000 | −200,000 | −1,100 | −1,800,000 | −28 | −36 | −47 | −16 | −47 |
| 2052 ..... | −8,100 | −40,000 | −200,000 | −1,100 | −1,800,000 | −28 | −36 | −48 | −17 | −48 |
| 2053 ..... | −8,200 | −41,000 | −200,000 | −1,100 | −1,800,000 | −28 | −37 | −49 | −17 | −49 |
| 2054 ..... | −8,200 | −41,000 | −200,000 | −1,100 | −1,800,000 | −29 | −37 | −49 | −17 | −49 |
| 2055 ..... | −8,300 | −41,000 | −200,000 | −1,100 | −1,800,000 | −29 | −37 | −50 | −17 | −49 |

Table 152 through Table 155 show reductions in vehicle emissions of air toxics. We expect this proposal would reduce emissions of air toxics from light- and medium-duty vehicles in three ways: The GPF technology that we project manufacturers would choose to use in meeting the proposed PM standards would decrease particle-phase pollutants, the NMOG+$NO_X$ standards would decrease gas-phase toxics, and the projected increase in BEVs we project manufacturers would choose to produce in complying with the GHG standards would result in lower air toxic emissions overall from the light- and medium-duty fleet.

For most air toxic emissions, we rely on estimates from EPA's MOVES emissions model. In MOVES, emissions of most gaseous toxic compounds are estimated as fractions of the emissions of VOC. Toxic species in the particulate phase (*e.g.,* polycyclic aromatic hydrocarbons (PAHs)) are estimated as fractions of total organic carbon smaller than 2.5 µm (OC2.5). Thus, reductions in air toxic emissions are proportional to modelled reductions in total VOCs and/or OC2.5.[768] Emission measurements of PAHs in EPA's recent GPF test program (see Section III.C.2 and DRIA Chapter 3.2.2) suggest this is a conservative estimate indicate reduction in emissions of particle-phase PAH compounds of over 99 percent, compared to about 95 percent for total PM.

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[768] U.S. EPA (2020) Air Toxic Emissions from Onroad Vehicles in MOVES3. Assessment and Standards Division, Office of Transportation and Air Quality. Report No. EPA–420–R–20–022. November 2020. *https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1010TJM.pdf.*

### TABLE 152—OMEGA ESTIMATED VEHICLE AIR TOXIC EMISSION IMPACTS OF THE PROPOSED STANDARDS RELATIVE TO THE NO ACTION SCENARIO, LIGHT-DUTY AND MEDIUM-DUTY

[U.S. tons per year]

| Calendar year | Acetaldehyde | Acrolein | Benzene | Ethylbenzene | Formaldehyde | Naphthalene | 1,3 Butadiene | 15 PAH |
|---|---|---|---|---|---|---|---|---|
| 2027 | −16 | −1 | −44 | −17 | −9.1 | −1.9 | −6.5 | −0.044 |
| 2028 | −38 | −2.4 | −110 | −53 | −22 | −4.7 | −16 | −0.11 |
| 2029 | −69 | −4.4 | −200 | −110 | −40 | −8.5 | −29 | −0.21 |
| 2030 | −100 | −6.6 | −310 | −190 | −60 | −13 | −43 | −0.43 |
| 2031 | −140 | −9.2 | −430 | −290 | −83 | −18 | −59 | −0.66 |
| 2032 | −190 | −12 | −570 | −400 | −110 | −23 | −78 | −0.9 |
| 2033 | −240 | −15 | −730 | −530 | −140 | −29 | −98 | −1.2 |
| 2034 | −290 | −19 | −900 | −680 | −170 | −36 | −120 | −1.4 |
| 2035 | −350 | −22 | −1100 | −850 | −200 | −42 | −140 | −1.7 |
| 2036 | −390 | −25 | −1200 | −1000 | −230 | −47 | −160 | −1.9 |
| 2037 | −430 | −28 | −1400 | −1200 | −250 | −53 | −180 | −2.2 |
| 2038 | −480 | −31 | −1500 | −1400 | −280 | −59 | −200 | −2.5 |
| 2039 | −520 | −34 | −1700 | −1600 | −310 | −64 | −210 | −2.7 |
| 2040 | −560 | −37 | −1800 | −1800 | −330 | −69 | −230 | −2.9 |
| 2041 | −610 | −39 | −2000 | −2000 | −360 | −74 | −250 | −3.2 |
| 2042 | −640 | −41 | −2100 | −2200 | −380 | −78 | −260 | −3.4 |
| 2043 | −670 | −44 | −2200 | −2300 | −400 | −82 | −270 | −3.6 |
| 2044 | −700 | −45 | −2300 | −2500 | −410 | −85 | −280 | −3.7 |
| 2045 | −720 | −47 | −2400 | −2600 | −430 | −88 | −290 | −3.9 |
| 2046 | −750 | −48 | −2500 | −2800 | −440 | −91 | −300 | −4.1 |
| 2047 | −760 | −49 | −2600 | −2900 | −450 | −93 | −310 | −4.2 |
| 2048 | −780 | −51 | −2600 | −3000 | −470 | −96 | −310 | −4.3 |
| 2049 | −800 | −52 | −2700 | −3100 | −480 | −98 | −320 | −4.4 |
| 2050 | −810 | −53 | −2800 | −3200 | −490 | −100 | −330 | −4.5 |
| 2051 | −820 | −54 | −2800 | −3300 | −490 | −100 | −330 | −4.5 |
| 2052 | −830 | −54 | −2800 | −3300 | −500 | −100 | −330 | −4.6 |
| 2053 | −840 | −55 | −2900 | −3300 | −500 | −100 | −330 | −4.6 |
| 2054 | −840 | −55 | −2900 | −3400 | −510 | −100 | −340 | −4.7 |
| 2055 | −840 | −55 | −2900 | −3400 | −510 | −100 | −340 | −4.7 |

### TABLE 153—ESTIMATED VEHICLE AIR TOXIC EMISSION IMPACTS OF THE ALTERNATIVE 1 STANDARDS RELATIVE TO THE NO ACTION SCENARIO, LIGHT-DUTY AND MEDIUM-DUTY

[U.S. tons per year]

| Calendar year | Acetaldehyde | Acrolein | Benzene | Ethylbenzene | Formaldehyde | Naphthalene | 1,3 Butadiene | 15 PAH |
|---|---|---|---|---|---|---|---|---|
| 2027 | −17 | −1.1 | −46 | −18 | −9.5 | −2 | −6.8 | −0.046 |
| 2028 | −41 | −2.6 | −120 | −56 | −23 | −5 | −17 | −0.12 |
| 2029 | −70 | −4.5 | −210 | −110 | −41 | −8.6 | −29 | −0.21 |
| 2030 | −110 | −7 | −330 | −200 | −63 | −13 | −45 | −0.44 |
| 2031 | −150 | −9.7 | −450 | −300 | −87 | −18 | −62 | −0.67 |
| 2032 | −200 | −13 | −600 | −420 | −110 | −24 | −81 | −0.91 |
| 2033 | −260 | −16 | −780 | −570 | −150 | −31 | −100 | −1.2 |
| 2034 | −310 | −20 | −970 | −740 | −180 | −38 | −130 | −1.5 |
| 2035 | −370 | −24 | −1100 | −930 | −210 | −45 | −150 | −1.7 |
| 2036 | −410 | −27 | −1300 | −1100 | −240 | −51 | −170 | −2 |
| 2037 | −470 | −30 | −1500 | −1300 | −270 | −57 | −190 | −2.3 |
| 2038 | −520 | −34 | −1700 | −1500 | −300 | −64 | −210 | −2.5 |
| 2039 | −570 | −37 | −1800 | −1800 | −330 | −69 | −230 | −2.8 |
| 2040 | −610 | −40 | −2000 | −2000 | −360 | −75 | −250 | −3 |
| 2041 | −660 | −42 | −2200 | −2200 | −390 | −81 | −270 | −3.2 |
| 2042 | −690 | −45 | −2300 | −2400 | −410 | −85 | −280 | −3.5 |
| 2043 | −730 | −47 | −2400 | −2600 | −430 | −90 | −300 | −3.7 |
| 2044 | −760 | −49 | −2500 | −2800 | −450 | −93 | −310 | −3.8 |
| 2045 | −790 | −51 | −2600 | −2900 | −470 | −97 | −320 | −4 |
| 2046 | −810 | −53 | −2800 | −3100 | −480 | −100 | −330 | −4.2 |
| 2047 | −830 | −54 | −2800 | −3200 | −490 | −100 | −340 | −4.3 |
| 2048 | −850 | −56 | −2900 | −3300 | −510 | −110 | −350 | −4.4 |
| 2049 | −870 | −57 | −3000 | −3400 | −520 | −110 | −350 | −4.5 |
| 2050 | −890 | −58 | −3000 | −3500 | −530 | −110 | −360 | −4.6 |
| 2051 | −900 | −59 | −3100 | −3600 | −540 | −110 | −360 | −4.7 |
| 2052 | −910 | −59 | −3100 | −3600 | −540 | −110 | −370 | −4.7 |
| 2053 | −910 | −60 | −3100 | −3700 | −550 | −110 | −370 | −4.8 |
| 2054 | −920 | −60 | −3100 | −3700 | −550 | −110 | −370 | −4.8 |
| 2055 | −920 | −60 | −3200 | −3700 | −550 | −110 | −370 | −4.8 |

### TABLE 154—ESTIMATED VEHICLE AIR TOXIC EMISSION IMPACTS OF THE ALTERNATIVE 2 STANDARDS RELATIVE TO THE NO ACTION SCENARIO, LIGHT-DUTY AND MEDIUM-DUTY

[U.S. tons per year]

| Calendar year | Acetaldehyde | Acrolein | Benzene | Ethylbenzene | Formaldehyde | Naphthalene | 1,3 Butadiene | 15 PAH |
|---|---|---|---|---|---|---|---|---|
| 2027 | −12 | −0.76 | −32 | −12 | −6.7 | −1.4 | −4.7 | −0.032 |
| 2028 | −27 | −1.8 | −78 | −38 | −16 | −3.3 | −11 | −0.08 |
| 2029 | −55 | −3.5 | −160 | −88 | −32 | −6.7 | −22 | −0.16 |
| 2030 | −82 | −5.3 | −240 | −150 | −48 | −10 | −34 | −0.38 |
| 2031 | −120 | −7.6 | −350 | −230 | −68 | −14 | −48 | −0.6 |
| 2032 | −160 | −10 | −480 | −320 | −93 | −19 | −64 | −0.83 |
| 2033 | −210 | −14 | −630 | −440 | −120 | −25 | −85 | −1.1 |
| 2034 | −260 | −17 | −790 | −580 | −150 | −32 | −110 | −1.4 |
| 2035 | −310 | −20 | −940 | −730 | −180 | −37 | −120 | −1.6 |
| 2036 | −340 | −22 | −1100 | −880 | −200 | −42 | −140 | −1.9 |
| 2037 | −390 | −25 | −1200 | −1000 | −230 | −48 | −160 | −2.1 |
| 2038 | −440 | −28 | −1400 | −1200 | −260 | −53 | −180 | −2.4 |
| 2039 | −480 | −31 | −1500 | −1400 | −280 | −58 | −190 | −2.6 |
| 2040 | −520 | −34 | −1700 | −1600 | −310 | −63 | −210 | −2.9 |
| 2041 | −550 | −36 | −1800 | −1700 | −330 | −68 | −220 | −3.1 |
| 2042 | −590 | −38 | −1900 | −1900 | −350 | −72 | −240 | −3.3 |
| 2043 | −620 | −40 | −2000 | −2100 | −370 | −76 | −250 | −3.5 |
| 2044 | −640 | −42 | −2100 | −2200 | −380 | −79 | −260 | −3.7 |
| 2045 | −660 | −43 | −2200 | −2400 | −400 | −81 | −270 | −3.8 |
| 2046 | −690 | −45 | −2300 | −2500 | −410 | −84 | −280 | −4 |
| 2047 | −700 | −46 | −2400 | −2600 | −420 | −86 | −280 | −4.1 |
| 2048 | −720 | −47 | −2400 | −2700 | −430 | −88 | −290 | −4.2 |
| 2049 | −740 | −48 | −2500 | −2800 | −440 | −90 | −300 | −4.3 |
| 2050 | −750 | −49 | −2500 | −2900 | −450 | −92 | −300 | −4.4 |
| 2051 | −760 | −50 | −2600 | −2900 | −460 | −93 | −300 | −4.5 |
| 2052 | −770 | −50 | −2600 | −3000 | −460 | −94 | −310 | −4.5 |
| 2053 | −770 | −51 | −2600 | −3000 | −460 | −94 | −310 | −4.5 |
| 2054 | −780 | −51 | −2600 | −3100 | −470 | −95 | −310 | −4.6 |
| 2055 | −780 | −51 | −2600 | −3100 | −470 | −95 | −310 | −4.6 |

### TABLE 155—ESTIMATED VEHICLE AIR TOXIC EMISSION IMPACTS OF THE ALTERNATIVE 3 STANDARDS RELATIVE TO THE NO ACTION SCENARIO, LIGHT-DUTY AND MEDIUM-DUTY

[U.S. tons per year]

| Calendar year | Acetaldehyde | Acrolein | Benzene | Ethylbenzene | Formaldehyde | Naphthalene | 1,3 Butadiene | 15 PAH |
|---|---|---|---|---|---|---|---|---|
| 2027 | −10 | −0.67 | −28 | −12 | −6 | −1.2 | −4.1 | −0.028 |
| 2028 | −25 | −1.6 | −71 | −36 | −14 | −3 | −10 | −0.073 |
| 2029 | −42 | −2.7 | −120 | −71 | −25 | −5.2 | −17 | −0.13 |
| 2030 | −68 | −4.4 | −200 | −120 | −40 | −8.3 | −28 | −0.34 |
| 2031 | −110 | −6.9 | −320 | −200 | −63 | −13 | −43 | −0.57 |
| 2032 | −150 | −10 | −460 | −300 | −90 | −19 | −63 | −0.81 |
| 2033 | −210 | −13 | −620 | −410 | −120 | −25 | −84 | −1.1 |
| 2034 | −260 | −17 | −800 | −560 | −150 | −32 | −110 | −1.3 |
| 2035 | −320 | −20 | −970 | −710 | −180 | −39 | −130 | −1.6 |
| 2036 | −360 | −23 | −1100 | −880 | −210 | −44 | −150 | −1.9 |
| 2037 | −410 | −27 | −1300 | −1100 | −240 | −50 | −170 | −2.1 |
| 2038 | −460 | −30 | −1400 | −1200 | −270 | −56 | −190 | −2.4 |
| 2039 | −510 | −33 | −1600 | −1400 | −300 | −62 | −210 | −2.6 |
| 2040 | −550 | −36 | −1800 | −1600 | −320 | −67 | −220 | −2.9 |
| 2041 | −590 | −38 | −1900 | −1800 | −350 | −72 | −240 | −3.1 |
| 2042 | −630 | −41 | −2000 | −2000 | −370 | −77 | −250 | −3.3 |
| 2043 | −660 | −43 | −2200 | −2200 | −390 | −81 | −270 | −3.5 |
| 2044 | −690 | −45 | −2300 | −2400 | −410 | −84 | −280 | −3.7 |
| 2045 | −710 | −46 | −2400 | −2600 | −420 | −88 | −290 | −3.9 |
| 2046 | −740 | −48 | −2500 | −2700 | −440 | −91 | −300 | −4 |
| 2047 | −760 | −49 | −2600 | −2800 | −450 | −93 | −310 | −4.2 |
| 2048 | −780 | −51 | −2600 | −3000 | −470 | −96 | −310 | −4.3 |
| 2049 | −800 | −52 | −2700 | −3100 | −480 | −98 | −320 | −4.4 |
| 2050 | −810 | −53 | −2800 | −3200 | −490 | −100 | −330 | −4.5 |
| 2051 | −820 | −54 | −2800 | −3200 | −490 | −100 | −330 | −4.5 |
| 2052 | −830 | −54 | −2800 | −3300 | −500 | −100 | −330 | −4.6 |
| 2053 | −840 | −55 | −2900 | −3300 | −500 | −100 | −340 | −4.6 |
| 2054 | −840 | −55 | −2900 | −3400 | −510 | −100 | −340 | −4.7 |
| 2055 | −850 | −55 | −2900 | −3400 | −510 | −100 | −340 | −4.7 |

### *B. How would the proposal affect air quality?*

In the very localized area in close proximity to roadways (*i.e.,* within 300–600 meters of the roadway), the decreases in vehicle emissions resulting from the proposal would decrease ambient levels of $PM_{2.5}$, $NO_2$, and other traffic-related pollutants described in Section II.C.8.

The changes in emissions that are presented in Section VII.A would also impact ambient levels of ozone, $PM_{2.5}$, $NO_2$, $SO_2$, CO, and air toxics over a larger geographic scale. Photochemical air quality modeling is necessary to predict these air quality impacts of the proposal's emissions changes, because many of these pollutants form in the atmosphere and their concentrations depend on many complex factors (including the spatial and temporal distribution of the emissions changes, atmospheric chemistry, and meteorology). EPA conducted an illustrative air quality modeling analysis of a regulatory scenario involving light- and medium-duty vehicle emission reductions and corresponding changes in ''upstream'' emission sources like EGU (electric generating unit) emissions and refinery emissions. Decisions about the emissions and other elements used in the air quality modeling were made early in the analytical process for the proposed rulemaking. Accordingly, the air quality analysis does not represent the proposal's regulatory scenario, nor does it reflect the expected impacts of the Inflation Reduction Act (IRA). Based on updated power sector modeling that incorporated expected generation mix impacts of the IRA, we are projecting the IRA will lead to a significantly cleaner power grid; nevertheless, the analysis provides some insights into potential air quality impacts associated with emissions increases and decreases from these multiple sectors. Chapter 8 of the DRIA provides details on the methodology, emissions inputs, and results of this illustrative air quality modeling.

On the basis of the exploratory air quality modeling, we conclude that in 2055 the proposal would result in widespread decreases in ozone, $PM_{2.5}$, $NO_2$, CO, and some air toxics, even when accounting for the impacts of increased electricity generation. While the results of the illustrative analysis include some increases in ambient pollutant concentrations, as the power sector becomes cleaner over time as a result of the IRA and future policies, these impacts would decrease. Although the specific locations of increased air pollution are uncertain, we expect them to be in more limited geographic areas, compared to the widespread decreases that we predict to result from the reductions in vehicle emissions.

## VIII. Estimated Costs and Benefits and Associated Considerations

This section presents a summary of costs, benefits, and net benefits plus additional considerations associated with these costs and benefits. We begin with a high-level summary in Section VIII.A. of this preamble, followed by more detailed content and discussion in subsequent subsections.

### *A. Summary of Costs and Benefits*

This section presents a high-level summary of monetized costs, benefits, and net benefits of the standards. Using the 3 percent average SC–GHG value for climate benefits, the net benefits for the proposal are $200 billion to $220 billion for calendar year (CY) 2055. The present value (PV) of net benefits for calendar years 2027 through 2055, with discounting to 2027, is $1.6 trillion using a 3 percent discount rate and $850 billion using a 7 percent discount rate. The equivalent annualized values (EAV) of those present values are $85 billion and $60 billion, respectively.[769]

Costs and benefits are categorized into non-emission costs, fueling impacts, non-emissions benefits, climate benefits, and criteria air pollutant benefits. Table 156 breaks down net benefits into costs and benefits for CY 2055, as well as present values (PV) and equivalent annualized values (EAV) using both 3 percent and 7 percent discount rates for all costs and benefits except for climate benefits. Table 156 shows the climate benefits using the central SC–GHG values at 5, 3 and 2.5 percent discount rate, as well as the 95th percentile values at 3 percent discount rate, and the associated net benefits.[770] The same discount rate used to discount the value of SC–GHGs (at 5, 3, and 2.5 percent) is used to calculate the present and equivalent annualized values of SC–GHGs for internal consistency, we discuss each of these categories in more depth in the following sections. We seek comment on the benefit-cost analysis.

Note that some non-emission costs are shown as negative values in Table 156. Those entries represent savings but are included as costs because, traditionally, things like repair and maintenance have been viewed as costs of vehicle operation. Where negative values are shown, we are estimating that those costs are lower in the proposal than in the no-action case. Congestion and noise costs are attributable to increased congestion and roadway noise resulting from our assumption that drivers may choose to drive more under the proposal versus the no action case. Those increased miles are known as rebound miles and are discussed in Section VIII.F.1 and Chapter 4 of the DRIA.

Similarly, some of the traditional benefits of rulemakings that result in lower fuel consumption by the transportation fleet, *i.e.,* the non-emission benefits, are shown as negative values. Our past GHG rules have estimated that time spent refueling vehicles would be reduced due to the lower fuel consumption of new vehicles; hence, a benefit. However, in this analysis, we are estimating that refueling time would increase somewhat due to our assumptions for mid-trip recharging events for electric vehicles. Therefore, the increased refueling time represents a disbenefit (a negative benefit) as shown. As noted in Section VIII.B.2, we consider our refueling time estimate to be dated considering the rapid changes taking place in electric vehicle charging infrastructure driven in no small part by the Inflation Reduction Act, and we request comment and data on how our estimates could be improved.

Table 157 through Table 159 show the same summary of benefits and costs for each of the three alternatives.

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[769] The equivalent annualized value (EAV) of benefits, costs, and net benefits represent a flow of constant annual values that, had they occurred in each year from 2027 to 2055, would yield an equivalent present value to those in each of the summary tables (using either a 3 percent or 7 percent discount rate).

[770] The 3 percent 95th percentile estimates are included to provide information on potentially higher-than-expected economic impacts from climate change, conditional on the 3 percent estimate of the discount rate.

TABLE 156—SUMMARY OF COSTS, FUEL SAVINGS AND BENEFITS OF THE PROPOSAL, LIGHT-DUTY AND MEDIUM-DUTY

[Billions of 2020 dollars] [a b c]

| | CY 2055 | PV, 3% | PV, 7% | EAV, 3% | EAV, 7% |
|---|---|---|---|---|---|
| **Non-Emission Costs** | | | | | |
| Vehicle Technology Costs | 10 | 280 | 180 | 15 | 15 |
| Repair Costs | −24 | −170 | −79 | −8.9 | −6.5 |
| Maintenance Costs | −51 | −410 | −200 | −21 | −16 |
| Congestion Costs | 0.16 | 2.3 | 1.3 | 0.12 | 0.11 |
| Noise Costs | 0.0025 | 0.037 | 0.021 | 0.0019 | 0.0017 |
| Sum of Non-Emission Costs | −65 | −290 | −96 | −15 | −7.8 |
| **Fueling Impacts** | | | | | |
| Pre-tax Fuel Savings | 93 | 890 | 450 | 46 | 37 |
| EVSE Port Costs | 7.1 | 120 | 68 | 6.2 | 5.6 |
| Sum of Fuel Savings less EVSE Port Costs | 86 | 770 | 380 | 40 | 31 |
| **Non-Emission Benefits** | | | | | |
| Drive Value Benefits | 0.31 | 4.8 | 2.7 | 0.25 | 0.22 |
| Refueling Time Benefits | −8.2 | −85 | −45 | −4.4 | −3.6 |
| Energy Security Benefits | 4.4 | 41 | 21 | 2.2 | 1.7 |
| Sum of Non-Emission Benefits | −3.6 | −39 | −21 | −2 | −1.7 |
| **Climate Benefits** | | | | | |
| 5% Average | 15 | 82 | 82 | 5.4 | 5.4 |
| 3% Average | 38 | 330 | 330 | 17 | 17 |
| 2.5% Average | 52 | 500 | 500 | 25 | 25 |
| 3% 95th Percentile | 110 | 1,000 | 1,000 | 52 | 52 |
| **Criteria Air Pollutant Benefits** | | | | | |
| $PM_{2.5}$ Health Benefits—Wu et al., 2020 | 16–18 | 140 | 63 | 7.5 | 5.1 |
| $PM_{2.5}$ Health Benefits—Pope III et al., 2019 | 31–34 | 280 | 130 | 15 | 10 |
| **Net Benefits** | | | | | |
| With Climate 5% Average | 180–200 | 1,400 | 610 | 74 | 48 |
| With Climate 3% Average | 200–220 | 1,600 | 850 | 85 | 60 |
| With Climate 2.5% Average | 210–230 | 1,800 | 1,000 | 93 | 67 |
| With Climate 3% 95th Percentile | 280–290 | 2,300 | 1,500 | 120 | 95 |

[a] The same discount rate used to discount the value of damages from future emissions (SC–GHG at 5, 3, 2.5 percent) is used to calculate present and equivalent annualized values of SC–GHGs for internal consistency, while all other costs and benefits are discounted at either 3 percent or 7 percent.

[b] $PM_{2.5}$-related health benefits are presented based on two different long-term exposure studies of mortality risk: a Medicare study (Wu et al., 2020) and a National Health Interview Survey study (Pope III et al., 2019). The criteria pollutant benefits associated with the standards presented here do not include the full complement of health and environmental benefits that, if quantified and monetized, would increase the total monetized benefits.

[c] For net benefits, the range in 2055 uses the low end of the Wu et al. (2020) range and the high end of the Pope III et al. (2019) range. The present and equivalent annualized value of net benefits for a 3 percent discount rate reflect benefits based on the Pope III et al. (2019) study while the present and equivalent annualized values of net benefits for a 7 percent discount rate reflect benefits based on the Wu et al. (2020) study.

TABLE 157—SUMMARY OF COSTS, FUEL SAVINGS AND BENEFITS OF THE ALTERNATIVE 1, LIGHT-DUTY AND MEDIUM-DUTY

[Billions of 2020 dollars] [a b c]

| | CY 2055 | PV, 3% | PV, 7% | EAV, 3% | EAV, 7% |
|---|---|---|---|---|---|
| **Non-Emission Costs** | | | | | |
| Vehicle Technology Costs | 11 | 330 | 220 | 17 | 18 |
| Repair Costs | −26 | −180 | −82 | −9.3 | −6.7 |
| Maintenance Costs | −57 | −450 | −220 | −24 | −18 |
| Congestion Costs | 0.11 | 3.5 | 2.2 | 0.18 | 0.18 |
| Noise Costs | 0.0017 | 0.055 | 0.034 | 0.0028 | 0.0027 |
| Sum of Non-Emission Costs | −71 | −300 | −82 | −15 | −6.7 |
| **Fueling Impacts** | | | | | |
| Pre-tax Fuel Savings | 100 | 990 | 510 | 51 | 41 |
| EVSE Port Costs | 7.1 | 120 | 68 | 6.2 | 5.6 |
| Sum of Fuel Savings less EVSE Port Costs | 95 | 870 | 440 | 45 | 36 |
| **Non-Emission Benefits** | | | | | |
| Drive Value Benefits | 0.22 | 6.5 | 3.9 | 0.34 | 0.32 |
| Refueling Time Benefits | −8.8 | −90 | −47 | −4.7 | −3.8 |
| Energy Security Benefits | 4.8 | 46 | 23 | 2.4 | 1.9 |
| Sum of Non-Emission Benefits | −3.8 | −38 | −20 | −2 | −1.6 |
| **Climate Benefits** | | | | | |
| 5% Average | 16 | 91 | 91 | 6 | 6 |
| 3% Average | 41 | 360 | 360 | 19 | 19 |

TABLE 157—SUMMARY OF COSTS, FUEL SAVINGS AND BENEFITS OF THE ALTERNATIVE 1, LIGHT-DUTY AND MEDIUM-DUTY—Continued

[Billions of 2020 dollars] [a b c]

| | CY 2055 | PV, 3% | PV, 7% | EAV, 3% | EAV, 7% |
|---|---|---|---|---|---|
| 2.5% Average | 57 | 560 | 560 | 27 | 27 |
| 3% 95th Percentile | 120 | 1,100 | 1,100 | 58 | 58 |
| **Criteria Air Pollutant Benefits** | | | | | |
| PM$_{2.5}$ Health Benefits—Wu et al., 2020 | 16–18 | 150 | 66 | 7.7 | 5.3 |
| PM$_{2.5}$ Health Benefits—Pope III et al., 2019 | 32–35 | 290 | 130 | 15 | 11 |
| **Net Benefits** | | | | | |
| With Climate 5% Average | 200–210 | 1,500 | 660 | 80 | 52 |
| With Climate 3% Average | 220–240 | 1,800 | 930 | 93 | 65 |
| With Climate 2.5% Average | 240–260 | 2,000 | 1,100 | 100 | 73 |
| With Climate 3% 95th Percentile | 300–320 | 2,500 | 1,700 | 130 | 100 |

[a] The same discount rate used to discount the value of damages from future emissions (SC–GHG at 5, 3, 2.5 percent) is used to calculate present and equivalent annualized values of SC–GHGs for internal consistency, while all other costs and benefits are discounted at either 3 percent or 7 percent.

[b] PM$_{2.5}$-related health benefits are presented based on two different long-term exposure studies of mortality risk: a Medicare study (Wu et al., 2020) and a National Health Interview Survey study (Pope III et al., 2019). The criteria pollutant benefits associated with the standards presented here do not include the full complement of health and environmental benefits that, if quantified and monetized, would increase the total monetized benefits.

[c] For net benefits, the range in 2055 uses the low end of the Wu et al. (2020) range and the high end of the Pope III et al. (2019) range. The present and equivalent annualized value of net benefits for a 3 percent discount rate reflect benefits based on the Pope III et al. (2019) study while the present and equivalent annualized values of net benefits for a 7 percent discount rate reflect benefits based on the Wu et al. (2020) study.

TABLE 158—SUMMARY OF COSTS, FUEL SAVINGS AND BENEFITS OF THE ALTERNATIVE 2, LIGHT-DUTY AND MEDIUM-DUTY

[Billions of 2020 dollars] [a b c]

| | CY 2055 | PV, 3% | PV, 7% | EAV, 3% | EAV, 7% |
|---|---|---|---|---|---|
| **Non-Emission Costs** | | | | | |
| Vehicle Technology Costs | 8.8 | 230 | 140 | 12 | 12 |
| Repair Costs | −22 | −160 | −74 | −8.3 | −6 |
| Maintenance Costs | −47 | −370 | −180 | −19 | −14 |
| Congestion Costs | 0.064 | 0.74 | 0.48 | 0.039 | 0.039 |
| Noise Costs | 0.001 | 0.012 | 0.0078 | 0.00064 | 0.00064 |
| Sum of Non-Emission Costs | −60 | −300 | −110 | −16 | −8.7 |
| **Fueling Impacts** | | | | | |
| Pre-tax Fuel Savings | 84 | 790 | 400 | 41 | 33 |
| EVSE Port Costs | 7.1 | 120 | 68 | 6.2 | 5.6 |
| Sum of Fuel Savings less EVSE Port Costs | 77 | 680 | 330 | 35 | 27 |
| **Non-Emission Benefits** | | | | | |
| Drive Value Benefits | 0.17 | 2.4 | 1.5 | 0.12 | 0.12 |
| Refueling Time Benefits | −7.6 | −79 | −41 | −4.1 | −3.3 |
| Energy Security Benefits | 3.9 | 37 | 19 | 1.9 | 1.5 |
| Sum of Non-Emission Benefits | −3.5 | −39 | −21 | −2 | −1.7 |
| **Climate Benefits** | | | | | |
| 5% Average | 13 | 74 | 74 | 4.9 | 4.9 |
| 3% Average | 34 | 290 | 290 | 15 | 15 |
| 2.5% Average | 47 | 450 | 450 | 22 | 22 |
| 3% 95th Percentile | 100 | 900 | 900 | 47 | 47 |
| **Criteria Air Pollutant Benefits** | | | | | |
| PM$_{2.5}$ Health Benefits—Wu et al., 2020 | 15–17 | 140 | 61 | 7.2 | 4.9 |
| PM$_{2.5}$ Health Benefits—Pope III et al., 2019 | 30–33 | 270 | 120 | 14 | 10 |
| **Net Benefits** | | | | | |
| With Climate 5% Average | 160–180 | 1,300 | 550 | 68 | 44 |
| With Climate 3% Average | 180–200 | 1,500 | 780 | 78 | 54 |
| With Climate 2.5% Average | 200–210 | 1,700 | 930 | 85 | 61 |
| With Climate 3% 95th Percentile | 250–270 | 2,100 | 1,400 | 110 | 86 |

[a] The same discount rate used to discount the value of damages from future emissions (SC–GHG at 5, 3, 2.5 percent) is used to calculate present and equivalent annualized values of SC–GHGs for internal consistency, while all other costs and benefits are discounted at either 3 percent or 7 percent.

[b] PM$_{2.5}$-related health benefits are presented based on two different long-term exposure studies of mortality risk: a Medicare study (Wu et al., 2020) and a National Health Interview Survey study (Pope III et al., 2019). The criteria pollutant benefits associated with the standards presented here do not include the full complement of health and environmental benefits that, if quantified and monetized, would increase the total monetized benefits.

[c] For net benefits, the range in 2055 uses the low end of the Wu et al. (2020) range and the high end of the Pope III et al. (2019) range. The present and equivalent annualized value of net benefits for a 3 percent discount rate reflect benefits based on the Pope III et al. (2019) study while the present and equivalent annualized values of net benefits for a 7 percent discount rate reflect benefits based on the Wu et al. (2020) study.

TABLE 159—SUMMARY OF COSTS, FUEL SAVINGS AND BENEFITS OF THE ALTERNATIVE 3, LIGHT-DUTY AND MEDIUM-DUTY

[Billions of 2020 dollars] [a] [b] [c]

| | CY 2055 | PV, 3% | PV, 7% | EAV, 3% | EAV, 7% |
|---|---|---|---|---|---|
| **Non-Emission Costs** | | | | | |
| Vehicle Technology Costs | 11 | 270 | 170 | 14 | 14 |
| Repair Costs | −24 | −170 | −77 | −8.6 | −6.3 |
| Maintenance Costs | −51 | −390 | −190 | −20 | −15 |
| Congestion Costs | 0.11 | 1.5 | 0.82 | 0.078 | 0.066 |
| Noise Costs | 0.0016 | 0.024 | 0.013 | 0.0012 | 0.0011 |
| Sum of Non-Emission Costs | −64 | −290 | −95 | −15 | −7.8 |
| **Fueling Impacts** | | | | | |
| Pre-tax Fuel Savings | 93 | 850 | 430 | 45 | 35 |
| EVSE Port Costs | 7.1 | 120 | 68 | 6.2 | 5.6 |
| Sum of Fuel Savings less EVSE Port Costs | 86 | 740 | 360 | 38 | 29 |
| **Non-Emission Benefits** | | | | | |
| Drive Value Benefits | 0.21 | 3.2 | 1.8 | 0.17 | 0.15 |
| Refueling Time Benefits | −8.2 | −83 | −43 | −4.3 | −3.5 |
| Energy Security Benefits | 4.4 | 40 | 20 | 2.1 | 1.6 |
| Sum of Non-Emission Benefits | −3.6 | −39 | −21 | −2.1 | −1.7 |
| **Climate Benefits** | | | | | |
| 5% Average | 15 | 80 | 80 | 5.3 | 5.3 |
| 3% Average | 38 | 320 | 320 | 17 | 17 |
| 2.5% Average | 52 | 490 | 490 | 24 | 24 |
| 3% 95th Percentile | 110 | 970 | 970 | 51 | 51 |
| **Criteria Air Pollutant Benefits** | | | | | |
| $PM_{2.5}$ Health Benefits—Wu et al., 2020 | 16–18 | 140 | 62 | 7.3 | 5.0 |
| $PM_{2.5}$ Health Benefits—Pope III et al., 2019 | 31–34 | 280 | 120 | 14 | 10 |
| **Net Benefits** | | | | | |
| With Climate 5% Average | 180–190 | 1,300 | 580 | 71 | 46 |
| With Climate 3% Average | 200–220 | 1,600 | 820 | 82 | 57 |
| With Climate 2.5% Average | 210–230 | 1,800 | 990 | 90 | 64 |
| With Climate 3% 95th Percentile | 270–290 | 2,200 | 1,500 | 120 | 91 |

[a] The same discount rate used to discount the value of damages from future emissions (SC–GHG at 5, 3, 2.5 percent) is used to calculate present and equivalent annualized values of SC–GHGs for internal consistency, while all other costs and benefits are discounted at either 3 percent or 7 percent.

[b] $PM_{2.5}$-related health benefits are presented based on two different long-term exposure studies of mortality risk: a Medicare study (Wu et al., 2020) and a National Health Interview Survey study (Pope III et al., 2019). The criteria pollutant benefits associated with the standards presented here do not include the full complement of health and environmental benefits that, if quantified and monetized, would increase the total monetized benefits.

[c] For net benefits, the range in 2055 uses the low end of the Wu et al. (2020) range and the high end of the Pope III et al. (2019) range. The present and equivalent annualized value of net benefits for a 3 percent discount rate reflect benefits based on the Pope III et al. (2019) study while the present and equivalent annualized values of net benefits for a 7 percent discount rate reflect benefits based on the Wu et al. (2020) study.

## *B. Vehicle Cost and Fueling Impacts*

### 1. Vehicle Technology and Purchase Price Impacts

Table 160 shows the estimated annual vehicle technology costs of the program for the indicated calendar years (CY). The table also shows the present-values (PV) of those costs and the equivalent annualized values (EAV) for the calendar years 2027–2055 using both 3 percent and 7 percent discount rates.[771]

We expect the technology costs of the program will result in a rise in the average purchase price for consumers, for both new and used vehicles. While we expect that vehicle manufacturers will strategically price vehicles (*e.g.,* subsidizing a lower price for some vehicles with a higher price for others), we assume in our modeling that increased vehicle technology costs will fully impact purchase prices paid by consumers. These projected vehicle technology costs represent the incremental costs to manufacturers. For consumers, projected vehicle technology costs are offset by savings in reduced operating costs, including fuel savings and reduced maintenance and repair costs, as discussed in Section VIII.B.3 and in Chapter 4 of the DRIA. Additionally, consumers may also benefit from IRA purchase incentives for PEVs.

TABLE 160—VEHICLE TECHNOLOGY COSTS ASSOCIATED WITH THE PROPOSAL AND EACH ALTERNATIVE, LIGHT-DUTY AND MEDIUM-DUTY

[Billions of 2020 dollars]

| Calendar year | Vehicle technology costs, proposal | Vehicle technology costs, alternative 1 | Vehicle technology costs, alternative 2 | Vehicle technology costs, alternative 3 |
|---|---|---|---|---|
| 2027 | 7.5 | 7.9 | 5.5 | 2.6 |

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[771] For the estimation of the stream of costs and benefits, we assume that after implementation of the MY 2027 and later standards, the MY 2032 standards apply to each year thereafter.

Table 160—Vehicle Technology Costs Associated With the Proposal and Each Alternative, Light-Duty and Medium-Duty—Continued

[Billions of 2020 dollars]

| Calendar year | Vehicle technology costs, proposal | Vehicle technology costs, alternative 1 | Vehicle technology costs, alternative 2 | Vehicle technology costs, alternative 3 |
|---|---|---|---|---|
| 2028 | 6.8 | 10 | 5 | 2.3 |
| 2029 | 6.6 | 14 | 5.8 | 1.8 |
| 2030 | 8.7 | 17 | 6.1 | 4.9 |
| 2031 | 13 | 20 | 11 | 12 |
| 2032 | 17 | 23 | 15 | 18 |
| 2035 | 22 | 24 | 17 | 24 |
| 2040 | 19 | 20 | 15 | 18 |
| 2045 | 13 | 13 | 10 | 13 |
| 2050 | 12 | 13 | 10 | 12 |
| 2055 | 10 | 11 | 8.8 | 11 |
| PV3 | 280 | 330 | 230 | 270 |
| PV7 | 180 | 220 | 140 | 170 |
| EAV3 | 15 | 17 | 12 | 14 |
| EAV7 | 15 | 18 | 12 | 14 |

### 2. Fueling Impacts

### i. Fuel Savings

The proposed standards are projected to reduce liquid fuel consumption (gasoline and diesel) while simultaneously increasing electricity consumption. The net effect of these changes in consumption for consumers is decreased fuel expenditures or fuel savings. Electric Vehicle Supply Equipment (EVSE) port costs, which reflect capital costs for procuring and installing PEV charging infrastructure, are also shown. For more information regarding fuel consumption, including other considerations like rebound driving, see DRIA Chapter 4. See Section IV of this Preamble and Chapter 5 of the DRIA for more detail on EVSE port costs.

Fuel savings arise from reduced expenditures on liquid-fuel due to reduced consumption of those fuels. Electricity consumption is expected to increase, with a corresponding increase in expenditures, due to electric vehicles replacing liquid-fueled vehicles. We describe how we calculate reduced fuel consumption and increased electricity consumption in Chapter 9 of the DRIA. Table 161 presents liquid-fuel consumption impacts and Table 162 presents electricity consumption impacts.

Table 161—Liquid-Fuel Consumption Impacts Associated With the Proposal and Each of the Alternatives, Light-Duty and Medium-Duty

[Billions of gallons of liquid fuel]

| Calendar year | Liquid-fuel impacts, proposal | Liquid-fuel impacts, alternative 1 | Liquid-fuel impacts, alternative 2 | Liquid-Fuel impacts, alternative 3 |
|---|---|---|---|---|
| 2027 | −0.89 | −0.93 | −0.65 | −0.53 |
| 2028 | −2.2 | −2.5 | −1.6 | −1.3 |
| 2029 | −4 | −4.4 | −3.2 | −2.3 |
| 2030 | −6.1 | −7 | −4.9 | −3.9 |
| 2031 | −8.6 | −9.8 | −7 | −6.3 |
| 2032 | −12 | −13 | −9.6 | −9.3 |
| 2035 | −21 | −23 | −19 | −19 |
| 2040 | −34 | −38 | −31 | −33 |
| 2045 | −42 | −47 | −38 | −42 |
| 2050 | −48 | −52 | −43 | −48 |
| 2055 | −49 | −54 | −44 | −49 |
| sum | −900 | −1,000 | −810 | −870 |

Table 162—Electricity Consumption Impacts Associated With the Proposal and Each of the Alternatives, Light-Duty and Medium-Duty

[Terawatt hours]

| Calendar year | Electricity impacts, proposal | Electricity impacts, alternative 1 | Electricity impacts, alternative 2 | Electricity impacts, alternative 3 |
|---|---|---|---|---|
| 2027 | 8.9 | 9.3 | 6.4 | 5.4 |
| 2028 | 21 | 23 | 15 | 13 |
| 2029 | 38 | 39 | 29 | 22 |
| 2030 | 56 | 61 | 44 | 36 |
| 2031 | 78 | 84 | 64 | 58 |
| 2032 | 100 | 110 | 86 | 85 |
| 2035 | 190 | 200 | 170 | 170 |

TABLE 162—ELECTRICITY CONSUMPTION IMPACTS ASSOCIATED WITH THE PROPOSAL AND EACH OF THE ALTERNATIVES, LIGHT-DUTY AND MEDIUM-DUTY—Continued

[Terawatt hours]

| Calendar year | Electricity impacts, proposal | Electricity impacts, alternative 1 | Electricity impacts, alternative 2 | Electricity impacts, alternative 3 |
|---|---|---|---|---|
| 2040 | 300 | 330 | 280 | 290 |
| 2045 | 380 | 420 | 350 | 380 |
| 2050 | 430 | 470 | 390 | 430 |
| 2055 | 440 | 490 | 400 | 440 |
| sum | 8,100 | 8,900 | 7,400 | 7,900 |

Table 163 presents the retail fuel savings, net of savings in liquid fuel expenditures and increases in electricity expenditures. These represent savings that consumers would realize. Table 164 presents the pretax fuel savings, net of savings in liquid fuel expenditures and increases in electricity expenditures. These represent the savings included in the net benefit calculation since fuel taxes do not contribute to the value of the fuel. We present fuel tax impacts along with other transfers in Section VIII.B.4. The net benefits calculation also includes the EVSE costs presented in Table 165.

The estimated present value pre-tax fuel savings associated with the proposed standards are $450 billion and $890 billion using 7 and 3 percent discount rates, respectively. Table 163 and Table 164 also show the undiscounted annual monetized fuel savings and the present value (PV) of those costs and equivalent annualized value (EAV) for the calendar years 2027–2055 using both 3 percent and 7 percent discount rates.

TABLE 163—RETAIL FUEL SAVINGS ASSOCIATED WITH THE PROPOSAL AND EACH ALTERNATIVE, LIGHT-DUTY AND MEDIUM-DUTY

[Billions of 2020 dollars] *

| Calendar year | Retail fuel savings, proposal | Retail fuel savings, alternative 1 | Retail fuel savings, alternative 2 | Retail fuel savings, alternative 3 |
|---|---|---|---|---|
| 2027 | 1.2 | 1.3 | 0.9 | 0.7 |
| 2028 | 3.2 | 3.7 | 2.4 | 1.9 |
| 2029 | 6 | 7 | 4.8 | 3.5 |
| 2030 | 10 | 12 | 8.1 | 6.5 |
| 2031 | 14 | 17 | 12 | 11 |
| 2032 | 20 | 23 | 17 | 16 |
| 2035 | 39 | 44 | 34 | 35 |
| 2040 | 69 | 77 | 61 | 66 |
| 2045 | 89 | 98 | 80 | 87 |
| 2050 | 100 | 110 | 93 | 100 |
| 2055 | 110 | 120 | 98 | 110 |
| PV3 | 1,100 | 1,200 | 950 | 1,000 |
| PV7 | 550 | 610 | 490 | 520 |
| EAV3 | 56 | 62 | 50 | 54 |
| EAV7 | 45 | 50 | 40 | 42 |

* Positive values represent monetary savings.

TABLE 164—PRETAX FUEL SAVINGS ASSOCIATED WITH THE PROPOSAL AND EACH ALTERNATIVE, LIGHT-DUTY AND MEDIUM-DUTY

[Billions of 2020 dollars] *

| Calendar year | Pretax fuel savings, proposal | Pretax fuel savings, alternative 1 | Pretax fuel savings, alternative 2 | Pretax fuel savings, alternative 3 |
|---|---|---|---|---|
| 2027 | 0.9 | 0.9 | 0.7 | 0.5 |
| 2028 | 2.4 | 2.8 | 1.8 | 1.5 |
| 2029 | 4.7 | 5.4 | 3.7 | 2.7 |
| 2030 | 7.7 | 9.2 | 6.2 | 5 |
| 2031 | 11 | 13 | 9.2 | 8.2 |
| 2032 | 16 | 18 | 13 | 13 |
| 2035 | 31 | 35 | 27 | 28 |
| 2040 | 56 | 63 | 50 | 54 |
| 2045 | 74 | 82 | 66 | 73 |
| 2050 | 88 | 97 | 79 | 87 |
| 2055 | 93 | 100 | 84 | 93 |
| PV3 | 890 | 990 | 790 | 850 |
| PV7 | 450 | 510 | 400 | 430 |
| EAV3 | 46 | 51 | 41 | 45 |

TABLE 164—PRETAX FUEL SAVINGS ASSOCIATED WITH THE PROPOSAL AND EACH ALTERNATIVE, LIGHT-DUTY AND MEDIUM-DUTY—Continued

[Billions of 2020 dollars] *

| Calendar year | Pretax fuel savings, proposal | Pretax fuel savings, alternative 1 | Pretax fuel savings, alternative 2 | Pretax fuel savings, alternative 3 |
|---|---|---|---|---|
| EAV7 | 37 | 41 | 33 | 35 |

* Positive values represent monetary savings.

TABLE 165—EVSE COSTS ASSOCIATED WITH THE PROPOSAL AND EACH ALTERNATIVE, LIGHT-DUTY AND MEDIUM-DUTY

[Billions of 2020 dollars] *

| Calendar year | EVSE costs, proposal and each alternative |
|---|---|
| 2027 | 1.3 |
| 2028 | 0.66 |
| 2029 | 1.1 |
| 2030 | 1.1 |
| 2031 | 8.3 |
| 2032 | 8.3 |
| 2035 | 6.7 |
| 2040 | 7.1 |
| 2045 | 7.3 |
| 2050 | 7.1 |
| 2055 | 7.1 |
| PV3 | 120 |
| PV7 | 68 |
| EAV3 | 6.2 |
| EAV7 | 5.6 |

* Positive values represent costs.

### ii. Refueling Time

In our analyses, we take into account refueling differences among liquid fuel vehicles, BEVs, and PHEVs. Stringent GHG standards have traditionally resulted in lower fuel consumption by liquid fueled vehicles. Provided fuel tanks on liquid fueled vehicles retain their capacity, lower fuel consumption is expected to reduce the frequency of refueling events and therefore reduce the time spent refueling resulting from less time spent seeking a refueling opportunity. OEMs may also elect to package smaller fuel tanks, leveraging lower fuel consumption to meet vehicle range, which would also lower the time spent refueling resulting from less time spent at the fuel pump. Consistent with past analyses, we have estimated the former of these possibilities with respect to liquid fueled vehicles.

Electric vehicles are fueled via charging events. Many charging events are expected to occur at an owner's residence via a personally owned charge point or during work hours using an employer owned charge point, both of which impose very little time burden on the driver. However, charging events will also occur in public places where the burden on the driver's time may be relatively long (*e.g.,* when drivers are in the midst of an extended road trip). Thus, liquid fueling events and mid-trip charging events are the focus of our refueling time analysis. See DRIA Chapter 4 for a more detailed discussion of this analysis. We request comment on our approach, specifically regarding the charging time for PEVs.

Note that the benefits associated with reduced refueling time are shown in Table 166 as negative values. In other words, we have estimated disbenefits associated with refueling time. The disbenefit arises from the time associated with BEV mid-trip refueling, which is estimated to result in more time spent refueling relative to our no-action scenario. As noted, we request comment on our approach which, in its current form is taken from the 2021 rule and given the pace of change in the BEV charging infrastructure and the presence of the IRA, can already be considered somewhat dated.

TABLE 166—REFUELING BENEFITS FROM TIME SAVED ASSOCIATED WITH THE PROPOSAL AND EACH ALTERNATIVE, LIGHT-DUTY AND MEDIUM-DUTY

[Billions of 2020 dollars] *

| Calendar year | Benefits associated with reduced refueling time, proposal | Benefits associated with reduced refueling time, alternative 1 | Benefits associated with reduced refueling time, alternative 2 | Benefits associated with reduced refueling time, alternative 3 |
|---|---|---|---|---|
| 2027 | −0.1 | −0.2 | −0.1 | −0.1 |
| 2028 | −0.36 | −0.38 | −0.27 | −0.25 |
| 2029 | −0.67 | −0.67 | −0.55 | −0.47 |
| 2030 | −1 | −1.1 | −0.88 | −0.78 |
| 2031 | −1.5 | −1.5 | −1.2 | −1.2 |
| 2032 | −1.9 | −1.9 | −1.6 | −1.6 |

TABLE 166—REFUELING BENEFITS FROM TIME SAVED ASSOCIATED WITH THE PROPOSAL AND EACH ALTERNATIVE, LIGHT-DUTY AND MEDIUM-DUTY—Continued

[Billions of 2020 dollars] *

| Calendar year | Benefits associated with reduced refueling time, proposal | Benefits associated with reduced refueling time, alternative 1 | Benefits associated with reduced refueling time, alternative 2 | Benefits associated with reduced refueling time, alternative 3 |
|---|---|---|---|---|
| 2035 | −3.4 | −3.5 | −3.1 | −3.2 |
| 2040 | −5.5 | −5.8 | −5.1 | −5.4 |
| 2045 | −6.9 | −7.4 | −6.5 | −6.9 |
| 2050 | −7.9 | −8.4 | −7.3 | −7.8 |
| 2055 | −8.2 | −8.8 | −7.6 | −8.2 |
| PV3 | −85 | −90 | −79 | −83 |
| PV7 | −45 | −47 | −41 | −43 |
| EAV3 | −4.4 | −4.7 | −4.1 | −4.3 |
| EAV7 | −3.6 | −3.8 | −3.3 | −3.5 |

* Negative values represent disbenefits.

### 3. Other Purchase Price and Fueling Considerations Affecting Consumers

The analysis monetizes vehicle technology costs and fueling impacts and informs net benefits associated with the standards. It also reflects impacts on consumers. In addition to the effects that we monetize, we look more closely into, but do not monetize, the effects of the standards on low-income households and on consumers of low-priced new vehicles and used vehicles. These effects depend, in large part, on two elements of vehicle ownership, namely (a) the purchase prices of vehicles and (b) fueling expenditures. Typically, the introduction of more stringent standards leads to higher purchase prices and lower fuel expenditures. The net effect varies across households. However, the reduction in fuel expenditures may be especially relevant for low-income households and consumers in the used and low-priced new vehicle markets. First, fuel expenditures are a larger portion of expenses for low-income households compared to higher income households. Second, lower-priced new vehicles have historically been more fuel efficient. Third, fuel economy and therefore fuel savings do not decline as vehicles age even though the price paid for vehicles typically declines as vehicles age and are resold. Fourth, low-income households are more likely to purchase lower-priced new vehicles and used vehicles (Hutchens et al. 2021), capturing their associated fuel savings.

Furthermore, for many vehicle consumers, access to credit for vehicle purchases is essential and may be of particular concern for low-income households. The effects of the standards on access to credit is influenced by the potentially countervailing forces of vehicle purchase costs and fuel costs. However, the degree of influence and the net effect is not clear (see Chapter 8.4.3 of the 2021 rule). Increased purchase prices and presumably higher loan principal may, in some cases, discourage lending, while reduced fuel expenditures may, in some cases, improve lenders' perceptions of borrowers' repayment reliability.

Finally, while access to conventional fuels can be assumed for the most part, the number and density of charging stations varies considerably.[772] Public and private charging infrastructure has been expanding alongside PEV adoption and is generally expected to continue to grow, particularly in light of public and private investments and consistent with local level priorities.[773] [774] This includes home charging events, which are likely to continue to grow with PEV adoption but are also expected to represent a declining proportion of charging events as PEV share increases and more drivers without easy access to home charging adopt PEVs and therefore use public charging.[775] Thus, publicly accessible charging is an important consideration, especially among renters and residents of multi-family housing and persons who charge away from home.[776] Households without access to charging at home or the workplace may incur additional charging costs, though there is ongoing interest in and development of alternative charging solutions (*e.g.,* curbside charging or use of mobile charging units) and business models (*e.g.,* providing charging as an amenity or as a subscription service for multi-family housing).[777] Though, especially among consumers who rely upon public charging, the higher price of public charging is important, improvements in access and availability to both public and private charging are expected, bolstered by private and public investment in charging infrastructure, including the recent Federal investments provided by the CHIPS Act, the BIL and the IRA, which will allow for increased investment along the vehicle supply chain, including charging infrastructure.[778] Please see Section IV.C.4 and Chapter 5 of the DRIA for a more detailed discussion of public and private investments in charging infrastructure, and our assessment of infrastructure needs and costs under this proposal.

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[772] *https://afdc.energy.gov/fuels/electricity_locations.html,* accessed 3/8/2022.

[773] Bui, Anh, Peter Slowik, and Nic Lutsey. 2020. Update on electric vehicle adoption across U.S. cities. International Council on Clean Transportation. *https://theicct.org/wp-content/uploads/2021/06/EV-cities-update-aug2020.pdf.*

[774] Greschak, Tressa, Matilda Kreider, and Nathan Legault. 2022. ''Consumer Adoption of Electric Vehicles: An Evaluation of Local Programs in the United States.'' School for Environment and Sustainability, University of Michigan, Ann Arbor, MI. *https://deepblue.lib.umich.edu/handle/2027.42/172221.*

[775] Ge, Yanbo, Christina Simeone, Andrew Duvall, and Andrew Wood. 2021. There's No Place Like Home: Residential Parking, Electrical Access, and Implications for the Future of Electric Vehicle Charging Infrastructure. NREL/TP–5400–81065, Golden, CO: National Renewable Energy Laboratory. *https://www.nrel.gov/docs/fy22osti/81065.pdf.*

[776] *https://advocacy.consumerreports.org/wp-content/uploads/2022/09/EV-Demographic-Survey-English-final.pdf.*

[777] Matt Alexander, Noel Crisostomo, Wendell Krell, Jeffrey Lu, Raja Ramesh, ''Assembly Bill 2127: Electric Vehicle Charging Infrastructure Assessment,'' July 2021, California Energy Commission. Accessed March 9, 2023, at *https://www.energy.ca.gov/programs-and-topics/programs/electric-vehicle-charging-infrastructure-assessment-ab-2127.*

[778] More information on these three acts can be found in the January, 2023 White House publication ''Building a Clean Energy Economy: A Guidebook to the Inflation Reduction Act's Investments in Clean Energy and Climate Action.'' found online at *https://www.whitehouse.gov/wp-content/uploads/2022/12/Inflation-Reduction-Act-Guidebook.pdf.*

### 4. Transfers

There are three types of transfers included in our analysis. Two of these transfers come in the form of tax credits arising from the Inflation Reduction Act to encourage investment in battery technology and the purchase of electrified vehicles. These are transfers from the government to producers of vehicles (the battery tax credit) or purchasers of vehicles (the vehicle purchase tax credit). The third is fuel taxes which are transfers from purchasers of fuel to the government. The proposal results in less liquid-fuel consumed and, therefore, less money transferred from purchasers of fuel to the government.

TABLE 167—BATTERY TAX CREDITS ASSOCIATED WITH THE PROPOSAL AND EACH ALTERNATIVE, LIGHT-DUTY AND MEDIUM-DUTY

[Billions of 2020 dollars]

| Calendar year | Battery tax credits, proposal | Battery tax credits, alternative 1 | Battery tax credits, alternative 2 | Battery tax credits, alternative 3 |
|---|---|---|---|---|
| 2027 | 6.8 | 7.1 | 4.8 | 4.1 |
| 2028 | 9.2 | 11 | 6.3 | 5.6 |
| 2029 | 13 | 13 | 11 | 6.9 |
| 2030 | 11 | 13 | 8.7 | 7.9 |
| 2031 | 9 | 9.3 | 7.6 | 8.4 |
| 2032 | 5.3 | 5.5 | 4.6 | 5.4 |
| 2035 | 0 | 0 | 0 | 0 |
| 2040 | 0 | 0 | 0 | 0 |
| 2045 | 0 | 0 | 0 | 0 |
| 2050 | 0 | 0 | 0 | 0 |
| 2055 | 0 | 0 | 0 | 0 |
| PV3 | 49 | 52 | 39 | 34 |
| PV7 | 43 | 46 | 34 | 30 |
| EAV3 | 2.6 | 2.7 | 2 | 1.8 |
| EAV7 | 3.5 | 3.8 | 2.8 | 2.4 |

TABLE 168—VEHICLE PURCHASE TAX CREDITS ASSOCIATED WITH THE PROPOSAL AND EACH ALTERNATIVE, LIGHT-DUTY AND MEDIUM-DUTY

[Billions of 2020 dollars]

| Calendar year | Purchase tax credits, proposal | Purchase tax credits, alternative 1 | Purchase tax credits, alternative 2 | Purchase tax credits, alternative 3 |
|---|---|---|---|---|
| 2027 | 6.7 | 7 | 4.8 | 4 |
| 2028 | 9.9 | 11 | 6.7 | 6.1 |
| 2029 | 14 | 14 | 13 | 7.7 |
| 2030 | 18 | 20 | 14 | 13 |
| 2031 | 22 | 23 | 19 | 21 |
| 2032 | 27 | 29 | 24 | 27 |
| 2035 | 0 | 0 | 0 | 0 |
| 2040 | 0 | 0 | 0 | 0 |
| 2045 | 0 | 0 | 0 | 0 |
| 2050 | 0 | 0 | 0 | 0 |
| 2055 | 0 | 0 | 0 | 0 |
| PV3 | 86 | 92 | 71 | 68 |
| PV7 | 74 | 79 | 60 | 58 |
| EAV3 | 4.5 | 4.8 | 3.7 | 3.6 |
| EAV7 | 6 | 6.4 | 4.9 | 4.7 |

TABLE 169—FUEL TAX TRANSFERS ASSOCIATED WITH THE PROPOSAL AND EACH ALTERNATIVE, LIGHT-DUTY AND MEDIUM-DUTY

[Billions of 2020 dollars]

| Calendar year | Fuel taxes, proposal | Fuel taxes, alternative 1 | Fuel taxes, alternative 2 | Fuel taxes, alternative 3 |
|---|---|---|---|---|
| 2027 | 0.31 | 0.32 | 0.22 | 0.18 |
| 2028 | 0.77 | 0.88 | 0.57 | 0.46 |
| 2029 | 1.4 | 1.6 | 1.1 | 0.81 |
| 2030 | 2.4 | 2.8 | 1.9 | 1.5 |
| 2031 | 3.3 | 3.9 | 2.7 | 2.4 |
| 2032 | 4.5 | 5.2 | 3.8 | 3.6 |
| 2035 | 8 | 9 | 7 | 7.3 |
| 2040 | 12 | 14 | 11 | 12 |
| 2045 | 15 | 16 | 13 | 14 |
| 2050 | 16 | 17 | 14 | 16 |

TABLE 169—FUEL TAX TRANSFERS ASSOCIATED WITH THE PROPOSAL AND EACH ALTERNATIVE, LIGHT-DUTY AND MEDIUM-DUTY—Continued

[Billions of 2020 dollars]

| Calendar year | Fuel taxes, proposal | Fuel taxes, alternative 1 | Fuel taxes, alternative 2 | Fuel taxes, alternative 3 |
|---|---|---|---|---|
| 2055 | 15 | 17 | 14 | 15 |
| PV3 | 180 | 200 | 160 | 170 |
| PV7 | 97 | 110 | 85 | 91 |
| EAV3 | 9.5 | 11 | 8.4 | 9 |
| EAV7 | 7.9 | 8.8 | 7 | 7.4 |

### *C. U.S. Vehicle Sales Impacts*

#### 1. Light-Duty Vehicle Sales Impacts

As discussed in Section IV.A of this Preamble, EPA used the OMEGA model to analyze impacts of this proposal, including impacts on vehicle sales. The OMEGA model accounts for interactions in producer and consumer decisions in total sales and in the share of ICE and BEV vehicles in the market. As in previous rulemakings, the sales impacts are based on a set of assumptions and inputs, including assumptions about the role of fuel consumption in vehicle purchase decisions, and assumptions on consumers' demand elasticity.[779]

In OMEGA, the amount of fuel savings considered in the purchase decisions is directly incorporated in the producer assumptions of how many years of fuel savings consumers consider in their purchase decision. In the 2021 rule, as well as in this proposed rule, EPA assumed that LD vehicle buyers account for about 2.5 years of fuel consumption in their purchase decision. However, as discussed in detail in the 2021 rule,[780] there is not a consensus around the role of fuel consumption in vehicle purchase decisions. Greene et al. (2018) provides a reference value of $1,150 for the value of reducing fuel costs by $0.01/mile over the lifetime of an average vehicle; for comparison, 2.5 years of fuel savings is only about 30 percent of that value, or about $334. This $334 is within the large standard deviation in Greene et al. (2018) for the willingness to pay to reduce fuel costs, but it is far lower than both the mean of $1,880 (160 percent of the reference value) and the median of $990 (85 percent of the reference value) per one cent per mile in the paper. On the other hand, the 2021 NAS report,[781] citing the 2015 NAS report, observed that automakers ''perceive that typical consumers would pay upfront for only one to four years of fuel savings'' (pp. 9–10), which is within the range of values identified in Greene et al. (2018) for consumer response, but well below the median or mean. In other words, though automakers seem to operate under a perception of consumer willingness to pay for additional fuel economy that is not inconsistent with estimates in the literature of how consumers actually behave, it does appear possible that automakers do not fully account for how those consumers actually behave. In comments on the 2021 rule, some commenters suggested that new vehicle buyers care more about fuel consumption than the use of 2.5 years suggests, and that EPA should model automaker adoption of fuel-saving technologies based on historical actions. As discussed in Section VIII.J and DRIA Chapter 4.4, we note that, historically, automakers did not provide fuel saving technology to customers, even though it was proven to pay for itself in short periods of time. However, EPA notes that the data, methods and ideas discussed here are based on historical data and focus on ICE vehicle sales. Automaker adoption of fuel-saving technologies and consumer response to fuel savings, and the amount of fuel savings considered in the purchase decision, may be different with electric vehicles and in an era of high BEV sales. We request comment on data, methods and perspectives on the role of fuel consumption in the vehicle purchase decision.

Continuing the approach used in the final 2021 rule, EPA will be using a demand elasticity for new LD vehicles of −0.4 based on a 2021 EPA peer reviewed report, which included a literature review on and estimates of the effects of new vehicle price changes on the new vehicle market.[782] However, as noted in EPA's report and by public commenters on the proposed 2021 rule, −0.4 appears to be the largest estimate (in absolute value) for a long-run new vehicle demand elasticity in recent studies. Further, EPA's report examining the relationship between new and used vehicle markets shows that, for plausible values reflecting that interaction, the new vehicle demand elasticity varies from −0.15 to −0.4. A smaller elasticity does not change the direction of sales effects, but it does reduce the magnitude of the effects. We chose the larger value of this range for our analysis because it will lead to more conservative estimates that are still within the range estimated within the report.

For this proposed rule, EPA is maintaining the previous assumptions of 2.5 years of fuel savings and a new vehicle demand elasticity of −0.4 for its modeling of LD sales impacts. These assumptions are applied to the Proposal, as well as the more stringent (Alternative 1(−10)) and less stringent (Alternative 2 (+10)) and Alternative 3 (linear phase-in)) options as described in Section III.E.

Under the Proposed scenario, there is a small change projected in total new LD vehicle sales compared to sales under the No Action scenario.[783] See Table 170 for total new vehicle sales impacts under the Proposed scenario. The table shows that sales decrease for two years, increase for the next two years, and then decrease again. Though the increase in the middle years may seem unexpected at first, as technology costs are increasing, the reduction in average per vehicle cost due to the 2.5 years of fuel cost savings incorporated

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[779] The demand elasticity is the percent change in quantity associated with percent increase in price. For price, we use net price, where net price is the difference in technology costs less an estimate of the change in fuel costs over the number of years we assume fuel costs are taken into account. BEV purchase incentives from the IRA are also accounted for in the net consumer prices used in OMEGA. See DRIA Chapter 2.6.8 for more information.

[780] 86 FR 74434, December 30, 2021, ''Revised 2023 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions Standards.''

[781] National Academies of Sciences, Engineering, and Medicine. 2021. Assessment of Technologies for Improving Light-Duty Vehicle Fuel Economy—2025–2035. Washington, DC: The National Academies Press. *https://doi.org/10.17226/26092.*

[782] U.S. EPA. 2021. The Effects of New-Vehicle Price Changes on New- and Used-Vehicle Markets and Scrappage. EPA–420–R–21–019. *https://cfpub.epa.gov/si/si_public_record_Report.cfm?dirEntryId=352754&Lab=OTAQ.*

[783] The No Action scenario consists of the 2021 rule standards and IRA provisions as explained in Section IV.B.

into the sales impact estimates offset the increase in the LD vehicle technology costs.

increase in the LD vehicle technology costs.

TABLE 170—TOTAL NEW LD SALES IMPACTS IN THE PROPOSED SCENARIO

| Year | No action | Proposed rule | |
|---|---|---|---|
| | Total sales | Total sales | Change from no action (%) |
| 2027 | 15,487,827 | 15,432,908 | −54,919 (−0.35%) |
| 2028 | 15,637,207 | 15,616,676 | −20,531 (−0.13%) |
| 2029 | 15,770,260 | 15,781,094 | 10,834 (0.07%) |
| 2030 | 15,807,049 | 15,814,296 | 7,247 (0.05%) |
| 2031 | 15,884,729 | 15,860,358 | −24,370 (−0.15%) |
| 2032 | 15,880,160 | 15,834,010 | −46,150 (−0.29%) |

Table 171 shows the total new vehicle sales impacts under the three alternative scenarios. All three alternatives also show a very small change in sales compared to the No Action scenario. The change is largest in magnitude under the most stringent alternative (Alternative 1), with the largest results projected to be a decrease of less than 0.8 percent in 2032. Alternative 3 projects the smallest, in magnitude, results in the first two years, with Alternative 2 projecting the smallest, in magnitude, results in the last two years.

TABLE 171—TOTAL NEW LD SALES IMPACTS IN ALTERNATIVE 1, ALTERNATIVE 2 AND ALTERNATIVE 3

| Year | Alternative 1 (−10) | | Alternative 2 (+10) | | Alternative 3 (linear) | |
|---|---|---|---|---|---|---|
| | Total sales | Change from no action (%) | Total sales | Change from no action (%) | Total sales | Change from no action (%) |
| 2027 | 15,429,939 | −57,889 (−0.37%) | 15,447,829 | −39,998 (−0.26%) | 15,476,391 | −11,436 (−0.07%) |
| 2028 | 15,582,224 | −54,983 (−0.35%) | 15,624,158 | −13,048 (−0.08%) | 15,643,941 | 6,734 (0.04%) |
| 2029 | 15,690,100 | −80,160 (−0.51%) | 15,778,412 | 8,153 (0.05%) | 15,795,393 | 25,133 (0.16%) |
| 2030 | 15,732,702 | −74,347 (−0.47%) | 15,821,919 | 14,871 (0.09%) | 15,823,563 | 16,514 (0.10%) |
| 2031 | 15,774,869 | −109,860 (−0.69%) | 15,864,090 | −20,639 (−0.13%) | 15,857,727 | −27,001 (−0.17%) |
| 2032 | 15,758,885 | −121,275 (−0.76%) | 15,834,633 | −45,527 (−0.29%) | 15,818,292 | −61,868 (−0.39%) |

### 2. Medium-Duty Sales Impacts

The cited literature is focused on light-duty vehicles, which are primarily purchased and used as personal vehicles by individuals and households. The medium-duty vehicle market, in contrast, largely serves commercial applications. The assumptions in our analysis of the LD sales response are specific to that market, and do not necessarily carry over to the MD vehicle market. Commercial vehicle owners purchase vehicles based on the needs for their business, and we believe they are less sensitive to changes in vehicle price than personal vehicle owners.[784] The elasticity of demand affects the sensitivity of vehicle buyers to a change in the price of vehicles: The smaller the elasticity, in absolute value, the smaller the estimated change in sales due to a change in vehicle price. Therefore, as explained in Chapter 4.4 of the DRIA, the estimates of a change in sales due to this rule depend on the elasticity of demand assumptions. For this proposal, we are assuming an elasticity of 0 for the MD vehicle sales impacts estimates, and we are not projecting any differences in the number of MD vehicles sold between the No Action and the Proposal. This implicitly assumes that the buyers of MD vehicles are not going to change purchase decisions if the price of the vehicle changes, all else equal. In other words, as long as the characteristics of the vehicle do not change, commercial buyers will still purchase the vehicle that fits their needs.

We seek comment on our assumptions for both LD and MD vehicle sales impacts.

### *D. Greenhouse Gas Emission Reduction Benefits*

EPA estimated the climate benefits for the final standards using measures of the social cost of three GHGs: Carbon, methane, and nitrous oxide. The social cost of each gas (*i.e.,* the social cost of carbon (SC–$CO_2$), methane (SC–$CH_4$), and nitrous oxide (SC–$N_2O$)) is the monetary value of the net harm to society associated with a marginal increase in emissions in a given year, or the benefit of avoiding that increase. Collectively, these values are referenced as the ‘‘social cost of greenhouse gases’’ (SC–GHG). In principle, SC–GHG includes the value of all climate change impacts, including (but not limited to) changes in net agricultural productivity, human health effects, property damage from increased flood risk and natural disasters, disruption of energy systems, risk of conflict, environmental migration, and the value of ecosystem services. The SC–GHG therefore, reflects the societal value of reducing emissions of the gas in question by one metric ton. EPA and other Federal agencies began regularly incorporating SC–GHG estimates in their benefit-cost analyses conducted under Executive Order (E.O.)

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[784] See DRIA Chapter 4.1.1 for more information.

12866[785] since 2008, following a Ninth Circuit Court of Appeals remand of a rule for failing to monetize the benefits of reducing $CO_2$ emissions in a rulemaking process.

We estimate the global social benefits of $CO_2$, $CH_4$, and $N_2O$ emission reductions expected from the proposed rule using the SC–GHG estimates presented in the February 2021 Technical Support Document (TSD): Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under E.O. 13990 (IWG 2021). These SC–GHG estimates are interim values developed under E.O. 13990 for use in benefit-cost analyses until updated estimates of the impacts of climate change can be developed based on the best available climate science and economics. We have evaluated the SC–GHG estimates in the TSD and have determined that these estimates are appropriate for use in estimating the global social benefits of $CO_2$, $CH_4$, and $N_2O$ emission reductions expected from this proposed rule. After considering the TSD, and the issues and studies discussed therein, EPA finds that these estimates, while likely an underestimate, are the best currently available SC–GHG estimates. These SC–GHG estimates were developed over many years, using a transparent process, peer-reviewed methodologies, the best science available at the time of that process, and with input from the public. As discussed in Chapter 10 of the DRIA, these interim SC–GHG estimates have a number of limitations, including that the models used to produce them do not include all of the important physical, ecological, and economic impacts of climate change recognized in the climate-change literature and that several modeling input assumptions are outdated. As discussed in the February 2021 TSD, the Interagency Working Group on the Social Cost of Greenhouse Gases (IWG) finds that, taken together, the limitations suggest that these SC–GHG estimates likely underestimate the damages from GHG emissions. The IWG is currently working on a comprehensive update of the SC–GHG estimates (under E.O. 13990) taking into consideration recommendations from the National Academies of Sciences, Engineering and Medicine, recent scientific literature, public comments received on the February 2021 TSD and other input from experts and diverse stakeholder groups. EPA is participating in the IWG's work. In addition, while that process continues, EPA is continuously reviewing developments in the scientific literature on the SC–GHG, including more robust methodologies for estimating damages from emissions, and looking for opportunities to further improve SC–GHG estimation going forward. Most recently, EPA has developed a draft updated SC–GHG methodology within a sensitivity analysis in the regulatory impact analysis of EPA's November 2022 supplemental proposal for oil and gas standards that is currently undergoing external peer review and a public comment process. See Chapter 10 of the DRIA for more discussion of this effort.

We monetize benefits of the proposed standards and evaluate other costs in part to enable a comparison of costs and benefits pursuant to E.O. 12866, but we recognize there are benefits that we are currently unable to fully quantify. EPA's practice has been to set standards to achieve improved air quality consistent with CAA section 202, and not to rely on cost-benefit calculations, with their uncertainties and limitations, as identifying the appropriate standards. In setting standards, we place weight on the emissions reductions the standards are projected to achieve, and we present the monetized benefits here and elsewhere as illustrative, taking into consideration their substantial uncertainties and limitations.

Table 172 through Table 175 show the benefits of reduced $CO_2$, $CH_4$, $N_2O$ and GHG emissions, respectively, and consequently the annual quantified benefits (*i.e.,* total GHG benefits), for each of the four interim social cost of GHG (SC–GHG) values estimated by the interagency working group. Table 176 through Table 179 show the same information for Alternative 1. Table 180 through Table 183 show the same information for Alternative 2, and Table 184 through Table 187 show this information for Alternative 3. See Chapter 10.4 of the DRIA for more on the application of SC–GHG estimates.

TABLE 172—CLIMATE BENEFITS FROM REDUCTIONS IN $CO_2$ EMISSIONS ASSOCIATED WITH THE PROPOSAL, LIGHT-DUTY AND MEDIUM-DUTY

[Billions of 2020 dollars]

| Calendar year | Discount rate and statistic | | | |
|---|---|---|---|---|
| | 5% Average | 3% Average | 2.5% Average | 3% 95th Percentile |
| 2027 | 0.1 | 0.34 | 0.5 | 1 |
| 2028 | 0.27 | 0.88 | 1.3 | 2.6 |
| 2029 | 0.51 | 1.6 | 2.4 | 5 |
| 2030 | 0.81 | 2.6 | 3.8 | 7.8 |
| 2031 | 1.2 | 3.8 | 5.5 | 11 |
| 2032 | 1.7 | 5.2 | 7.5 | 16 |
| 2035 | 3.5 | 10 | 15 | 32 |
| 2040 | 6.6 | 19 | 27 | 59 |
| 2045 | 9.9 | 27 | 38 | 84 |
| 2050 | 13 | 35 | 48 | 110 |
| 2055 | 15 | 37 | 52 | 110 |
| PV | 82 | 330 | 500 | 1000 |

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[785] Benefit-cost analyses have been an integral part of executive branch rulemaking for decades. Presidents since the 1970s have issued executive orders requiring agencies to conduct analysis of the economic consequences of regulations as part of the rulemaking development process. E.O. 12866, released in 1993 and still in effect today, requires that for all regulatory actions that are significant under 3(f)(1), an agency provide an assessment of the potential costs and benefits of the regulatory action, and that this assessment include a quantification of benefits and costs to the extent feasible.

## Table 172—Climate Benefits From Reductions in $CO_2$ Emissions Associated With the Proposal, Light-Duty and Medium-Duty—Continued

[Billions of 2020 dollars]

| Calendar year | Discount rate and statistic | | | |
|---|---|---|---|---|
| | 5% Average | 3% Average | 2.5% Average | 3% 95th Percentile |
| EAV | 5.4 | 17 | 24 | 52 |

**Notes:** The present value of reduced GHG emissions is calculated differently than other benefits. The same discount rate used to discount the value of damages from future emissions (SC–GHGs at 5, 3, 2.5 percent) is used to calculate the present value of SC–GHGs for internal consistency. The 95th percentile of estimates based on a 3 percent discount rate are included to provide information on potentially higher-than-expected economic impacts from climate change, conditional on the 3 percent estimate of the discount rate. Annual benefits shown are undiscounted values.

## Table 173—Climate Benefits From Reductions in $CH_4$ Emissions Associated With the Proposal, Light-Duty and Medium-Duty

[Billions of 2020 dollars]

| Calendar year | Discount rate and statistic | | | |
|---|---|---|---|---|
| | 5% Average | 3% Average | 2.5% Average | 3% 95th Percentile |
| 2027 | 0.000022 | 0.000046 | 0.000059 | 0.00012 |
| 2028 | 0.000068 | 0.00014 | 0.00018 | 0.00038 |
| 2029 | 0.00015 | 0.00032 | 0.00041 | 0.00085 |
| 2030 | 0.00026 | 0.00054 | 0.00069 | 0.0014 |
| 2031 | 0.00042 | 0.00086 | 0.0011 | 0.0023 |
| 2032 | 0.00063 | 0.0013 | 0.0016 | 0.0034 |
| 2035 | 0.0017 | 0.0034 | 0.0043 | 0.009 |
| 2040 | 0.0046 | 0.009 | 0.011 | 0.024 |
| 2045 | 0.0086 | 0.016 | 0.02 | 0.044 |
| 2050 | 0.013 | 0.025 | 0.03 | 0.066 |
| 2055 | 0.015 | 0.027 | 0.033 | 0.07 |
| PV | 0.067 | 0.19 | 0.26 | 0.49 |
| EAV | 0.0044 | 0.0097 | 0.012 | 0.026 |

**Notes:** The present value of reduced GHG emissions is calculated differently than other benefits. The same discount rate used to discount the value of damages from future emissions (SC–GHGs at 5, 3, 2.5 percent) is used to calculate the present value of SC–GHGs for internal consistency. The 95th percentile of estimates based on a 3 percent discount rate are included to provide information on potentially higher-than-expected economic impacts from climate change, conditional on the 3 percent estimate of the discount rate. Annual benefits shown are undiscounted values.

## Table 174—Climate Benefits From Reductions in $N_2O$ Emissions Associated With the Proposal, Light-Duty and Medium-Duty

[Billions of 2020 dollars]

| Calendar year | Discount rate and statistic | | | |
|---|---|---|---|---|
| | 5% Average | 3% Average | 2.5% Average | 3% 95th Percentile |
| 2027 | 0.00094 | 0.0028 | 0.0041 | 0.0074 |
| 2028 | 0.0021 | 0.0063 | 0.0091 | 0.017 |
| 2029 | 0.0039 | 0.012 | 0.017 | 0.03 |
| 2030 | 0.0061 | 0.018 | 0.026 | 0.047 |
| 2031 | 0.0091 | 0.026 | 0.038 | 0.07 |
| 2032 | 0.013 | 0.036 | 0.052 | 0.096 |
| 2035 | 0.026 | 0.072 | 0.1 | 0.19 |
| 2040 | 0.049 | 0.13 | 0.19 | 0.35 |
| 2045 | 0.073 | 0.19 | 0.26 | 0.51 |
| 2050 | 0.096 | 0.24 | 0.33 | 0.64 |
| 2055 | 0.11 | 0.27 | 0.37 | 0.73 |
| PV | 0.61 | 2.3 | 3.5 | 6.1 |
| EAV | 0.04 | 0.12 | 0.17 | 0.32 |

**Notes:** The present value of reduced GHG emissions is calculated differently than other benefits. The same discount rate used to discount the value of damages from future emissions (SC–GHGs at 5, 3, 2.5 percent) is used to calculate the present value of SC–GHGs for internal consistency. The 95th percentile of estimates based on a 3 percent discount rate are included to provide information on potentially higher-than-expected economic impacts from climate change, conditional on the 3 percent estimate of the discount rate. Annual benefits shown are undiscounted values.

### Table 175—Climate Benefits From Reductions in GHG Emissions Associated With the Proposal, Light-Duty and Medium-Duty

[Billions of 2020 dollars]

| Calendar year | Discount rate and statistic | | | |
|---|---|---|---|---|
| | 5% Average | 3% Average | 2.5% Average | 3% 95th Percentile |
| 2027 | 0.1 | 0.34 | 0.5 | 1 |
| 2028 | 0.27 | 0.88 | 1.3 | 2.7 |
| 2029 | 0.52 | 1.7 | 2.4 | 5 |
| 2030 | 0.82 | 2.6 | 3.8 | 7.9 |
| 2031 | 1.2 | 3.8 | 5.5 | 12 |
| 2032 | 1.7 | 5.3 | 7.6 | 16 |
| 2035 | 3.5 | 11 | 15 | 32 |
| 2040 | 6.7 | 19 | 27 | 60 |
| 2045 | 10 | 28 | 38 | 85 |
| 2050 | 13 | 35 | 48 | 110 |
| 2055 | 15 | 38 | 52 | 110 |
| PV | 82 | 330 | 500 | 1000 |
| EAV | 5.4 | 17 | 25 | 52 |

**Notes:** The present value of reduced GHG emissions is calculated differently than other benefits. The same discount rate used to discount the value of damages from future emissions (SC–GHGs at 5, 3, 2.5 percent) is used to calculate the present value of SC–GHGs for internal consistency. The 95th percentile of estimates based on a 3 percent discount rate are included to provide information on potentially higher-than-expected economic impacts from climate change, conditional on the 3 percent estimate of the discount rate. Annual benefits shown are undiscounted values.

### Table 176—Climate Benefits From Reductions in $CO_2$ Emissions Associated With Alternative 1, Light-Duty and Medium-Duty

[Billions of 2020 dollars]

| Calendar year | Discount rate and statistic | | | |
|---|---|---|---|---|
| | 5% Average | 3% Average | 2.5% Average | 3% 95th Percentile |
| 2027 | 0.11 | 0.36 | 0.52 | 1.1 |
| 2028 | 0.31 | 1 | 1.5 | 3 |
| 2029 | 0.58 | 1.9 | 2.7 | 5.6 |
| 2030 | 0.95 | 3 | 4.4 | 9.2 |
| 2031 | 1.4 | 4.4 | 6.3 | 13 |
| 2032 | 1.9 | 5.9 | 8.6 | 18 |
| 2035 | 3.9 | 12 | 17 | 36 |
| 2040 | 7.4 | 21 | 30 | 66 |
| 2045 | 11 | 30 | 42 | 93 |
| 2050 | 14 | 38 | 53 | 120 |
| 2055 | 16 | 41 | 57 | 120 |
| PV | 91 | 360 | 550 | 1100 |
| EAV | 6 | 19 | 27 | 58 |

**Notes:** The present value of reduced GHG emissions is calculated differently than other benefits. The same discount rate used to discount the value of damages from future emissions (SC–GHGs at 5, 3, 2.5 percent) is used to calculate the present value of SC–GHGs for internal consistency. The 95th percentile of estimates based on a 3 percent discount rate are included to provide information on potentially higher-than-expected economic impacts from climate change, conditional on the 3 percent estimate of the discount rate. Annual benefits shown are undiscounted values.

### Table 177—Climate Benefits From Reductions in $CH_4$ Emissions Associated With Alternative 1, Light-Duty and Medium-Duty

[Billions of 2020 dollars]

| Calendar year | Discount rate and statistic | | | |
|---|---|---|---|---|
| | 5% Average | 3% Average | 2.5% Average | 3% 95th Percentile |
| 2027 | 0.000023 | 0.000048 | 0.000062 | 0.00013 |
| 2028 | 0.000065 | 0.00014 | 0.00018 | 0.00036 |
| 2029 | 0.00014 | 0.00029 | 0.00037 | 0.00077 |
| 2030 | 0.00024 | 0.0005 | 0.00065 | 0.0013 |
| 2031 | 0.00041 | 0.00084 | 0.0011 | 0.0022 |
| 2032 | 0.00063 | 0.0013 | 0.0016 | 0.0034 |
| 2035 | 0.0018 | 0.0035 | 0.0045 | 0.0094 |
| 2040 | 0.0049 | 0.0096 | 0.012 | 0.026 |
| 2045 | 0.0094 | 0.018 | 0.022 | 0.047 |
| 2050 | 0.015 | 0.027 | 0.033 | 0.072 |
| 2055 | 0.016 | 0.03 | 0.036 | 0.077 |
| PV | 0.072 | 0.2 | 0.28 | 0.53 |

TABLE 177—CLIMATE BENEFITS FROM REDUCTIONS IN $CH_4$ EMISSIONS ASSOCIATED WITH ALTERNATIVE 1, LIGHT-DUTY AND MEDIUM-DUTY—Continued

[Billions of 2020 dollars]

| Calendar year | Discount rate and statistic | | | |
|---|---|---|---|---|
| | 5% Average | 3% Average | 2.5% Average | 3% 95th Percentile |
| EAV | 0.0047 | 0.01 | 0.013 | 0.028 |

**Notes:** The present value of reduced GHG emissions is calculated differently than other benefits. The same discount rate used to discount the value of damages from future emissions (SC–GHGs at 5, 3, 2.5 percent) is used to calculate the present value of SC–GHGs for internal consistency. The 95th percentile of estimates based on a 3 percent discount rate are included to provide information on potentially higher-than-expected economic impacts from climate change, conditional on the 3 percent estimate of the discount rate. Annual benefits shown are undiscounted values.

TABLE 178—CLIMATE BENEFITS FROM REDUCTIONS IN $N_2O$ EMISSIONS ASSOCIATED WITH ALTERNATIVE 1, LIGHT-DUTY AND MEDIUM-DUTY

[Billions of 2020 dollars]

| Calendar year | Discount rate and statistic | | | |
|---|---|---|---|---|
| | 5% Average | 3% Average | 2.5% Average | 3% 95th Percentile |
| 2027 | 0.00097 | 0.0029 | 0.0042 | 0.0077 |
| 2028 | 0.0023 | 0.0068 | 0.0098 | 0.018 |
| 2029 | 0.004 | 0.012 | 0.017 | 0.031 |
| 2030 | 0.0065 | 0.019 | 0.027 | 0.05 |
| 2031 | 0.0096 | 0.028 | 0.04 | 0.073 |
| 2032 | 0.013 | 0.038 | 0.054 | 0.1 |
| 2035 | 0.027 | 0.076 | 0.11 | 0.2 |
| 2040 | 0.053 | 0.14 | 0.2 | 0.38 |
| 2045 | 0.08 | 0.21 | 0.29 | 0.55 |
| 2050 | 0.1 | 0.26 | 0.36 | 0.7 |
| 2055 | 0.12 | 0.3 | 0.4 | 0.79 |
| PV | 0.66 | 2.5 | 3.7 | 6.5 |
| EAV | 0.044 | 0.13 | 0.18 | 0.34 |

**Notes:** The present value of reduced GHG emissions is calculated differently than other benefits. The same discount rate used to discount the value of damages from future emissions (SC–GHGs at 5, 3, 2.5 percent) is used to calculate the present value of SC–GHGs for internal consistency. The 95th percentile of estimates based on a 3 percent discount rate are included to provide information on potentially higher-than-expected economic impacts from climate change, conditional on the 3 percent estimate of the discount rate. Annual benefits shown are undiscounted values.

TABLE 179—CLIMATE BENEFITS FROM REDUCTIONS IN GHG EMISSIONS ASSOCIATED WITH ALTERNATIVE 1, LIGHT-DUTY AND MEDIUM-DUTY

[Billions of 2020 dollars]

| Calendar year | Discount rate and statistic | | | |
|---|---|---|---|---|
| | 5% Average | 3% Average | 2.5% Average | 3% 95th Percentile |
| 2027 | 0.11 | 0.36 | 0.52 | 1.1 |
| 2028 | 0.31 | 1 | 1.5 | 3 |
| 2029 | 0.58 | 1.9 | 2.7 | 5.6 |
| 2030 | 0.96 | 3.1 | 4.4 | 9.2 |
| 2031 | 1.4 | 4.4 | 6.3 | 13 |
| 2032 | 1.9 | 6 | 8.6 | 18 |
| 2035 | 3.9 | 12 | 17 | 36 |
| 2040 | 7.5 | 22 | 30 | 66 |
| 2045 | 11 | 31 | 43 | 94 |
| 2050 | 14 | 38 | 53 | 120 |
| 2055 | 16 | 41 | 57 | 120 |
| PV | 91 | 360 | 560 | 1100 |
| EAV | 6 | 19 | 27 | 58 |

**Notes:** The present value of reduced GHG emissions is calculated differently than other benefits. The same discount rate used to discount the value of damages from future emissions (SC–GHGs at 5, 3, 2.5 percent) is used to calculate the present value of SC–GHGs for internal consistency. The 95th percentile of estimates based on a 3 percent discount rate are included to provide information on potentially higher-than-expected economic impacts from climate change, conditional on the 3 percent estimate of the discount rate. Annual benefits shown are undiscounted values.

Table 180—Climate Benefits From Reductions in $CO_2$ Emissions Associated With Alternative 2, Light-Duty and Medium-Duty

[Billions of 2020 dollars]

| Calendar year | Discount rate and statistic | | | |
|---|---|---|---|---|
| | 5% Average | 3% Average | 2.5% Average | 3% 95th Percentile |
| 2027 | 0.076 | 0.25 | 0.36 | 0.74 |
| 2028 | 0.2 | 0.64 | 0.94 | 1.9 |
| 2029 | 0.41 | 1.3 | 1.9 | 4 |
| 2030 | 0.65 | 2.1 | 3 | 6.3 |
| 2031 | 0.99 | 3.1 | 4.5 | 9.4 |
| 2032 | 1.4 | 4.4 | 6.3 | 13 |
| 2035 | 3 | 9.2 | 13 | 28 |
| 2040 | 6 | 17 | 24 | 53 |
| 2045 | 8.9 | 25 | 35 | 76 |
| 2050 | 12 | 31 | 43 | 96 |
| 2055 | 13 | 34 | 47 | 100 |
| PV | 73 | 290 | 450 | 890 |
| EAV | 4.8 | 15 | 22 | 47 |

**Notes:** The present value of reduced GHG emissions is calculated differently than other benefits. The same discount rate used to discount the value of damages from future emissions (SC–GHGs at 5, 3, 2.5 percent) is used to calculate the present value of SC–GHGs for internal consistency. The 95th percentile of estimates based on a 3 percent discount rate are included to provide information on potentially higher-than-expected economic impacts from climate change, conditional on the 3 percent estimate of the discount rate. Annual benefits shown are undiscounted values.

Table 181—Climate Benefits From Reductions in $CH_4$ Emissions Associated With Alternative 2, Light-Duty and Medium-Duty

[Billions of 2020 dollars]

| Calendar year | Discount rate and statistic | | | |
|---|---|---|---|---|
| | 5% Average | 3% Average | 2.5% Average | 3% 95th Percentile |
| 2027 | 0.000018 | 0.000038 | 0.000049 | 0.0001 |
| 2028 | 0.000052 | 0.00011 | 0.00014 | 0.00029 |
| 2029 | 0.00013 | 0.00027 | 0.00035 | 0.00072 |
| 2030 | 0.00021 | 0.00044 | 0.00057 | 0.0012 |
| 2031 | 0.00035 | 0.00072 | 0.00092 | 0.0019 |
| 2032 | 0.00054 | 0.0011 | 0.0014 | 0.003 |
| 2035 | 0.0015 | 0.003 | 0.0038 | 0.0081 |
| 2040 | 0.0042 | 0.0082 | 0.01 | 0.022 |
| 2045 | 0.008 | 0.015 | 0.019 | 0.04 |
| 2050 | 0.012 | 0.023 | 0.028 | 0.061 |
| 2055 | 0.014 | 0.025 | 0.031 | 0.065 |
| PV | 0.061 | 0.17 | 0.24 | 0.46 |
| EAV | 0.004 | 0.0089 | 0.011 | 0.024 |

**Notes:** The present value of reduced GHG emissions is calculated differently than other benefits. The same discount rate used to discount the value of damages from future emissions (SC–GHGs at 5, 3, 2.5 percent) is used to calculate the present value of SC–GHGs for internal consistency. The 95th percentile of estimates based on a 3 percent discount rate are included to provide information on potentially higher-than-expected economic impacts from climate change, conditional on the 3 percent estimate of the discount rate. Annual benefits shown are undiscounted values.

Table 182—Climate Benefits From Reductions in $N_2O$ Emissions Associated With Alternative 2, Light-Duty and Medium-Duty

[Billions of 2020 dollars]

| Calendar year | Discount rate and statistic | | | |
|---|---|---|---|---|
| | 5% Average | 3% Average | 2.5% Average | 3% 95th Percentile |
| 2027 | 0.00073 | 0.0022 | 0.0031 | 0.0057 |
| 2028 | 0.0016 | 0.0047 | 0.0068 | 0.012 |
| 2029 | 0.0032 | 0.0093 | 0.013 | 0.025 |
| 2030 | 0.005 | 0.015 | 0.021 | 0.038 |
| 2031 | 0.0076 | 0.022 | 0.031 | 0.058 |
| 2032 | 0.011 | 0.031 | 0.044 | 0.082 |
| 2035 | 0.023 | 0.065 | 0.092 | 0.17 |
| 2040 | 0.046 | 0.12 | 0.17 | 0.33 |
| 2045 | 0.068 | 0.18 | 0.25 | 0.47 |
| 2050 | 0.09 | 0.22 | 0.31 | 0.6 |
| 2055 | 0.11 | 0.26 | 0.35 | 0.68 |
| PV | 0.56 | 2.1 | 3.2 | 5.6 |

### TABLE 182—CLIMATE BENEFITS FROM REDUCTIONS IN $N_2O$ EMISSIONS ASSOCIATED WITH ALTERNATIVE 2, LIGHT-DUTY AND MEDIUM-DUTY—Continued

[Billions of 2020 dollars]

| Calendar year | Discount rate and statistic | | | |
|---|---|---|---|---|
| | 5% Average | 3% Average | 2.5% Average | 3% 95th Percentile |
| EAV | 0.037 | 0.11 | 0.16 | 0.29 |

**Notes:** The present value of reduced GHG emissions is calculated differently than other benefits. The same discount rate used to discount the value of damages from future emissions (SC–GHGs at 5, 3, 2.5 percent) is used to calculate the present value of SC–GHGs for internal consistency. The 95th percentile of estimates based on a 3 percent discount rate are included to provide information on potentially higher-than-expected economic impacts from climate change, conditional on the 3 percent estimate of the discount rate. Annual benefits shown are undiscounted values.

### TABLE 183—CLIMATE BENEFITS FROM REDUCTIONS IN GHG EMISSIONS ASSOCIATED WITH ALTERNATIVE 2, LIGHT-DUTY AND MEDIUM-DUTY

[Billions of 2020 dollars]

| Calendar year | Discount rate and statistic | | | |
|---|---|---|---|---|
| | 5% Average | 3% Average | 2.5% Average | 3% 95th Percentile |
| 2027 | 0.076 | 0.25 | 0.36 | 0.75 |
| 2028 | 0.2 | 0.65 | 0.95 | 2 |
| 2029 | 0.41 | 1.3 | 1.9 | 4 |
| 2030 | 0.66 | 2.1 | 3 | 6.3 |
| 2031 | 0.99 | 3.1 | 4.5 | 9.5 |
| 2032 | 1.4 | 4.4 | 6.4 | 13 |
| 2035 | 3.1 | 9.3 | 13 | 28 |
| 2040 | 6 | 17 | 25 | 54 |
| 2045 | 9 | 25 | 35 | 77 |
| 2050 | 12 | 32 | 44 | 97 |
| 2055 | 13 | 34 | 47 | 100 |
| PV | 74 | 290 | 450 | 900 |
| EAV | 4.9 | 15 | 22 | 47 |

**Notes:** The present value of reduced GHG emissions is calculated differently than other benefits. The same discount rate used to discount the value of damages from future emissions (SC–GHGs at 5, 3, 2.5 percent) is used to calculate the present value of SC–GHGs for internal consistency. The 95th percentile of estimates based on a 3 percent discount rate are included to provide information on potentially higher-than-expected economic impacts from climate change, conditional on the 3 percent estimate of the discount rate. Annual benefits shown are undiscounted values.

### TABLE 184—CLIMATE BENEFITS FROM REDUCTIONS IN $CO_2$ EMISSIONS ASSOCIATED WITH ALTERNATIVE 3, LIGHT-DUTY AND MEDIUM-DUTY

[Billions of 2020 dollars]

| Calendar year | Discount rate and statistic | | | |
|---|---|---|---|---|
| | 5% Average | 3% Average | 2.5% Average | 3% 95th Percentile |
| 2027 | 0.061 | 0.2 | 0.29 | 0.6 |
| 2028 | 0.16 | 0.53 | 0.77 | 1.6 |
| 2029 | 0.3 | 0.97 | 1.4 | 2.9 |
| 2030 | 0.52 | 1.7 | 2.4 | 5 |
| 2031 | 0.88 | 2.8 | 4 | 8.4 |
| 2032 | 1.4 | 4.3 | 6.1 | 13 |
| 2035 | 3.2 | 9.6 | 14 | 29 |
| 2040 | 6.4 | 19 | 26 | 57 |
| 2045 | 9.8 | 27 | 38 | 83 |
| 2050 | 13 | 35 | 48 | 110 |
| 2055 | 15 | 37 | 52 | 110 |
| PV | 79 | 320 | 480 | 960 |
| EAV | 5.2 | 16 | 24 | 50 |

**Notes:** The present value of reduced GHG emissions is calculated differently than other benefits. The same discount rate used to discount the value of damages from future emissions (SC–GHGs at 5, 3, 2.5 percent) is used to calculate the present value of SC–GHGs for internal consistency. The 95th percentile of estimates based on a 3 percent discount rate are included to provide information on potentially higher-than-expected economic impacts from climate change, conditional on the 3 percent estimate of the discount rate. Annual benefits shown are undiscounted values.

### TABLE 185—CLIMATE BENEFITS FROM REDUCTIONS IN $CH_4$ EMISSIONS ASSOCIATED WITH ALTERNATIVE 3, LIGHT-DUTY AND MEDIUM-DUTY

[Billions of 2020 dollars]

| Calendar year | Discount rate and statistic | | | |
|---|---|---|---|---|
| | 5% Average | 3% Average | 2.5% Average | 3% 95th Percentile |
| 2027 | 0.00002 | 0.000042 | 0.000054 | 0.00011 |
| 2028 | 0.000055 | 0.00012 | 0.00015 | 0.00031 |
| 2029 | 0.00011 | 0.00023 | 0.0003 | 0.00061 |
| 2030 | 0.00019 | 0.00039 | 0.0005 | 0.001 |
| 2031 | 0.00032 | 0.00066 | 0.00085 | 0.0018 |
| 2032 | 0.00051 | 0.0011 | 0.0013 | 0.0028 |
| 2035 | 0.0015 | 0.0031 | 0.0039 | 0.0082 |
| 2040 | 0.0044 | 0.0087 | 0.011 | 0.023 |
| 2045 | 0.0085 | 0.016 | 0.02 | 0.043 |
| 2050 | 0.013 | 0.025 | 0.03 | 0.066 |
| 2055 | 0.015 | 0.027 | 0.033 | 0.07 |
| PV | 0.065 | 0.18 | 0.25 | 0.49 |
| EAV | 0.0043 | 0.0095 | 0.012 | 0.025 |

**Notes:** The present value of reduced GHG emissions is calculated differently than other benefits. The same discount rate used to discount the value of damages from future emissions (SC–GHGs at 5, 3, 2.5 percent) is used to calculate the present value of SC–GHGs for internal consistency. The 95th percentile of estimates based on a 3 percent discount rate are included to provide information on potentially higher-than-expected economic impacts from climate change, conditional on the 3 percent estimate of the discount rate. Annual benefits shown are undiscounted values.

### TABLE 186—CLIMATE BENEFITS FROM REDUCTIONS IN $N_2O$ EMISSIONS ASSOCIATED WITH ALTERNATIVE 3, LIGHT-DUTY AND MEDIUM-DUTY

[Billions of 2020 dollars]

| Calendar year | Discount rate and statistic | | | |
|---|---|---|---|---|
| | 5% Average | 3% Average | 2.5% Average | 3% 95th Percentile |
| 2027 | 0.00065 | 0.0019 | 0.0028 | 0.0051 |
| 2028 | 0.0014 | 0.0043 | 0.0062 | 0.011 |
| 2029 | 0.0025 | 0.0075 | 0.011 | 0.02 |
| 2030 | 0.0042 | 0.012 | 0.018 | 0.033 |
| 2031 | 0.0071 | 0.02 | 0.029 | 0.054 |
| 2032 | 0.011 | 0.031 | 0.044 | 0.081 |
| 2035 | 0.024 | 0.067 | 0.095 | 0.18 |
| 2040 | 0.048 | 0.13 | 0.18 | 0.35 |
| 2045 | 0.073 | 0.19 | 0.26 | 0.5 |
| 2050 | 0.097 | 0.24 | 0.33 | 0.65 |
| 2055 | 0.11 | 0.28 | 0.37 | 0.73 |
| PV | 0.6 | 2.2 | 3.4 | 5.9 |
| EAV | 0.039 | 0.12 | 0.17 | 0.31 |

**Notes:** The present value of reduced GHG emissions is calculated differently than other benefits. The same discount rate used to discount the value of damages from future emissions (SC–GHGs at 5, 3, 2.5 percent) is used to calculate the present value of SC–GHGs for internal consistency. The 95th percentile of estimates based on a 3 percent discount rate are included to provide information on potentially higher-than-expected economic impacts from climate change, conditional on the 3 percent estimate of the discount rate. Annual benefits shown are undiscounted values.

### TABLE 187—CLIMATE BENEFITS FROM REDUCTIONS IN GHG EMISSIONS ASSOCIATED WITH ALTERNATIVE 3, LIGHT-DUTY AND MEDIUM-DUTY

[Billions of 2020 dollars]

| Calendar year | Discount rate and statistic | | | |
|---|---|---|---|---|
| | 5% Average | 3% Average | 2.5% Average | 3% 95th Percentile |
| 2027 | 0.062 | 0.2 | 0.3 | 0.61 |
| 2028 | 0.17 | 0.54 | 0.78 | 1.6 |
| 2029 | 0.3 | 0.98 | 1.4 | 2.9 |
| 2030 | 0.53 | 1.7 | 2.4 | 5.1 |
| 2031 | 0.89 | 2.8 | 4.1 | 8.5 |
| 2032 | 1.4 | 4.3 | 6.2 | 13 |
| 2035 | 3.2 | 9.7 | 14 | 29 |
| 2040 | 6.5 | 19 | 26 | 58 |
| 2045 | 9.9 | 27 | 38 | 84 |
| 2050 | 13 | 35 | 48 | 110 |
| 2055 | 15 | 38 | 52 | 110 |
| PV | 80 | 320 | 490 | 970 |

TABLE 187—CLIMATE BENEFITS FROM REDUCTIONS IN GHG EMISSIONS ASSOCIATED WITH ALTERNATIVE 3, LIGHT-DUTY AND MEDIUM-DUTY—Continued

[Billions of 2020 dollars]

| Calendar year | Discount rate and statistic | | | |
|---|---|---|---|---|
| | 5% Average | 3% Average | 2.5% Average | 3% 95th Percentile |
| EAV | 5.3 | 17 | 24 | 51 |

**Notes:** The present value of reduced GHG emissions is calculated differently than other benefits. The same discount rate used to discount the value of damages from future emissions (SC–GHGs at 5, 3, 2.5 percent) is used to calculate the present value of SC–GHGs for internal consistency. The 95th percentile of estimates based on a 3 percent discount rate are included to provide information on potentially higher-than-expected economic impacts from climate change, conditional on the 3 percent estimate of the discount rate. Annual benefits shown are undiscounted values.

### *E. Criteria Pollutant Health and Environmental Benefits*

The light-duty passenger cars and light trucks and medium-duty vehicles subject to the proposed standards are significant sources of mobile source air pollution, including directly-emitted $PM_{2.5}$ as well as $NO_X$ and VOC emissions (both precursors to ozone formation and secondarily-formed $PM_{2.5}$). The proposed program would reduce exhaust emissions of these pollutants from the regulated vehicles, which would in turn reduce ambient concentrations of ozone and $PM_{2.5}$. Emissions from upstream sources would likely increase in some cases (*e.g.,* power plants) and decrease in others (*e.g.,* refineries). We project that in total, the proposed standards would result in substantial net reductions of emissions of pollutants like $PM_{2.5}$, NOx and VOCs. Criteria and toxic pollutant emissions changes attributable to the proposed standards are presented in Section VII of this Preamble. Exposures to ambient pollutants such as $PM_{2.5}$ and ozone are linked to adverse environmental and human health impacts, such as premature deaths and non-fatal illnesses (as explained in Section II.C of this Preamble). Reducing human exposure to these pollutants results in significant and measurable health benefits.

This section discusses the economic benefits from reductions in adverse health and environmental impacts resulting from criteria pollutant emission reductions that can be expected to occur as a result of the proposed emission standards. When feasible, EPA conducts full-scale photochemical air quality modeling to demonstrate how its national mobile source regulatory actions affect ambient concentrations of regional pollutants throughout the United States. The estimation of the human health impacts of a regulatory action requires national-scale photochemical air quality modeling to conduct a full-scale assessment of $PM_{2.5}$ and ozone-related health benefits.

EPA conducted an illustrative air quality modeling analysis of a regulatory scenario involving light- and medium-duty vehicle emission reductions and corresponding changes in ''upstream'' emission sources like EGU (electric generating unit) emissions and refinery emissions (see DRIA Chapter 8). Decisions about the emissions and other elements used in the air quality modeling were made early in the analytical process for the proposed rulemaking. Accordingly, the air quality analysis does not represent the proposal's regulatory scenario, nor does it reflect the expected impacts of the Inflation Reduction Act (IRA). Based on updated power sector modeling that incorporated expected generation mix impacts of the IRA, we are projecting the IRA will lead to a significantly cleaner power grid. Because the air quality analysis does not account for these impacts on EGU emissions, we instead used the OMEGA-based emissions analysis (see Preamble Section VII.A) and benefit-per-ton (BPT) values to estimate the criteria pollutant ($PM_{2.5}$) health benefits of the proposed standards.

The BPT approach estimates the monetized economic value of $PM_{2.5}$-related emission reductions or increases (such as direct PM, $NO_X$, and $SO_2$) due to implementation of the proposed program. Similar to the SC–GHG approach for monetizing reductions in GHGs, the BPT approach monetizes the health benefits of avoiding one ton of $PM_{2.5}$-related emissions from a particular onroad mobile or upstream source. The value of health benefits from reductions (or increases) in $PM_{2.5}$ emissions associated with this proposal were estimated by multiplying $PM_{2.5}$-related BPT values by the corresponding annual reduction (or increase) in tons of directly-emitted $PM_{2.5}$ and $PM_{2.5}$ precursor emissions (NOx and $SO_2$). As explained in Chapter 7.4 in the DRIA, the $PM_{2.5}$ BPT values represent the monetized value of human health benefits, including reductions in both premature mortality and morbidity.

The mobile sector BPT estimates used in this proposal were published in 2019, but were recently updated using the suite of premature mortality and morbidity studies in use by EPA for the 2023 p.m. NAAQS Reconsideration Proposal.[786] [787] The upstream BPT estimates used in this proposal were also recently updated.[788] The health benefits Technical Support Document (Benefits TSD) that accompanied the 2023 p.m. NAAQS Proposal details the approach used to estimate the $PM_{2.5}$-related benefits reflected in these BPTs.[789] For more detailed information about the benefits analysis conducted for this proposal, including the BPT unit values used in this analysis, please refer to Chapter 7.4 of the DRIA.

A chief limitation to using $PM_{2.5}$-related BPT values is that they do not reflect benefits associated with reducing ambient concentrations of ozone. The $PM_{2.5}$-related BPT values also do not capture the benefits associated with reductions in direct exposure to $NO_2$ and mobile source air toxics, nor do they account for improved ecosystem effects or visibility. The estimated benefits of this proposal would be larger if we were able to monetize these unquantified benefits at this time.

Table 188 presents the annual, undiscounted $PM_{2.5}$-related health

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[786] Wolfe, P.; Davidson, K.; Fulcher, C.; Fann, N.; Zawacki, M.; Baker, K. R. 2019. Monetized Health Benefits Attributable to Mobile Source Emission Reductions across the United States in 2025. Sci. Total Environ. 650, 2490–2498. Available at: *https://doi.org/10.1016/J.SCITOTENV.2018.09.273.*

[787] U.S. Environmental Protection Agency (U.S. EPA). 2022. PM NAAQS Reconsideration Proposal RIA. EPA–HQ–OAR–2019–0587. December.

[788] U.S. Environmental Protection Agency (U.S. EPA). 2023. Technical Support Document: Estimating the Benefit per Ton of Reducing Directly-Emitted $PM_{2.5}$, $PM_{2.5}$ Precursors and Ozone Precursors from 21 Sectors. January.

[789] U.S. Environmental Protection Agency (U.S. EPA). 2023. Estimating $PM_{2.5}$- and Ozone-Attributable Health Benefits. Technical Support Document (TSD) for the PM NAAQS Reconsideration Proposal RIA. EPA–HQ–OAR–2019–0587. January.

benefits estimated for the stream of years beginning with the first year of rule implementation, 2027, through 2055 for the proposed standards. Benefits are presented by source (onroad and upstream) and are estimated using either a 3 percent or 7 percent discount rate to account for avoided health outcomes that are expected to accrue over more than a single year (the ‘‘cessation’’ lag between the change in PM exposures and the total realization of changes in health effects). Because premature mortality typically constitutes the vast majority of monetized benefits in a $PM_{2.5}$ benefits assessment, we present benefits based on risk estimates reported from two different long-term exposure studies using different cohorts to account for uncertainty in the benefits associated with avoiding PM-related premature deaths.[790,791]

The total present value of $PM_{2.5}$-related benefits for the proposed program between 2027 and 2055 (discounted back to 2027) is $140 to $280 billion at a 3 percent discount rate and $63 to $130 billion at a 7 percent discount rate (2020 dollars).

TABLE 188—MONETIZED $PM_{2.5}$ HEALTH BENEFITS OF ONROAD AND UPSTREAM EMISSIONS REDUCTIONS ASSOCIATED WITH THE PROPOSAL, LIGHT-DUTY AND MEDIUM-DUTY

[Billions of 2020 dollars]

| | Onroad | | Upstream | | Total benefits | |
|---|---|---|---|---|---|---|
| | 3% Discount rate | 7% Discount rate | 3% Discount rate | 7% Discount rate | 3% Discount rate | 7% Discount rate |
| 2027 | 0.053–0.11 | 0.048–0.1 | 0.011–0.026 | 0.01–0.023 | 0.064–0.14 | 0.058–0.13 |
| 2028 | 0.13–0.28 | 0.12–0.25 | 0.039–0.088 | 0.035–0.08 | 0.17–0.37 | 0.15–0.33 |
| 2029 | 0.24–0.52 | 0.22–0.47 | 0.083–0.19 | 0.075–0.17 | 0.33–0.71 | 0.29–0.63 |
| 2030 | 0.65–1.3 | 0.58–1.2 | 0.15–0.33 | 0.14–0.29 | 0.8–1.7 | 0.72–1.5 |
| 2031 | 1–2.1 | 0.93–1.9 | 0.24–0.52 | 0.22–0.47 | 1.3–2.7 | 1.2–2.4 |
| 2032 | 1.4–3 | 1.3–2.7 | 0.36–0.77 | 0.33–0.69 | 1.8–3.7 | 1.6–3.4 |
| 2033 | 1.9–3.9 | 1.7–3.5 | 0.51–1.1 | 0.45–0.96 | 2.4–4.9 | 2.1–4.4 |
| 2034 | 2.3–4.8 | 2.1–4.3 | 0.67–1.4 | 0.6–1.3 | 3–6.2 | 2.7–5.6 |
| 2035 | 3.2–6.4 | 2.9–5.8 | 0.98–2 | 0.88–1.8 | 4.2–8.4 | 3.7–7.6 |
| 2036 | 3.7–7.4 | 3.3–6.6 | 1.2–2.4 | 1–2.2 | 4.8–9.8 | 4.3–8.8 |
| 2037 | 4.2–8.4 | 3.7–7.5 | 1.4–2.8 | 1.2–2.6 | 5.6–11 | 5–10 |
| 2038 | 4.7–9.4 | 4.2–8.5 | 1.6–3.3 | 1.5–3 | 6.3–13 | 5.6–11 |
| 2039 | 5.1–10 | 4.6–9.3 | 1.9–3.8 | 1.7–3.4 | 7–14 | 6.3–13 |
| 2040 | 6.3–13 | 5.7–11 | 2.4–4.8 | 2.1–4.3 | 8.7–17 | 7.8–16 |
| 2041 | 6.8–14 | 6.1–12 | 2.7–5.3 | 2.4–4.8 | 9.5–19 | 8.5–17 |
| 2042 | 7.3–14 | 6.6–13 | 2.9–5.8 | 2.6–5.2 | 10–20 | 9.2–18 |
| 2043 | 7.8–15 | 7–14 | 3.2–6.4 | 2.9–5.8 | 11–22 | 9.8–20 |
| 2044 | 8.1–16 | 7.3–14 | 3.4–6.9 | 3.1–6.2 | 12–23 | 10–21 |
| 2045 | 9.3–18 | 8.4–16 | 3.7–7.4 | 3.3–6.6 | 13–26 | 12–23 |
| 2046 | 9.7–19 | 8.7–17 | 4–7.9 | 3.6–7.1 | 14–27 | 12–24 |
| 2047 | 10–20 | 9–18 | 4.2–8.3 | 3.8–7.5 | 14–28 | 13–25 |
| 2048 | 10–20 | 9.2–18 | 4.3–8.6 | 3.9–7.7 | 15–29 | 13–26 |
| 2049 | 11–21 | 9.4–18 | 4.4–8.9 | 4–8 | 15–29 | 13–26 |
| 2050 | 12–22 | 10–20 | 4.6–9.1 | 4.1–8.2 | 16–31 | 14–28 |
| 2051 | 12–23 | 11–20 | 4.6–9.2 | 4.1–8.2 | 16–32 | 15–29 |
| 2052 | 12–23 | 11–21 | 4.6–9.2 | 4.1–8.3 | 16–32 | 15–29 |
| 2053 | 12–23 | 11–21 | 4.6–9.3 | 4.2–8.3 | 17–32 | 15–29 |
| 2054 | 12–23 | 11–21 | 4.6–9.3 | 4.2–8.3 | 17–32 | 15–29 |
| 2055 | 13–25 | 12–22 | 4.6–9.3 | 4.2–8.3 | 18–34 | 16–31 |
| Present Value | 100–200 | 46–91 | 39–79 | 17–35 | 140–280 | 63–130 |
| Equivalent Annualized Value | 5.4–11 | 3.7–7.4 | 2.1–4.1 | 1.4–2.8 | 7.5–15 | 5.1–10 |

**Notes:** The range of benefits in this table reflect the range of premature mortality estimates derived from the Medicare study (Wu et al., 2020) and the NHIS study (Pope III et al., 2019). All benefits estimates are rounded to two significant figures. Annual benefit values presented here are not discounted. The present value of benefits is the total aggregated value of the series of discounted annual benefits that occur between 2027–2055 (in 2020 dollars) using either a 3 percent or 7 percent discount rate. The benefits associated with the standards presented here do not include the full complement of health and environmental benefits that, if quantified and monetized, would increase the total monetized benefits.

TABLE 189—MONETIZED $PM_{2.5}$ HEALTH BENEFITS OF ONROAD AND UPSTREAM EMISSIONS REDUCTIONS ASSOCIATED WITH ALTERNATIVE 1, LIGHT-DUTY AND MEDIUM-DUTY

[Billions of 2020 dollars]

| | Onroad | | Upstream | | Total benefits | |
|---|---|---|---|---|---|---|
| | 3% Discount rate | 7% Discount rate | 3% Discount rate | 7% Discount rate | 3% Discount rate | 7% Discount rate |
| 2027 | 0.055–0.12 | 0.05–0.11 | 0.012–0.027 | 0.011–0.025 | 0.067–0.15 | 0.06–0.13 |
| 2028 | 0.14–0.3 | 0.13–0.27 | 0.048–0.11 | 0.044–0.098 | 0.19–0.41 | 0.17–0.37 |
| 2029 | 0.25–0.53 | 0.22–0.48 | 0.11–0.23 | 0.095–0.21 | 0.35–0.76 | 0.32–0.69 |

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[790] Wu, X, Braun, D, Schwartz, J, Kioumourtzoglou, M and Dominici, F (2020). Evaluating the impact of long-term exposure to fine particulate matter on mortality among the elderly. Science advances 6(29): eaba5692.

[791] Pope III, CA, Lefler, JS, Ezzati, M, Higbee, JD, Marshall, JD, Kim, S–Y, Bechle, M, Gilliat, KS, Vernon, SE and Robinson, AL (2019). Mortality risk and fine particulate air pollution in a large, representative cohort of US adults. Environmental health perspectives 127(7): 077007.

### TABLE 189—MONETIZED $PM_{2.5}$ HEALTH BENEFITS OF ONROAD AND UPSTREAM EMISSIONS REDUCTIONS ASSOCIATED WITH ALTERNATIVE 1, LIGHT-DUTY AND MEDIUM-DUTY—Continued

[Billions of 2020 dollars]

| | Onroad | | Upstream | | Total benefits | |
|---|---|---|---|---|---|---|
| | 3% Discount rate | 7% Discount rate | 3% Discount rate | 7% Discount rate | 3% Discount rate | 7% Discount rate |
| 2030 | 0.66–1.4 | 0.59–1.2 | 0.2–0.42 | 0.18–0.38 | 0.85–1.8 | 0.77–1.6 |
| 2031 | 1–2.2 | 0.93–1.9 | 0.31–0.65 | 0.28–0.59 | 1.3–2.8 | 1.2–2.5 |
| 2032 | 1.4–3 | 1.3–2.7 | 0.44–0.94 | 0.4–0.84 | 1.9–3.9 | 1.7–3.5 |
| 2033 | 1.9–3.9 | 1.7–3.5 | 0.61–1.3 | 0.55–1.2 | 2.5–5.2 | 2.2–4.6 |
| 2034 | 2.3–4.8 | 2.1–4.3 | 0.78–1.7 | 0.71–1.5 | 3.1–6.5 | 2.8–5.8 |
| 2035 | 3.2–6.5 | 2.9–5.8 | 1.1–2.3 | 1–2.1 | 4.3–8.8 | 3.9–7.9 |
| 2036 | 3.7–7.4 | 3.3–6.7 | 1.3–2.7 | 1.2–2.5 | 5–10 | 4.5–9.1 |
| 2037 | 4.2–8.5 | 3.8–7.6 | 1.6–3.2 | 1.4–2.9 | 5.8–12 | 5.2–11 |
| 2038 | 4.7–9.5 | 4.2–8.6 | 1.8–3.7 | 1.6–3.4 | 6.5–13 | 5.9–12 |
| 2039 | 5.2–10 | 4.7–9.4 | 2.1–4.2 | 1.9–3.8 | 7.3–15 | 6.5–13 |
| 2040 | 6.4–13 | 5.7–11 | 2.7–5.3 | 2.4–4.8 | 9.1–18 | 8.1–16 |
| 2041 | 6.9–14 | 6.2–12 | 3–5.9 | 2.7–5.3 | 9.9–20 | 8.9–18 |
| 2042 | 7.4–15 | 6.6–13 | 3.2–6.5 | 2.9–5.8 | 11–21 | 9.5–19 |
| 2043 | 7.8–15 | 7–14 | 3.5–7.1 | 3.2–6.4 | 11–23 | 10–20 |
| 2044 | 8.2–16 | 7.4–15 | 3.8–7.6 | 3.4–6.8 | 12–24 | 11–21 |
| 2045 | 9.4–18 | 8.5–17 | 4.1–8.2 | 3.7–7.3 | 14–27 | 12–24 |
| 2046 | 9.8–19 | 8.8–17 | 4.4–8.8 | 3.9–7.9 | 14–28 | 13–25 |
| 2047 | 10–20 | 9.1–18 | 4.6–9.2 | 4.1–8.3 | 15–29 | 13–26 |
| 2048 | 10–20 | 9.3–18 | 4.8–9.5 | 4.3–8.6 | 15–30 | 14–27 |
| 2049 | 11–21 | 9.5–19 | 4.9–9.8 | 4.4–8.8 | 16–31 | 14–27 |
| 2050 | 12–23 | 11–20 | 5–10 | 4.5–9 | 17–33 | 15–29 |
| 2051 | 12–23 | 11–21 | 5–10 | 4.5–9.1 | 17–33 | 15–30 |
| 2052 | 12–23 | 11–21 | 5.1–10 | 4.6–9.1 | 17–33 | 15–30 |
| 2053 | 12–23 | 11–21 | 5.1–10 | 4.6–9.1 | 17–33 | 15–30 |
| 2054 | 12–23 | 11–21 | 5.1–10 | 4.6–9.1 | 17–34 | 15–30 |
| 2055 | 13–25 | 12–23 | 5.1–10 | 4.6–9.1 | 18–35 | 16–32 |
| Present Value | 100–210 | 46–92 | 44–88 | 19–39 | 150–290 | 66–130 |
| Equivalent Annualized Value | 5.4–11 | 3.8–7.5 | 2.3–4.6 | 1.6–3.2 | 7.7–15 | 5.3–11 |

**Notes:** The range of benefits in this table reflect the range of premature mortality estimates derived from the Medicare study (Wu et al., 2020) and the NHIS study (Pope III et al., 2019). All benefits estimates are rounded to two significant figures. Annual benefit values presented here are not discounted. The present value of benefits is the total aggregated value of the series of discounted annual benefits that occur between 2027–2055 (in 2020 dollars) using either a 3 percent or 7 percent discount rate. The benefits associated with the standards presented here do not include the full complement of health and environmental benefits that, if quantified and monetized, would increase the total monetized benefits.

### TABLE 190—MONETIZED $PM_{2.5}$ HEALTH BENEFITS OF ONROAD AND UPSTREAM EMISSIONS REDUCTIONS ASSOCIATED WITH ALTERNATIVE 2, LIGHT-DUTY AND MEDIUM-DUTY

[Billions of 2020 dollars]

| | Onroad | | Upstream | | Total benefits | |
|---|---|---|---|---|---|---|
| | 3% Discount rate | 7% Discount rate | 3% Discount rate | 7% Discount rate | 3% Discount rate | 7% Discount rate |
| 2027 | 0.039–0.083 | 0.035–0.075 | 0.0083–0.019 | 0.0075–0.017 | 0.047–0.1 | 0.042–0.092 |
| 2028 | 0.094–0.2 | 0.084–0.18 | 0.031–0.07 | 0.028–0.063 | 0.13–0.27 | 0.11–0.24 |
| 2029 | 0.19–0.41 | 0.17–0.37 | 0.069–0.15 | 0.062–0.14 | 0.26–0.56 | 0.23–0.51 |
| 2030 | 0.59–1.2 | 0.53–1.1 | 0.12–0.27 | 0.11–0.24 | 0.71–1.5 | 0.64–1.3 |
| 2031 | 0.97–2 | 0.87–1.8 | 0.2–0.43 | 0.18–0.39 | 1.2–2.4 | 1.1–2.2 |
| 2032 | 1.4–2.8 | 1.2–2.5 | 0.31–0.65 | 0.28–0.59 | 1.7–3.5 | 1.5–3.1 |
| 2033 | 1.8–3.7 | 1.6–3.3 | 0.44–0.94 | 0.4–0.85 | 2.2–4.6 | 2–4.2 |
| 2034 | 2.2–4.6 | 2–4.2 | 0.59–1.2 | 0.53–1.1 | 2.8–5.9 | 2.5–5.3 |
| 2035 | 3.1–6.2 | 2.8–5.6 | 0.87–1.8 | 0.78–1.6 | 4–8 | 3.6–7.2 |
| 2036 | 3.6–7.2 | 3.2–6.5 | 1–2.1 | 0.92–1.9 | 4.6–9.3 | 4.1–8.4 |
| 2037 | 4.1–8.2 | 3.7–7.4 | 1.2–2.5 | 1.1–2.3 | 5.3–11 | 4.8–9.6 |
| 2038 | 4.6–9.2 | 4.1–8.3 | 1.4–2.9 | 1.3–2.6 | 6–12 | 5.4–11 |
| 2039 | 5.1–10 | 4.5–9.2 | 1.6–3.4 | 1.5–3 | 6.7–14 | 6–12 |
| 2040 | 6.2–12 | 5.6–11 | 2.1–4.3 | 1.9–3.8 | 8.4–17 | 7.5–15 |
| 2041 | 6.7–13 | 6.1–12 | 2.4–4.8 | 2.1–4.3 | 9.1–18 | 8.2–16 |
| 2042 | 7.2–14 | 6.5–13 | 2.6–5.2 | 2.4–4.7 | 9.8–19 | 8.8–18 |
| 2043 | 7.7–15 | 6.9–14 | 2.9–5.8 | 2.6–5.2 | 11–21 | 9.5–19 |
| 2044 | 8–16 | 7.2–14 | 3.1–6.2 | 2.8–5.6 | 11–22 | 10–20 |
| 2045 | 9.2–18 | 8.3–16 | 3.3–6.6 | 3–6 | 13–25 | 11–22 |
| 2046 | 9.6–19 | 8.6–17 | 3.6–7.1 | 3.2–6.4 | 13–26 | 12–23 |
| 2047 | 9.9–19 | 8.9–17 | 3.8–7.5 | 3.4–6.8 | 14–27 | 12–24 |
| 2048 | 10–20 | 9.1–18 | 3.9–7.8 | 3.5–7 | 14–28 | 13–25 |
| 2049 | 10–20 | 9.4–18 | 4–8 | 3.6–7.2 | 14–28 | 13–26 |

### TABLE 190—MONETIZED PM$_{2.5}$ HEALTH BENEFITS OF ONROAD AND UPSTREAM EMISSIONS REDUCTIONS ASSOCIATED WITH ALTERNATIVE 2, LIGHT-DUTY AND MEDIUM-DUTY—Continued

[Billions of 2020 dollars]

| | Onroad | | Upstream | | Total benefits | |
|---|---|---|---|---|---|---|
| | 3% Discount rate | 7% Discount rate | 3% Discount rate | 7% Discount rate | 3% Discount rate | 7% Discount rate |
| 2050 | 11–22 | 10–20 | 4.1–8.3 | 3.7–7.4 | 16–30 | 14–27 |
| 2051 | 12–22 | 10–20 | 4.2–8.3 | 3.7–7.5 | 16–31 | 14–28 |
| 2052 | 12–23 | 11–20 | 4.2–8.3 | 3.8–7.5 | 16–31 | 14–28 |
| 2053 | 12–23 | 11–20 | 4.2–8.4 | 3.8–7.5 | 16–31 | 14–28 |
| 2054 | 12–23 | 11–21 | 4.2–8.4 | 3.8–7.5 | 16–31 | 14–28 |
| 2055 | 13–25 | 12–22 | 4.2–8.4 | 3.8–7.5 | 17–33 | 15–30 |
| Present Value | 100–200 | 45–89 | 35–71 | 15–31 | 140–270 | 61–120 |
| Equivalent Annualized Value | 5.3–10 | 3.7–7.3 | 1.8–3.7 | 1.3–2.5 | 7.2–14 | 4.9–9.8 |

**Notes:** The range of benefits in this table reflect the range of premature mortality estimates derived from the Medicare study (Wu et al., 2020) and the NHIS study (Pope III et al., 2019). All benefits estimates are rounded to two significant figures. Annual benefit values presented here are not discounted. The present value of benefits is the total aggregated value of the series of discounted annual benefits that occur between 2027–2055 (in 2020 dollars) using either a 3 percent or 7 percent discount rate. The benefits associated with the standards presented here do not include the full complement of health and environmental benefits that, if quantified and monetized, would increase the total monetized benefits.

### TABLE 191—MONETIZED PM$_{2.5}$ HEALTH BENEFITS OF ONROAD AND UPSTREAM EMISSIONS REDUCTIONS ASSOCIATED WITH ALTERNATIVE 3, LIGHT-DUTY AND MEDIUM-DUTY

[Billions of 2020 dollars]

| | Onroad | | Upstream | | Total Benefits | |
|---|---|---|---|---|---|---|
| | 3% Discount rate | 7% Discount rate | 3% Discount rate | 7% Discount rate | 3% Discount rate | 7% Discount rate |
| 2027 | 0.034–0.073 | 0.031–0.066 | 0.0057–0.013 | 0.0051–0.012 | 0.04–0.086 | 0.036–0.078 |
| 2028 | 0.085–0.18 | 0.076–0.16 | 0.023–0.052 | 0.021–0.047 | 0.11–0.23 | 0.097–0.21 |
| 2029 | 0.15–0.32 | 0.14–0.29 | 0.049–0.11 | 0.044–0.098 | 0.2–0.43 | 0.18–0.39 |
| 2030 | 0.54–1.1 | 0.48–1 | 0.098–0.21 | 0.088–0.19 | 0.63–1.3 | 0.57–1.2 |
| 2031 | 0.92–1.9 | 0.83–1.7 | 0.18–0.38 | 0.16–0.34 | 1.1–2.3 | 0.99–2.1 |
| 2032 | 1.3–2.7 | 1.2–2.4 | 0.29–0.62 | 0.26–0.56 | 1.6–3.3 | 1.4–3 |
| 2033 | 1.7–3.6 | 1.6–3.3 | 0.43–0.92 | 0.39–0.83 | 2.2–4.5 | 2–4.1 |
| 2034 | 2.2–4.6 | 2–4.1 | 0.6–1.3 | 0.54–1.1 | 2.8–5.8 | 2.5–5.2 |
| 2035 | 3–6.1 | 2.7–5.5 | 0.9–1.8 | 0.81–1.7 | 3.9–8 | 3.5–7.2 |
| 2036 | 3.5–7.1 | 3.2–6.4 | 1.1–2.2 | 0.97–2 | 4.6–9.3 | 4.1–8.4 |
| 2037 | 4–8.1 | 3.6–7.3 | 1.3–2.7 | 1.2–2.4 | 5.3–11 | 4.8–9.7 |
| 2038 | 4.6–9.2 | 4.1–8.3 | 1.5–3.1 | 1.4–2.8 | 6.1–12 | 5.5–11 |
| 2039 | 5–10 | 4.5–9.1 | 1.8–3.6 | 1.6–3.3 | 6.8–14 | 6.1–12 |
| 2040 | 6.2–12 | 5.6–11 | 2.3–4.6 | 2.1–4.1 | 8.5–17 | 7.7–15 |
| 2041 | 6.7–13 | 6–12 | 2.6–5.2 | 2.3–4.6 | 9.3–18 | 8.4–17 |
| 2042 | 7.2–14 | 6.5–13 | 2.8–5.7 | 2.6–5.1 | 10–20 | 9–18 |
| 2043 | 7.7–15 | 6.9–14 | 3.1–6.3 | 2.8–5.6 | 11–21 | 9.7–19 |
| 2044 | 8–16 | 7.2–14 | 3.4–6.8 | 3–6.1 | 11–23 | 10–20 |
| 2045 | 9.3–18 | 8.3–16 | 3.6–7.3 | 3.3–6.5 | 13–25 | 12–23 |
| 2046 | 9.7–19 | 8.7–17 | 3.9–7.8 | 3.5–7 | 14–27 | 12–24 |
| 2047 | 9.9–19 | 8.9–17 | 4.1–8.3 | 3.7–7.4 | 14–28 | 13–25 |
| 2048 | 10–20 | 9.2–18 | 4.3–8.6 | 3.9–7.7 | 15–29 | 13–26 |
| 2049 | 10–20 | 9.4–18 | 4.4–8.9 | 4–8 | 15–29 | 13–26 |
| 2050 | 12–22 | 10–20 | 4.6–9.1 | 4.1–8.2 | 16–31 | 14–28 |
| 2051 | 12–23 | 10–20 | 4.6–9.2 | 4.1–8.2 | 16–32 | 15–29 |
| 2052 | 12–23 | 11–21 | 4.6–9.2 | 4.1–8.3 | 16–32 | 15–29 |
| 2053 | 12–23 | 11–21 | 4.6–9.2 | 4.2–8.3 | 16–32 | 15–29 |
| 2054 | 12–23 | 11–21 | 4.6–9.3 | 4.2–8.3 | 17–32 | 15–29 |
| 2055 | 13–25 | 12–22 | 4.6–9.3 | 4.2–8.3 | 18–34 | 16–31 |
| Present Value | 100–200 | 45–89 | 38–77 | 17–33 | 140–280 | 62–120 |
| Equivalent Annualized Value | 5.3–10 | 3.7–7.3 | 2–4 | 1.4–2.7 | 7.3–14 | 5–10 |

**Notes:** The range of benefits in this table reflect the range of premature mortality estimates derived from the Medicare study (Wu et al., 2020) and the NHIS study (Pope III et al., 2019). All benefits estimates are rounded to two significant figures. Annual benefit values presented here are not discounted. The present value of benefits is the total aggregated value of the series of discounted annual benefits that occur between 2027–2055 (in 2020 dollars) using either a 3 percent or 7 percent discount rate. The benefits associated with the standards presented here do not include the full complement of health and environmental benefits that, if quantified and monetized, would increase the total monetized benefits.

This analysis includes many data sources that are each subject to uncertainty, including projected emission inventories, air quality data from models, population data, population estimates, health effect estimates from epidemiology studies, economic data, and assumptions regarding the future state of the world (*i.e.,* regulations, technology, and human behavior). When compounded, even small uncertainties can greatly influence the size of the total quantified benefits. There are also inherent limitations associated with using the BPT approach. Despite these uncertainties, we believe the criteria pollutant benefits presented here are our best estimate of benefits absent air quality modeling and we have confidence in the BPT approach and the appropriateness of relying on BPT health estimates for this rulemaking. Please refer to DRIA Chapter 7 for more information on the uncertainty associated with the benefits presented here.

### *F. Other Impacts Including Maintenance and Repair*

We present here the estimated impacts associated with rebound driving (drive value, congestion, noise) and the impacts on maintenance and repair costs. Lastly, we briefly discuss the safety-related impacts. More information on each of these topics is presented in Chapter 4 and Chapter 9 of the DRIA.

#### 1. Impacts Associated With Rebound Driving

The rebound effect might occur when an increase in vehicle fuel efficiency makes it possible for people to choose to drive more without spending more because of the lower cost per mile of driving. Additional driving can lead to costs and benefits that can be monetized. Note that we do not estimate or further discuss the size of the rebound effect in this Preamble. See DRIA Chapter 4 for that discussion. We request comment on the assumptions described there. In this section, we take the size of the rebound effect determined in the DRIA and highlight the costs and benefits associated with additional driving.

#### i. Drive Value

The increase in travel associated with the rebound effect produces social and economic opportunities that become accessible with additional travel. We estimate the economic benefits from increased rebound-effect driving as the sum of the fuel costs paid to drive those miles and the owner/operator surplus from the additional accessibility that driving provides. These benefits are known as the drive value and appear in Table 192.

The fuel costs of the rebound miles driven are simply the number of rebound miles multiplied by the cost per mile of driving them. The economic value of the increased owner/operator surplus provided by added driving is estimated as one half of the product of the fuel savings per mile and rebound miles. Because fuel savings differ among vehicles in response to standards, the value of benefits from increased vehicle use differs by model year and varies across alternative standards.

TABLE 192—DRIVE VALUE BENEFITS ASSOCIATED WITH THE PROPOSAL AND EACH ALTERNATIVE, LIGHT-DUTY AND MEDIUM-DUTY

[Billions of 2020 dollars] *

| Calendar year | Drive value benefits, proposal | Drive value benefits, alternative 1 | Drive value benefits, alternative 2 | Drive value benefits, alternative 3 |
|---|---|---|---|---|
| 2027 | 0.0011 | 0.0019 | 0.0026 | −0.0036 |
| 2028 | 0.024 | 0.045 | 0.028 | 0.0068 |
| 2029 | 0.049 | 0.12 | 0.049 | 0.02 |
| 2030 | 0.086 | 0.2 | 0.077 | 0.041 |
| 2031 | 0.12 | 0.28 | 0.11 | 0.063 |
| 2032 | 0.16 | 0.37 | 0.16 | 0.1 |
| 2035 | 0.26 | 0.5 | 0.22 | 0.21 |
| 2040 | 0.37 | 0.51 | 0.15 | 0.26 |
| 2045 | 0.34 | 0.37 | 0.087 | 0.22 |
| 2050 | 0.34 | 0.29 | 0.11 | 0.21 |
| 2055 | 0.31 | 0.22 | 0.17 | 0.21 |
| PV3 | 4.8 | 6.5 | 2.4 | 3.2 |
| PV7 | 2.7 | 3.9 | 1.5 | 1.8 |
| EAV3 | 0.25 | 0.34 | 0.12 | 0.17 |
| EAV7 | 0.22 | 0.32 | 0.12 | 0.15 |

* Positive values represent benefits.

#### ii. Congestion and Noise

In contrast to the benefits of additional driving are the costs associated with that driving. Increased vehicle use associated with a positive rebound effect also contributes to increased traffic congestion and highway noise. Delays associated with congestion impose higher costs on road users in the form of increased travel time and operating expenses. Likewise, vehicles driving more miles on roadways leads to more road noise from tires, wind, engines, and motors.

As in past rulemakings (*i.e.,* GHG 2010, 2012, and 2021), EPA relies on estimates of congestion and noise costs developed by the Federal Highway Administration's (FHWA's), specifically the ''Middle'' estimates for marginal congestion and noise costs, to estimate the increased external costs caused by added driving due to the rebound effect. FHWA's congestion and noise cost estimates focus on freeways. EPA, however, applies the congestion cost to all vehicle miles, freeway and non-freeway and including rebound miles to ensure that these costs are not underestimated. Table 193 shows the values used as inputs to OMEGA and adjusted within the model to the dollar basis used in the analysis.

Table 194 presents the congestion costs associated with the proposal and each of the alternatives, while Table 195 shows the same information for noise costs.

### TABLE 193—COSTS ASSOCIATED WITH CONGESTION AND NOISE

[2018 Dollars per vehicle mile]

| | Sedans/wagons | CUVs/SUVs/vans | Pickups |
|---|---|---|---|
| Congestion | 0.0634 | 0.0634 | 0.0566 |
| Noise | 0.0009 | 0.0009 | 0.0009 |

### TABLE 194—CONGESTION COSTS ASSOCIATED WITH THE PROPOSAL AND EACH ALTERNATIVE, LIGHT-DUTY AND MEDIUM-DUTY

[Billions of 2020 dollars] *

| Calendar year | Congestion costs, proposal | Congestion costs, alternative 1 | Congestion costs, alternative 2 | Congestion costs, alternative 3 |
|---|---|---|---|---|
| 2027 | −0.00023 | 0.00063 | 0.00072 | −0.0039 |
| 2028 | 0.01 | 0.025 | 0.012 | −0.00089 |
| 2029 | 0.022 | 0.071 | 0.02 | 0.0042 |
| 2030 | 0.038 | 0.11 | 0.03 | 0.012 |
| 2031 | 0.055 | 0.17 | 0.046 | 0.023 |
| 2032 | 0.074 | 0.21 | 0.065 | 0.039 |
| 2035 | 0.12 | 0.28 | 0.082 | 0.088 |
| 2040 | 0.19 | 0.27 | 0.037 | 0.12 |
| 2045 | 0.17 | 0.2 | 0.0096 | 0.11 |
| 2050 | 0.17 | 0.14 | 0.028 | 0.11 |
| 2055 | 0.16 | 0.11 | 0.064 | 0.11 |
| PV3 | 2.3 | 3.5 | 0.74 | 1.5 |
| PV7 | 1.3 | 2.2 | 0.48 | 0.82 |
| EAV3 | 0.12 | 0.18 | 0.039 | 0.078 |
| EAV7 | 0.11 | 0.18 | 0.039 | 0.066 |

* Positive values represent costs.

### TABLE 195—NOISE COSTS ASSOCIATED WITH THE PROPOSAL AND EACH ALTERNATIVE, LIGHT-DUTY AND MEDIUM-DUTY

[Billions of 2020 dollars] *

| Calendar year | Noise costs, proposal | Noise costs, alternative 1 | Noise costs, alternative 2 | Noise costs, alternative 3 |
|---|---|---|---|---|
| 2027 | −0.000014 | −0.0000017 | 0.0000041 | −0.000059 |
| 2028 | 0.00014 | 0.00037 | 0.00018 | −0.000006 |
| 2029 | 0.00033 | 0.0011 | 0.00031 | 0.000076 |
| 2030 | 0.00059 | 0.0018 | 0.00047 | 0.0002 |
| 2031 | 0.00087 | 0.0026 | 0.00073 | 0.00038 |
| 2032 | 0.0012 | 0.0033 | 0.001 | 0.00064 |
| 2035 | 0.0019 | 0.0043 | 0.0013 | 0.0015 |
| 2040 | 0.0029 | 0.0043 | 0.00064 | 0.002 |
| 2045 | 0.0027 | 0.0031 | 0.00021 | 0.0017 |
| 2050 | 0.0027 | 0.0022 | 0.00048 | 0.0017 |
| 2055 | 0.0025 | 0.0017 | 0.001 | 0.0016 |
| PV3 | 0.037 | 0.055 | 0.012 | 0.024 |
| PV7 | 0.021 | 0.034 | 0.0078 | 0.013 |
| EAV3 | 0.0019 | 0.0028 | 0.00064 | 0.0012 |
| EAV7 | 0.0017 | 0.0027 | 0.00064 | 0.0011 |

* Positive values represent costs.

### 2. Maintenance and Repair Costs

Maintenance and repair (M&R) are large components of vehicle cost of ownership for any vehicle. According to Edmunds, maintenance costs consist of two types of maintenance: Scheduled and unscheduled. Scheduled maintenance is the performance of factory-recommended items at periodic mileage or calendar intervals. Unscheduled maintenance includes wheel alignment and the replacement of items such as the battery, brakes, headlights, hoses, exhaust system parts, taillight/turn signal bulbs, tires, and wiper blades/inserts.[792] Repairs, in contrast, are done to fix malfunctioning parts that inhibit the use of the vehicle. The differentiation between the items that are included in unscheduled maintenance versus repairs is likely arbitrary, but the items considered repairs seem to follow the systems that are covered in vehicle comprehensive (*i.e.,* ''bumper-to-bumper'') warranties offered by automakers, which exclude common ''wear'' items like tires, brakes, and starter batteries.[793]

To estimate maintenance and repair costs, we have used the data gathered and summarized by Argonne National Laboratory (ANL) in their evaluation of the total cost of ownership for vehicles of various sizes and powertrains.[794]

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[792] Edmunds, ''*Edmunds.com/tco.html*,'' Edmunds, [Online]. Available: *Edmunds.com/tco.html.* [Accessed 24 February 2022].

[793] D. Muller, ''Warranties Defined: The Truth behind the Promises,'' Car and Driver, 29 May 2017.

[794] ''Comprehensive Total Cost of Ownership Quantification for Vehicles with Different Size Classes and Powertrains, ANL/ESD–21/4,'' Argonne

i. Maintenance Costs

Maintenance costs are an important consideration in the full accounting of social benefits and costs and in a consumer's purchase decision process. In their study, ANL developed a generic maintenance service schedule for various powertrain types using owner's manuals from various vehicle makes and models, assuming that drivers would follow the recommended service intervals. After developing the maintenance schedules, the authors collected national average costs for each of the preventative and unscheduled services, noting several instances where differences in consumer characteristics and in vehicle attributes were likely important but not quantified/quantifiable.

Using the schedules and costs developed by the authors and presented in the DRIA, OMEGA calculates the cumulative maintenance costs from mile zero through mile 225,000. Because maintenance costs typically increase over the life of the vehicle, we estimate maintenance and repair costs per mile at a constant slope with an intercept set to $0 per mile such that the cumulative costs per the maintenance schedule are reached at 225,000 miles. Following this approach, the maintenance cost per mile curves calculated within OMEGA are as shown in Figure 38.

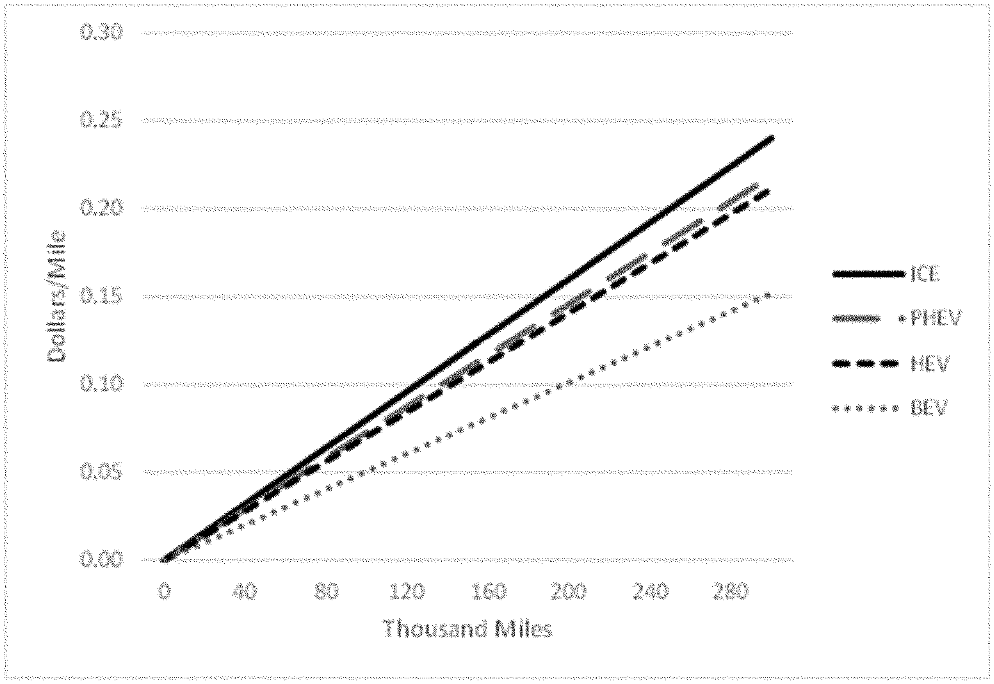

**Figure 38. Maintenance cost per mile (2019 dollars) at various odometer readings.**

Using these maintenance cost per mile curves, OMEGA then calculates the estimated maintenance costs in any given year of a vehicle's life based on the miles traveled in that year. Table 196 presents the maintenance costs (savings) associated with the proposal and each alternative. For a more detailed discussion of maintenance costs, see DRIA Chapter 4.

TABLE 196—MAINTENANCE COSTS ASSOCIATED WITH THE PROPOSAL AND EACH OF THE ALTERNATIVES, LIGHT-DUTY AND MEDIUM-DUTY

[Billions of 2020 dollars] *

| Calendar year | Maintenance costs, proposal | Maintenance costs, alternative 1 | Maintenance costs, alternative 2 | Maintenance costs, alternative 3 |
|---|---|---|---|---|
| 2027 | −0.048 | −0.048 | −0.032 | −0.044 |
| 2028 | −0.34 | −0.32 | −0.24 | −0.22 |
| 2029 | −0.91 | −0.8 | −0.68 | −0.54 |
| 2030 | −1.7 | −1.6 | −1.3 | −1 |
| 2031 | −2.7 | −2.7 | −2.1 | −1.7 |
| 2032 | −4 | −4.1 | −3.2 | −2.7 |
| 2035 | −9.7 | −10 | −8.2 | −7.7 |
| 2040 | −23 | −26 | −21 | −21 |
| 2045 | −37 | −42 | −34 | −36 |
| 2050 | −47 | −52 | −43 | −47 |

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National Laboratory, Energy Systems Division, April 2021.

TABLE 196—MAINTENANCE COSTS ASSOCIATED WITH THE PROPOSAL AND EACH OF THE ALTERNATIVES, LIGHT-DUTY AND MEDIUM-DUTY—Continued

[Billions of 2020 dollars] *

| Calendar year | Maintenance costs, proposal | Maintenance costs, alternative 1 | Maintenance costs, alternative 2 | Maintenance costs, alternative 3 |
|---|---|---|---|---|
| 2055 | −51 | −57 | −47 | −51 |
| PV3 | −410 | −450 | −370 | −390 |
| PV7 | −200 | −220 | −180 | −190 |
| EAV3 | −21 | −24 | −19 | −20 |
| EAV7 | −16 | −18 | −14 | −15 |

* Negative values denote negative costs, *i.e.,* savings.

ii. Repair Costs

Repairs are done to fix malfunctioning parts that inhibit the use of the vehicle and are generally considered to address problems associated with parts or systems that are covered under typical manufacturer bumper-to-bumper type warranties. In the ANL study, the authors were able to develop a repair cost curve for a gasoline car and a series of scalers that could be applied to that curve to estimate repair costs for other powertrains and vehicle types.

OMEGA makes use of ANL's cost curve and multipliers to estimate repair costs per mile at any age in a vehicle's life. Figure 39 provides repair cost per mile for a $35,000 car, van/SUV, and pickup.

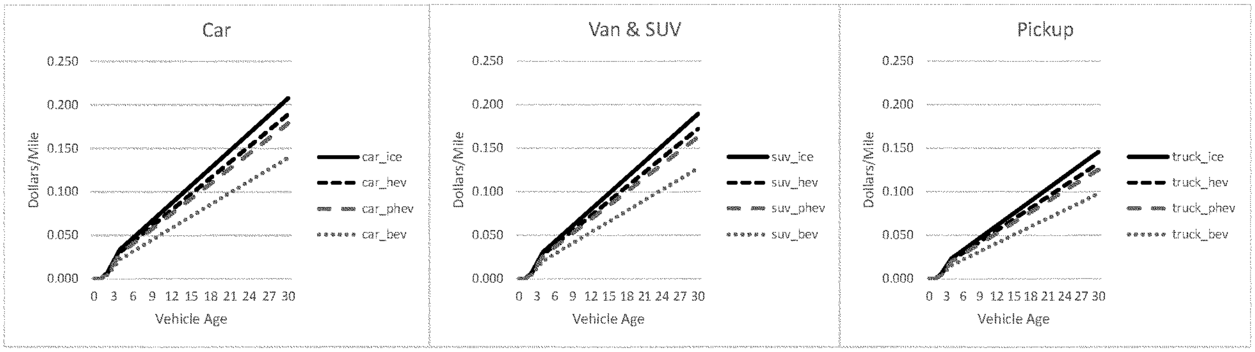

**Figure 39. Repair cost per mile (2019 dollars) for a $35,000 car, van/SUV, and pickup with various powertrains by vehicle age in years.**

Table 197 presents the repair costs associated with the proposal and each of the alternatives. A more detailed discussion of repair costs appears in DRIA Chapter 4.

TABLE 197—REPAIR COSTS ASSOCIATED WITH THE PROPOSAL AND EACH OF THE ALTERNATIVES, LIGHT-DUTY AND MEDIUM-DUTY

[Billions of 2020 dollars]

| Calendar year | Repair costs, proposal | Repair costs, alternative 1 | Repair costs, alternative 2 | Repair costs, alternative 3 |
|---|---|---|---|---|
| 2027 | 0.057 | 0.06 | 0.043 | 0.016 |
| 2028 | 0.078 | 0.11 | 0.058 | 0.012 |
| 2029 | 0.017 | 0.13 | 0.0065 | −0.049 |
| 2030 | −0.15 | 0.032 | −0.13 | −0.19 |
| 2031 | −0.43 | −0.17 | −0.36 | −0.39 |
| 2032 | −0.84 | −0.51 | −0.7 | −0.66 |
| 2035 | −2.8 | −2.4 | −2.5 | −2.3 |
| 2040 | −9 | −9 | −8.4 | −8.5 |
| 2045 | −16 | −17 | −15 | −16 |
| 2050 | −21 | −23 | −20 | −21 |
| 2055 | −24 | −26 | −22 | −24 |
| PV3 | −170 | −180 | −160 | −170 |
| PV7 | −79 | −82 | −74 | −77 |
| EAV3 | −8.9 | −9.3 | −8.3 | −8.6 |

TABLE 197—REPAIR COSTS ASSOCIATED WITH THE PROPOSAL AND EACH OF THE ALTERNATIVES, LIGHT-DUTY AND MEDIUM-DUTY—Continued

[Billions of 2020 dollars]

| Calendar year | Repair costs, proposal | Repair costs, alternative 1 | Repair costs, alternative 2 | Repair costs, alternative 3 |
|---|---|---|---|---|
| EAV7 | −6.5 | −6.7 | −6 | −6.3 |

* Negative values denote negative costs, *i.e.,* savings.

### 3. Safety Impacts

EPA has long considered the safety implications of its emission standards. Section 202(a)(4) of the CAA specifically prohibits the use of an emission control device, system or element of design that will cause or contribute to an unreasonable risk to public health, welfare, or safety. With respect to its light-duty greenhouse gas emission regulations, EPA has historically considered the potential impacts of GHG standards on safety in its light-duty GHG rulemakings.

The potential relationship between GHG emissions standards and safety is multi-faceted, and can be influenced not only by control technologies, but also by consumer decisions about vehicle ownership and use. EPA has estimated the impacts of this rule on safety by accounting for changes in new vehicle purchase, fleet turnover and VMT, and changes in vehicle weight that occur either as an emissions control strategy or as a result of the adoption of emissions control technologies such as vehicle electrification. Safety impacts related to changes in the use of vehicles in the fleet, relative mass changes, and the turnover of fleet to newer and safer vehicles have been estimated and considered in the standard setting process.

The GHG emissions standards are attribute-based standards, using vehicle footprint as the attribute. Footprint is defined as a vehicle's wheelbase multiplied by its average track width—in other words, the area enclosed by the points at which the wheels meet the ground. The standards are therefore generally based on a vehicle's size: Larger vehicles have numerically higher GHG emissions targets and smaller vehicles have numerically lower GHG emissions targets. Footprint-based standards help to distribute the burden of compliance across all vehicle footprints and across all manufacturers. Manufacturers are not compelled to build vehicles of any particular size or type, and each manufacturer has its own fleetwide standard for its car and truck fleets in each year that reflects the light-duty vehicles it chooses to produce. EPA has evaluated the relationship between vehicle footprint and GHG emissions targets and is proposing GHG standards that are intended to minimize incentives to change footprint as a compliance strategy. EPA is not projecting any changes in vehicle safety due to changes in footprint as a result of this proposed rule.

While EPA has not conducted new studies on the safety implications of electrified vehicles, there is strong reason to believe that BEVs are at least as safe as conventional vehicles,[795] if not more so. For example, the BEV architecture often lends itself to the addition of a ''frunk'' or front trunk. The frunk can provide additional crush space and occupant protection in frontal or front offset impacts. In addition, high voltage, large capacity batteries are often packaged under the vehicle and are integral to the vehicle construction. The increase in mass low in the vehicle provides additional vehicle stability and could reduce the propensity for vehicle rollover, especially in vehicles with a higher ride height, such as SUVs. In addition, the battery is typically an integral part of the body design and can provide additional side impact protection. For each of these reasons EPA believes that applying the historical relationship between mass and safety is appropriate for this rulemaking and may be conservative given the potential safety improvements provided by vehicle electrification.

Consistent with previous light-duty GHG analyses, EPA conducted a quantitative assessment of the potential of the proposed standards to affect vehicle safety. EPA applied the same historical relationships between mass, size, and fatality risk that were established and documented in the 2021 rulemaking. These relationships are based on the statistical analysis of historical crash data, which included an analysis performed by using the most recently available crash studies based on data for model years 2007 to 2011. EPA used these findings to estimate safety impacts of the modeled adoption of mass reduction as technology to reduce emissions, and the adoption of BEVs that result in some vehicle weights that are higher than comparable ICE vehicles due to the addition of the battery. Based on the findings of our safety analysis, we concluded there are no changes to the vehicles themselves, nor the combined effects of fleet composition and vehicle design, that will have a statistically significant impact on safety.[796] The only fatality projections presented here that are statistically significant are due to changes in use (VMT) rather than changes to the vehicles themselves. When including non-significant effects, EPA estimates that the proposed standards would result in an average 0.2 percent increase in the annual fatalities per billion miles driven in the 27-year period from 2027 through 2055 (increasing from 5.053 fatalities per billion miles under the proposal compared to 5.040 fatalities per billion miles under the no-action case.)

EPA has also estimated, over the same 27-year period, that total fatalities will increase by 1,595, with 330 deaths attributed to increased driving and 1,265 deaths attributed to the non-statistically significant increase in fatality risk. Our analysis projects that there will be an increase in vehicle miles traveled (VMT) under the revised standards of 65 billion miles compared to the No Action case in 2027 through 2055 (an increase of about 0.06 percent). As noted, the only statistically significant changes in the fatalities projected are the result from the projected increased driving—*i.e.,* people choosing to drive more due to the lower operating costs of more efficient vehicles. Our cost-benefit analysis accounts for the value of this additional driving, which we assume is an important consideration in the decision to drive.

On the whole, EPA considers safety impacts in the context of all projected health impacts from the rule including public health benefits from the

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[795] *https://www.iihs.org/news/detail/with-more-electric-vehicles-comes-more-proof-of-safety.*

[796] None of the mass-safety coefficients that were developed for the 2020 and 2021 Rulemakings are statistically significant at the 95th percentile confidence level. EPA is including the presentation of non-significant changes in fatality rate here for the purpose of comparison with previous rulemaking assessments.

projected reductions in air pollution. Considering these estimates in the context of public health benefits anticipated from the proposed standards, EPA notes that the estimated present value of monetized benefits of reduced $PM_{2.5}$ through 2055 is between $63 billion and $280 billion (depending on study and discount rate), and that the illustrative air quality modeling which, as discussed further in Chapter 8 of the DRIA, assesses a regulatory scenario with lower rates of PEV penetration than EPA is projecting for the proposal, estimates that in 2055 such a scenario would prevent between 730 and 1,400 premature deaths associated with exposure to $PM_{2.5}$ and prevent between 15 and 330 premature deaths associated with exposure to ozone. We expect that the cumulative number of premature deaths avoided that would occur during the entire period from 2027 to 2055 would be much larger than the estimate of deaths avoided projected to occur in 2055.

### *G. Energy Security Impacts*

In this section, we evaluate the energy security impacts of the proposed standards. Energy security is broadly defined as the uninterrupted availability of energy sources at affordable prices.[797] Energy independence and energy security are distinct but related concepts, and an analysis of energy independence informs our assessment of energy security. The goal of U.S. energy independence is the elimination of all U.S. imports of petroleum and other foreign sources of energy, but more broadly, it is the elimination of U.S. sensitivity to variations in the price and supply of foreign sources of energy.[798] See Chapter 11 of the DRIA for a more detailed assessment of energy security and energy independence impacts of this proposed rule. See Preamble Section IV.C.6 and Chapter 3.1.3 of the DRIA for a discussion of critical materials and PEV supply chains.

The U.S.'s oil consumption had been gradually increasing in recent years (2015–2019) before the COVID–19 pandemic in 2020 dramatically decreased U.S. and global oil consumption.[799] By July 2021, U.S. oil consumption had returned to pre-pandemic levels and has remained fairly stable since then.[800] The U.S. has increased its production of oil, particularly ''tight'' (*i.e.,* shale) oil, over the last decade.[801] As a result of the recent increase in U.S. oil production, the U.S. became a net exporter of crude oil and refined petroleum products in 2020 and is projected to be a net exporter of crude oil and refined petroleum products for the foreseeable future.[802] This is a significant reversal of the U.S.'s net export position since the U.S. has been a substantial net importer of crude oil and refined petroleum products starting in the early 1950s.[803]

Oil is a commodity that is globally traded and, as a result, an oil price shock is transmitted globally. Given that the U.S. is projected to be a modest net exporter of crude oil and refined petroleum products for the time frame of this analysis (2027–2055), one could reason that the U.S. no longer has a significant energy security problem. However, U.S. refineries still rely on significant imports of heavy crude oil which could be subject to supply disruptions. Also, oil exporters with a large share of global production have the ability to raise or lower the price of oil by exerting the market power associated with the Organization of Petroleum Exporting Countries (OPEC) to alter oil supply relative to demand. These factors contribute to the vulnerability of the U.S. economy to episodic oil supply shocks and price spikes, even when the U.S. is projected to be an overall net exporter of crude oil and refined products.

We anticipate that U.S. consumption and net imports of petroleum will be reduced as a result of this proposed rule, both from an increase in fuel efficiency of LMDVs using petroleum-based fuels and from the greater use of PEVs which are fueled with electricity. A reduction of U.S. net petroleum imports reduces both financial and strategic risks caused by potential sudden disruptions in the supply of petroleum to the U.S. and global market, thus increasing U.S. energy security. Table 198 presents the impacts on imported oil.

TABLE 198—OIL IMPORT IMPACTS ASSOCIATED WITH THE PROPOSAL AND EACH OF THE ALTERNATIVES, LIGHT-DUTY AND MEDIUM-DUTY

[Million barrels of imported oil per day in the given year]

| Calendar year | Oil import impacts, proposal | Oil import impacts, alternative 1 | Oil import impacts, alternative 2 | Oil import impacts, alternative 3 |
|---|---|---|---|---|
| 2027 | −0.042 | −0.044 | −0.031 | −0.025 |
| 2028 | −0.1 | −0.12 | −0.076 | −0.063 |
| 2029 | −0.19 | −0.21 | −0.15 | −0.11 |
| 2030 | −0.29 | −0.33 | −0.23 | −0.18 |
| 2031 | −0.41 | −0.46 | −0.33 | −0.3 |
| 2032 | −0.54 | −0.61 | −0.45 | −0.44 |
| 2035 | −0.99 | −1.1 | −0.88 | −0.91 |
| 2040 | −1.6 | −1.8 | −1.4 | −1.6 |
| 2045 | −2 | −2.2 | −1.8 | −2 |
| 2050 | −2.3 | −2.5 | −2 | −2.2 |
| 2055 | −2.3 | −2.5 | −2.1 | −2.3 |

It is anticipated that manufacturers will choose to comply with the proposed standards with an increased penetration of PEVs. Compared to the use of petroleum-based fuels to power vehicles, electricity used in PEVs is anticipated to be generally more affordable and more stable in its price, *i.e.,* have less price volatility. See

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[797] IEA, Energy Security: ensuring the uninterrupted availability of energy sources at an affordable price. 2019. December.

[798] Greene, D. 2010. Measuring energy security: Can the United States achieve oil independence? *Energy Policy.* 38. pp. 1614–1621.

[799] EIA. Monthly Energy Review. Table 3.1. Petroleum Overview. December 2022.

[800] Ibid.

[801] Ibid.

[802] EIA. Annual Energy Outlook 2022. Table A11: Petroleum and Other Liquid Supply and Disposition (Reference Case). 2022.

[803] U.S. EIA. Oil and Petroleum Products Explained. November 2nd, 2022.

Chapter 11.3 of the DRIA for an analysis of PEV affordability and electricity price stability compared to gasoline prices. Thus, the greater use of electricity for PEVs is anticipated to improve the U.S.'s overall energy security position. Also, since the electricity to power PEVs will likely be almost exclusively produced in the U.S., this proposal will move the U.S. towards the goal of energy independence. See Chapter 11.3 of the DRIA for more discussion of how the proposed rule moves the U.S. to the goal of energy independence.

In order to understand the energy security implications of reducing U.S. oil imports, EPA has worked with Oak Ridge National Laboratory (ORNL), which has developed approaches for evaluating the social costs and energy security implications of oil use. When conducting this analysis, ORNL estimates the risk of reductions in U.S. economic output and disruption to the U.S. economy caused by sudden disruptions in world oil supply and associated price shocks (*i.e.,* labeled the avoided macroeconomic disruption/adjustment costs). These risks are quantified as ''macroeconomic oil security premiums'', *i.e.,* the extra costs of using oil besides its market price, associated with oil use.

For this proposed rule, EPA is using macroeconomic oil security premiums estimated using ORNL's methodology, which incorporates updated oil price projections and energy market and economic trends from the U.S. Department of Energy's Energy Information Administration's (EIA) Annual Energy Outlook (AEO) 2021. EPA and ORNL have worked together to revise the macroeconomic oil security premiums based upon recent energy security literature. We do not consider military cost impacts as a result of reductions in U.S. oil imports from this proposed rule due to methodological issues in quantifying these impacts. If military cost impacts could be quantified and monetized, the estimated benefits of this proposed rule would be larger.

To calculate the oil security benefits of this proposed rule, EPA is using the ORNL macroeconomic oil security premium methodology with: (1) Estimated oil savings calculated by EPA, and (2) an oil import reduction factor of 90.7 percent, which reflects our estimate of how much U.S. oil imports are reduced from changes in U.S. oil consumption. Below EPA presents the macroeconomic oil security premiums used for the proposed standards for selected years from 2027–2055 in Table 199. The energy security benefits of this proposed rule are presented in Table 200.

TABLE 199—MACROECONOMIC OIL SECURITY PREMIUMS FOR SELECTED YEARS FROM 2027–2055

[2020$/Barrel] *

| Calendar year | Macroeconomic oil security premiums (range) |
|---|---|
| 2027 | $3.41 ($0.74–$6.36) |
| 2030 | 3.55 (0.65–6.68) |
| 2032 | 3.70 (0.68–6.94) |
| 2035 | 3.91 (0.73–7.34) |
| 2040 | 4.39 (1.08–8.09) |
| 2050 | 5.15 (1.52–9.28) |
| 2055 | 5.15 (1.52–9.28) |

* Top values in each cell are the mid-points, the values in parentheses are the 90 percent confidence intervals.

TABLE 200—ENERGY SECURITY BENEFITS ASSOCIATED WITH THE PROPOSAL AND EACH OF THE ALTERNATIVES, LIGHT-DUTY AND MEDIUM-DUTY

[In billions of 2020 dollars]

| Calendar year | Energy security benefits, proposal | Energy security benefits, alternative 1 | Energy security benefits, alternative 2 | Energy security benefits, alternative 3 |
|---|---|---|---|---|
| 2027 | 0.052 | 0.055 | 0.038 | 0.031 |
| 2028 | 0.13 | 0.15 | 0.095 | 0.08 |
| 2029 | 0.24 | 0.27 | 0.19 | 0.14 |
| 2030 | 0.37 | 0.43 | 0.3 | 0.24 |
| 2031 | 0.54 | 0.61 | 0.44 | 0.4 |
| 2032 | 0.73 | 0.82 | 0.61 | 0.6 |
| 2035 | 1.4 | 1.6 | 1.3 | 1.3 |
| 2040 | 2.6 | 2.9 | 2.3 | 2.5 |
| 2045 | 3.5 | 3.8 | 3.1 | 3.4 |
| 2050 | 4.2 | 4.7 | 3.8 | 4.2 |
| 2055 | 4.4 | 4.8 | 3.9 | 4.4 |
| PV3 | 41 | 46 | 37 | 40 |
| PV7 | 21 | 23 | 19 | 20 |
| EAV3 | 2.2 | 2.4 | 1.9 | 2.1 |
| EAV7 | 1.7 | 1.9 | 1.5 | 1.6 |

### *H. Employment Impacts*

If the U.S. economy is at full employment, even a large-scale environmental regulation is unlikely to have a noticeable impact on aggregate net employment. Instead, labor would primarily be reallocated from one productive use to another, and net national employment effects from environmental regulation would be small and transitory (*e.g.,* as workers move from one job to another). Affected sectors may nevertheless experience transitory effects as workers change jobs. Some workers may retrain or relocate in anticipation of new requirements or require time to search for new jobs, while shortages in some sectors or regions could bid up wages to attract workers. These adjustment costs can lead to local labor disruptions. Even if the net change in the national workforce is small, localized reductions in employment may adversely impact individuals and communities just as localized increases may have positive impacts. If the economy is operating at less than full employment, economic theory does not clearly indicate the direction or magnitude of the net impact of environmental regulation on employment; it could cause either a short-run net increase or short-run net decrease.

Economic theory of labor demand indicates that employers affected by environmental regulation may change their demand for different types of labor in different ways. They may increase their demand for some types, decrease demand for other types, or maintain demand for still other types. The uncertain direction of labor impacts is due to the different channels by which regulations affect labor demand. A variety of conditions can affect employment impacts of environmental regulation, including baseline labor market conditions, employer and worker characteristics, industry, and region. In general, the employment effects of environmental regulation are difficult to disentangle from other economic changes (especially the state of the macroeconomy) and business decisions that affect employment, both over time and across regions and industries. In light of these difficulties, we look to economic theory to provide a constructive framework for approaching these assessments and for better understanding the inherent complexities in such assessments.

### 1. Background on Employment Effects

In addition to the employment effects, we have discussed in previous rules (for example the 2021 rule), where we estimated a partial employment effect on LD ICE vehicle manufacturing due to the increase in technical costs of the rule, the increasing penetration of electric vehicles in the market is likely to affect both the number and the nature of employment in the auto and parts sectors and related sectors, such as providers of charging infrastructure. Over time, as BEVs become a greater portion of the new vehicle fleet, the kinds of jobs in auto manufacturing are expected to change. For instance, there will be no need for engine and exhaust system assembly for BEVs, while many assembly tasks will involve electrical rather than mechanical fitting. In addition, batteries represent a significant portion of the manufacturing content of an electrified vehicle, and some automakers are likely to purchase the cells, if not pre-assembled modules or packs, from suppliers. Employment in building and maintaining charging infrastructure needed to support the ever-increasing number of BEVs on the road is also expected to affect the nature of employment in automotive and related sectors. For much of these effects, there is considerable uncertainty in the data to quantitatively assess how employment might change as a function of the increased electrification expected to result under the proposed standards.

Results from California's ACC II program analysis suggest that there may be a small decrease, not exceeding 0.3 percent of baseline California employment in any year, in total employment across all industries in CA through 2040.[804] A report by the Economic Policy Institute suggests that U.S. employment in the auto sector could increase if the share of vehicles, or powertrains, sold in the United States that are produced in the United States increases.[805] The BlueGreen Alliance also states that though BEVs have fewer parts than their ICE counterparts, there is potential for job growth in electric vehicle component manufacturing, including batteries, electric motors, regenerative braking systems and semiconductors, and manufacturing those components in the United States can lead to an increase in jobs.[806] They go on to state that if the United States does not become a major producer for these components, there is risk of job loss.

The UAW states that re-training programs will be needed to support auto workers in a market with an increasing share of electric vehicles in order to prepare workers that might be displaced by the shift to the new technology.[807] Volkswagen states that labor requirements for ICE vehicles are about 70 percent higher than their electric counterpart, but these changes in employment intensities in the manufacturing of the vehicles can be offset by shifting to the production of new components, for example batteries or battery cells.[808] Research from the Seattle Jobs Initiative indicates that employment in a collection of sectors related to both BEV and ICE vehicle manufacturing is expected to grow slightly through 2029.[809] Climate Nexus also indicates that the increasing penetration of electric vehicles will lead to a net increase in jobs, a claim that is partially supported by the rising investment in batteries, vehicle manufacturing and charging stations.[810] This expected private investment is also supported by recent Federal investment which will encourage increased investment along the vehicle supply chain, including domestic battery manufacturing, charging infrastructure, and vehicle manufacturing. The BIL was signed in November 2021 and provides over $24 billion in investment in electric vehicle chargers, critical minerals, and components needed by domestic manufacturers of EV batteries and for clean transit and school buses.[811] The CHIPS and Science Act, signed in August, 2022, invests in expanding America's manufacturing capacity for the semiconductors used in electric vehicles and chargers. [812] The IRA provides incentives for producers to expand domestic manufacturing of BEVs and domestic sourcing of components and critical minerals needed to produce them. The act also provides incentives for consumers to purchase both new and used BEVs. These pieces of legislation are expected to create domestic employment opportunities along the full automotive sector supply chain, from components and equipment manufacturing and processing to final assembly, as well as incentivize the development of reliable EV battery supply chains.[813] The BlueGreen Alliance and the Political

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[804] *https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2022/accii/isor.pdf.*

[805] *https://www.epi.org/publication/ev-policy-workers/.*

[806] *https://www.bluegreenalliance.org/wp-content/uploads/2021/04/Backgrounder-EVs-Are-Coming.-Will-They-Be-Made-in-the-USA-vFINAL.pdf.*

[807] *https://uaw.org/wp-content/uploads/2019/07/190416-EV-White-Paper-REVISED-January-2020-Final.pdf.*

[808] *https://www.volkswagenag.com/presence/stories/2020/12/frauenhofer-studie/6095_EMDI_VW_Summary_um.pdf.*

[809] *https://www.seattle.gov/Documents/Departments/OSE/ClimateDocs/TE/EV%20Field%20in%20OR%20and%20WA_February20.pdf.*

[810] *https://climatenexus.org/climate-issues/energy/ev-job-impacts/.*

[811] The Bipartisan Infrastructure Law is officially titled the Infrastructure Investment and Jobs Act. More information can be found at *https://www.fhwa.dot.gov/bipartisan-infrastructure-law/.*

[812] The CHIPS and Science Act was signed by President Biden in August, 2022 to boost investment in, and manufacturing of, semiconductors in the U.S. The fact sheet can be found at *https://www.whitehouse.gov/briefing-room/statements-releases/2022/08/09/fact-sheet-chips-and-science-act-will-lower-costs-create-jobs-strengthen-supply-chains-and-counter-china/.*

[813] "Building a Clean Energy Economy: A Guidebook to the Inflation Reduction Act's Investments in Clean Energy and Climate Action." January 2023. Whitehouse.gov. *https://www.whitehouse.gov/wp-content/uploads/2022/12/Inflation-Reduction-Act-Guidebook.pdf.*

Economy Research Institute estimate that IRA will create over 9 million jobs over the next decade, with about 400,000 of those jobs being attributed directly to the battery and fuel cell vehicle provisions in the act.[814] In addition, the IRA is expected to lead to increased demand for BEVs through tax credits for purchasers of BEVs.

2. Demand, Cost and Factor Shift Effect on Employment

In DRIA Chapter 4.96, we describe three ways employment at the firm level might be affected by changes in a firm's production costs due to environmental regulation: A demand effect, caused by higher production costs increasing market prices and decreasing demand; a cost effect, caused by additional environmental protection costs leading regulated firms to increase their use of inputs; and a factor- shift effect, in which post-regulation production technologies may have different labor intensities than their pre-regulation counterparts.[815] [816] Due to data limitations, EPA is not quantifying the impacts of the final regulation on firm-level employment for affected companies, although we acknowledge these potential impacts. Instead, we discuss factor- shift, demand, and cost employment effects for the regulated sector at the industry level.

Factor- shift effects are due to changes in labor intensity of production due to the standards. We do not have data on how the regulation might affect labor intensity of production within ICE vehicle production. There is ongoing research on the different labor intensity of production between BEV and ICE vehicle production, with inconsistent results. Some research indicates that the labor hours needed to produce a BEV are fewer than those needed to produce an ICE vehicle, while other research indicates there are no real differences. EPA worked with a research group to produce a peer-reviewed tear-down study of a BEV to its comparable ICE vehicle counterpart.[817] Study results were delivered in January 2023, and a peer review of the study is planned. Included in this study are estimates of labor intensity needed to produce each vehicle. We hope to use this information in additional analytical discussions in the final rule. Given the current lack of data and inconsistency in the existing literature, we are unable to estimate a factor-shift effect of increasing relative BEV production as a function of this rule.

The factor shift effect would occur where a BEV is replacing an ICE vehicle and does not account for a change in the total number of vehicles sold. Demand effects on employment are due to changes in labor due to changes in demand. In general, if the regulation causes total sales of new vehicles to increase, as we are estimating due to this proposed rule, more workers will be needed to assemble vehicles and manufacture their components. If BEVs and ICE vehicles have different labor intensities of production, the relative change in BEV and ICE vehicles sales will impact the demand effect on employment. Assume that sales of both BEV and ICE vehicles increase. This would mean that the change in employment due to an increase demand will depend on the labor intensity of BEV production and the increase in BEV sales, as well as in the labor intensity of ICE vehicle production and the increase in ICE sales. Now assume that BEV sales increased while ICE vehicle sales decreased. If total sales increased, that would indicate that BEVs replaced ICE vehicles, but there was new sales demand as well. The change in employment under this scenario would depend on the factor shift effect (the relative BEV and ICE vehicle labor intensity) for the replaced ICE vehicles, and the demand effect (labor intensity of BEVs) for the new sales demand. For the same reason we cannot estimate a factor- shift effect, namely that we do not know the labor intensity of BEV vs ICE vehicle production, we are not currently able to estimate a demand-shift effect on employment. However, because we are estimating increased new vehicle sales due to this rule, we would expect to see an increase in employment due to the demand effect.

The cost effects on employment are due to changes in labor associated with increases in costs of production.

BEVs and ICE vehicles require different inputs and have different costs of production, though there are interchangeable, common, parts as well. In previous LD and HD rules, we have estimated a partial employment effect due to the change in costs of production. We estimated the cost effect using the historic share of labor in the cost of production to extrapolate future estimates of impacts on labor due to new compliance activities in response to the regulations. Specifically, we multiplied the share of labor in production costs by the production cost increase estimated as an impact of the rule. This provided a sense of the magnitude of potential impacts on employment.

As described in Chapter 4.6 of the DRIA, we used historical data on the number of employees per $1 million in expenditures from the Employment Requirements Matrix (ERM) provided by the U.S. Bureau of Labor Statistics (BLS) to examine labor needs of five manufacturing sectors related to ICE and BEV vehicle production to determine trends over time. Two of these sectors (electrical equipment and manufacturing and other electrical equipment and component manufacturing) are more closely related to BEV production, while the other three (motor vehicle manufacturing, motor vehicle body and trailer manufacturing, and motor vehicle parts manufacturing) are sectors that are more generally related to both BEV and ICE vehicle production.

Over time, the amount of labor needed in the motor vehicle industry has changed: Automation and improved methods have led to significant productivity increases, which is reflected in the estimates from the BLS ERM. For example, in 1997 about 1.2 workers in the Motor Vehicle Manufacturing sector were needed per $1 million, but only 0.5 workers by 2021 (in 2020$).[818] Though the two sectors mainly associated with BEV manufacturing, electrical equipment manufacturing, and other electrical equipment and component manufacturing, show an increase in recent years.

3. Partial Employment Effect

We attempt to estimate partial employment effects of this proposed rule by separating out costs for BEVs and ICE vehicles, as well as the costs that are common between them,

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[814] Political Economy Research Institute. (2022). *Job Creation Estimates Through Proposed Inflation Reduction Act.* University of Massachusetts Amherst. Retrieved from *https://www.bluegreenalliance.org/site/9-million-good-jobs-from-climate-action-the-inflation-reduction-act/.*

[815] Morgenstern, Richard D., William A. Pizer, and Jhih-Shyang Shih (2002). ''Jobs Versus the Environment: An Industry-Level Perspective.'' Journal of Environmental Economics and Management 43: 412–436.

[816] Berman and Bui have a similar framework in which they consider output and substitution effects that are similar to Morgenstern et al.'s three effect (Berman, E. and L. T. M. Bui (2001). ''Environmental Regulation and Labor Demand: Evidence from the South Coast Air Basin.'' Journal of Public Economics 79(2): 265–295).

[817] See DRIA Chapter 2.5.2.2.3 for more information.

[818] *http://www.bls.gov/emp/ep_data_emp_requirements.htm;* this analysis used data for sectors electrical equipment and manufacturing, other electrical equipment and component manufacturing, motor vehicle manufacturing, motor vehicle body and trailer manufacturing, and motor vehicle parts manufacturing from ''Chain-weighted (2012 dollars) real domestic employment requirements tables;'' see ''Cost Effect Employment Impacts calculation'' in the docket.

applying the BEV cost changes to data from sectors primarily focused on BEV production, ICE vehicle costs to sectors primarily focused on ICE vehicle production, and costs common for BEV and ICE vehicles to sectors that are common to BEV and ICE vehicle production.[819] For more information on how we estimated this partial employment effect, see DRIA Chapter 4.5.4.

In previous rules, we have estimated the cost effect, which is done while keeping sales constant. However, OMEGA estimates costs and changes in sales concurrently. Therefore, the partial employment effect we are estimating here is not a straight cost effect, nor is it a demand effect, as the demand effect is due to a change in sales, keeping costs and factor intensities constant. This estimate we provide here is a combined cost and demand effect, and is meant to give a sense of possible partial employment effects, including directionality and relative magnitude. These estimates include effects due to both LD and MD cost changes, as the costs used in the analysis were the combined estimated costs for the light- and medium-duty sectors, as well as the change in new vehicle sales in the LD market.[820] It does not include economy-wide labor effects, possible factor intensity effects, or effects from possible changes to domestic production.

Results are provided in job-years, where a job-year is, for example, one year of full-time work for one person, or one year of half-time work for two people. Table 201 shows our partial employment results for the Proposal scenario. See Chapter 4.5.4 of the DRIA for more information on the employment analysis, as well as the partial employment effects for the three alternative scenarios.

TABLE 201—ESTIMATED PARTIAL EMPLOYMENT EFFECTS IN JOB-YEARS FOR BEV AND ICE VEHICLE SECTORS, SECTORS COMMON TO BEV AND ICE, AND THE NET MINIMUM AND MAXIMUM ACROSS ALL SECTORS

| Year | Common | | BEV | | ICE vehicle | | Net | |
|---|---|---|---|---|---|---|---|---|
| | Min | Max | Min | Max | Min | Max | Min | Max |
| 2027 | 7,620 | 54,000 | −9,800 | −11,700 | −10,200 | −11,500 | −12,380 | 30,800 |
| 2028 | 8,600 | 61,600 | −9,100 | −11,600 | −13,900 | −15,700 | −14,400 | 34,300 |
| 2029 | 10,300 | 75,200 | −9,000 | −12,100 | −19,200 | −21,600 | −17,900 | 41,500 |
| 2030 | 11,700 | 86,900 | −9,100 | −12,800 | −21,600 | −24,300 | −19,000 | 49,800 |
| 2031 | 14,600 | 109,900 | −10,100 | −15,100 | −26,100 | −29,300 | −21,600 | 65,500 |
| 2032 | 17,500 | 133,300 | −11,100 | −17,500 | −30,500 | −34,300 | −24,100 | 81,500 |

These results show negative employment effects in the ICE and BEV focused sectors, while there are positive effects in the common sectors. These results also suggest that there could be either an increase or decrease in net employment in the automotive manufacturing industries examined as part of this analysis.

EPA contracted with FEV to perform a detailed tear-down study comparing two similar vehicles, one a BEV (the 2021 Volkswagen ID.4) and the other an ICE vehicle (the 2021 Volkswagen Tiguan (see DRIA Chapter 2.5.2.2.3 for more details on this study). In the process of compiling the detailed information, FEV estimated the number of labor hours it takes to build each of the two vehicles. Under a realistic scenario of assembly based on what OEMs are currently doing, their results suggest that the labor hours needed to assemble the BEV and ICE vehicles are very similar.[821] This indicates that changes in employment in the auto manufacturing sectors from increasing electrification will not come from the assembling of the vehicles at the auto manufacturer, but from changing sales.

4. Employment in Related Sectors

With respect to possible employment effects in other sectors, economy-wide impacts on employment are generally driven by broad macroeconomic effects. However, employment impacts, both positive and negative, in sectors upstream and downstream from the regulated sector, or in sectors producing substitute or complementary products, may also occur as a result of this rule. For example, changes in electricity generation may have consequences for labor demand in those upstream industries. Lower per-mile fuel costs could lead to labor effects in ride-sharing or ride-hailing services through an increase in demand for those services. Reduced demand for gasoline may lead to impacts on demand for labor in the gas station sector, although the fact that many gas stations provide other goods, such as food and car washes, will moderate possible losses in this sector. There may also be an increase in demand for labor in sectors that build and maintain charging stations. The magnitude of all of these impacts depends on a variety of factors including the labor intensities of the related sectors, as well as the nature of the linkages (which can be reflected in measures of elasticity) between them and the regulated firms.

Electrification of the vehicle fleet is likely to affect both the number and the nature of employment in the auto and parts sectors and related sectors, such as providers of charging infrastructure. In addition, the type and number of jobs related to vehicle maintenance are expected to change as well, though we expect this to happen over a longer time span due to the nature of fleet turnover. Given the timeline, we expect opportunities for workers to retrain from ICE vehicle maintenance to other positions, for example within BEV maintenance, charging station infrastructure, or elsewhere in the economy.

Reduced consumption of petroleum fuel represents fuel savings for

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[819] A recent report from the Seattle Jobs Initiative examined how electrification in the automotive industry might advance workforce development in Oregon and Washington. As part of that study, the authors identified the sectors classified by the North American Industry Classification System (NAICS) codes most strongly associated with automotive production in general, those exclusive to ICE vehicles, and those primarily associated with BEV production. The report can be found at: *https://www.seattle.gov/Documents/Departments/OSE/ClimateDocs/TE/EV%20Field%20in%20OR%20and%20WA_February20.pdf.*

[820] We do not estimate a change in new MD vehicle sales. See Section VIII.C above, or DRIA Chapter 4.4.2 for more information on the change in sales estimated due to this proposed rule.

[821] In the realistic scenario, FEV assumes that the automakers purchase EV battery modules and assembles the pack. Under assumptions that the auto manufacturers provide the least amount of added value in assemble, the Tiguan (ICE vehicle) is estimated to more man hours to assemble than the ID.4 (BEV). Under assumptions that the auto manufacturers perform most of the sub system manufacturing and assembly, including the engine, transmission and battery pack modules, the ID.4 (BEV) takes more man hours per vehicle than the Tiguan (ICE vehicle).

purchasers of fuel, as well as a potential loss in value of output for the petroleum refining industry, fuel distributors, and gasoline stations, which may result in reduced employment in these sectors. However, because the fuel production sector is material-intensive, the employment effect is not expected to be large. In addition, it may be difficult to distinguish these effects from other trends, such as increases in petroleum sector labor productivity that may also lower labor demand.

As discussed in Preamble Section I, there have been several legislative and administrative efforts enacted since 2021 aimed at improving the domestic supply chain for electric vehicles, including electric vehicle chargers, critical minerals, and components needed by domestic manufacturers of EV batteries. These actions are also expected to provide opportunities for domestic employment in these associated sectors.

The standards may affect employment for auto dealers through a change in vehicles sold, with increasing sales being associated with an increase in labor demand. However, vehicle sales are also affected by macroeconomic effects, and it is difficult to separate out the effects of the standards on sales from effects due to macroeconomic conditions. In addition, auto dealers may also be affected by changes in maintenance and service costs, as well as through changes in the maintenance needs of the vehicles sold. For example, reduced maintenance needs of BEVs would lead to reduced demand for maintenance labor.

## *I. Environmental Justice*

### 1. Overview

People of color and people of low socioeconomic status face cumulative impacts associated with environmental exposures of multiple types, as well as non-chemical stressors. Numerous studies have found that environmental hazards such as air pollution are more prevalent in areas where people of color and low-income populations represent a higher fraction of the population compared with the general population.[822] [823] In addition, compared to non-Hispanic Whites, some other racial groups experience greater levels of health problems during some life stages. For example, in 2018–2020, about 12 percent of non-Hispanic Black; 9 percent of non-Hispanic American Indian/Alaska Native; and 7 percent of Hispanic children were estimated to currently have asthma, compared with 6 percent of non-Hispanic White children.[824] Nationally, on average, non-Hispanic Black and Non-Hispanic American Indian or Alaska Native people also have lower than average life expectancy based on 2019 data, the latest year for which CDC estimates are available.[825]

EPA's 2016 ''Technical Guidance for Assessing Environmental Justice in Regulatory Analysis'' provides recommendations on conducting the highest quality analysis feasible, though not prescriptive, recognizing that data limitations, time and resource constraints, and analytic challenges will vary by media and regulatory context.[826] Where applicable and practicable, the Agency endeavors to conduct such an analysis. There is evidence that communities with EJ concerns are disproportionately impacted by vehicle emissions associated with this proposed rule.[827] EPA did not consider any potential disproportionate impacts of vehicle emissions in selecting the proposed standards, but we view mitigation of disproportionate impacts of vehicle emissions as one element of protecting public health consistent with CAA section 202. In general, we expect reduced tailpipe emissions of GHGs, criteria pollutants, and air toxics as described in Sections VI and VII of this Preamble.

A key consideration in EPA's Technical Guidance is consistency with the assumptions underlying other parts of the regulatory analysis when evaluating the baseline and regulatory options. When assessing the potential for disproportionately high and adverse health or environmental impacts of regulatory actions on populations with potential EJ concerns, EPA strives to answer three broad questions: (1) Is there evidence of potential EJ concerns in the baseline (the state of the world absent the regulatory action)? Assessing the baseline will allow EPA to determine whether pre-existing disparities are associated with the pollutant(s) under consideration (*e.g.,* if the effects of the pollutant(s) are more concentrated in some population groups). (2) Is there evidence of potential EJ concerns for the regulatory option(s) under consideration? Specifically, how are the pollutant(s) and its effects distributed for the regulatory options under consideration? And, (3) do the regulatory option(s) under consideration exacerbate or mitigate EJ concerns relative to the baseline?

In this section, we discuss the environmental justice impacts of this proposal from the reduction of GHGs, criteria pollutants and air toxics tailpipe emissions. This section also discusses EJ impacts from upstream sources and the underlying uncertainty in our EJ analysis.

### 2. GHG Impacts

In 2009, under the Endangerment and Cause or Contribute Findings for Greenhouse Gases Under section 202(a) of the CAA (''Endangerment Finding''), the Administrator considered how climate change threatens the health and welfare of the U.S. population. As part of that consideration, she also considered risks to people of color and low-income individuals and communities, finding that certain parts of the U.S. population may be especially vulnerable based on their characteristics or circumstances. These groups include economically and socially vulnerable communities; individuals at vulnerable life stages, such as the elderly, the very young, and pregnant or nursing women; those already in poor health or with comorbidities; the disabled; those experiencing homelessness, mental illness, or substance abuse; and/or Indigenous or minority populations dependent on one or limited resources for subsistence due to factors including but not limited to geography, access, and mobility.

Scientific assessment reports produced over the past decade by the U.S. Global Change Research Program (USGCRP),[828] [829] the Intergovernmental

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[822] Rowangould, G.M. (2013) A census of the near-roadway population: public health and environmental justice considerations. Trans Res D 25: 59–67. *http://dx.doi.org/10.1016/j.trd.2013.08.003.*

[823] Marshall, J.D. (2000) Environmental inequality: Air pollution exposures in California's South Coast Air Basin. Atmos Environ 21: 5499–5503. *https://doi.org/10.1016/j.atmosenv.2008.02.005.*

[824] Current Asthma Prevalence by Race and Ethnicity (2018–2020). [Online at *https://www.cdc.gov/asthma/most_recent_national_asthma_data.htm.*]

[825] Arias, E. Xu, J. (2022) United States Life Tables, 2019. National Vital Statistics Report, Volume 70, Number 19. [Online at *https://www.cdc.gov/nchs/data/nvsr/nvsr70/nvsr70-19.pdf.*]

[826] ''Technical Guidance for Assessing Environmental Justice in Regulatory Analysis.'' Epa.gov, Environmental Protection Agency, *https://www.epa.gov/sites/production/files/2016-06/documents/ejtg_5_6_16_v5.1.pdf.* (June 2016).

[827] Mohai, P.; Pellow, D.; Roberts Timmons, J. (2009) Environmental justice. Annual Reviews 34: 405–430. *https://doi.org/10.1146/annurev-environ082508-094348.*

[828] USGCRP, 2018: Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 1515 pp. doi: 10.7930/NCA4.2018.

[829] USGCRP, 2016: The Impacts of Climate Change on Human Health in the United States: A

Continued

Panel on Climate Change IPCC),[830] [831] [832] [833] and the National Academies of Science, Engineering, and Medicine [834] [835] add more evidence that the impacts of climate change raise potential environmental justice concerns. These reports conclude that poorer or predominantly non-White communities can be especially vulnerable to climate change impacts because they tend to have limited adaptive capacities and are more dependent on climate-sensitive resources such as local water and food supplies or have less access to social and information resources. Some communities of color, specifically populations defined jointly by ethnic/racial characteristics and geographic location, may be uniquely vulnerable to climate change health impacts in the U.S. In particular, the 2016 scientific assessment on the Impacts of Climate Change on Human Health [836] found with high confidence that vulnerabilities are place- and time-specific, life stages and ages are linked to immediate and future health impacts, and social determinants of health are linked to a greater extent and severity of climate change-related health impacts. The GHG emission reductions from this proposal would contribute to efforts to reduce the probability of severe impacts related to climate change.

### i. Effects on Specific Populations of Concern

Individuals living in socially and economically vulnerable communities, such as those living at or below the poverty line or who are experiencing homelessness or social isolation, are at greater risk of health effects from climate change. This is also true with respect to people at vulnerable life stages, specifically women who are pre- and perinatal, or are nursing; in utero fetuses; children at all stages of development; and the elderly. Per the Fourth National Climate Assessment (NCA4), ''Climate change affects human health by altering exposures to heat waves, floods, droughts, and other extreme events; vector-, food- and waterborne infectious diseases; changes in the quality and safety of air, food, and water; and stresses to mental health and well-being.'' [837] Many health conditions such as cardiopulmonary or respiratory illness and other health impacts are associated with and exacerbated by an increase in GHGs and climate change outcomes, which is problematic as these diseases occur at higher rates within vulnerable communities. Importantly, negative public health outcomes include those that are physical in nature, as well as mental, emotional, social, and economic.

To this end, the scientific assessment literature, including the aforementioned reports, demonstrates that there are myriad ways in which these populations may be affected at the individual and community levels. Individuals face differential exposure to criteria pollutants, in part due to the proximities of highways, trains, factories, and other major sources of pollutant-emitting sources to less-affluent residential areas. Outdoor workers, such as construction or utility crews and agricultural laborers, who frequently are comprised of already at-risk groups, are exposed to poor air quality and extreme temperatures without relief. Furthermore, individuals within EJ populations of concern face greater housing, clean water, and food insecurity and bear disproportionate economic impacts and health burdens associated with climate change effects. They have less or limited access to healthcare and affordable, adequate health or homeowner insurance. Finally, resiliency and adaptation are more difficult for economically vulnerable communities: They have less liquidity, individually and collectively, to move or to make the types of infrastructure or policy changes to limit or reduce the hazards they face. They frequently are less able to self-advocate for resources that would otherwise aid in building resilience and hazard reduction and mitigation.

The assessment literature cited in EPA's 2009 and 2016 Endangerment and Cause or Contribute Findings, as well as Impacts of Climate Change on Human Health, also concluded that certain populations and life stages, including children, are most vulnerable to climate-related health effects.[838] The assessment literature produced from 2016 to the present strengthens these conclusions by providing more detailed findings regarding related vulnerabilities and the projected impacts youth may experience. These assessments—including the NCA4 and The Impacts of Climate Change on Human Health in the United States (2016)—describe how children's unique physiological and developmental factors contribute to making them particularly vulnerable to climate change. Impacts to children are expected from heat waves, air pollution, infectious and waterborne illnesses, and mental health effects resulting from extreme weather events. In addition, children are among those especially

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Scientific Assessment. Crimmins, A., J. Balbus, J.L. Gamble, C.B. Beard, J.E. Bell, D. Dodgen, R.J. Eisen, N. Fann, M.D. Hawkins, S.C. Herring, L. Jantarasami, D.M. Mills, S. Saha, M.C. Sarofim, J. Trtanj, and L. Ziska, Eds. U.S. Global Change Research Program, Washington, DC, 312 pp. *http://dx.doi.org/10.7930/J0R49NQX.*

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[831] Porter, J.R., L. Xie, A.J. Challinor, K. Cochrane, S.M. Howden, M.M. Iqbal, D.B. Lobell, and M.I. Travasso, 2014: Food security and food production systems. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L.White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 485–533.

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[834] National Research Council. 2011. America's Climate Choices. Washington, DC: The National Academies Press. *https://doi.org/10.17226/12781.*

[835] National Academies of Sciences, Engineering, and Medicine. 2017. Communities in Action: Pathways to Health Equity. Washington, DC: The National Academies Press. *https://doi.org/10.17226/24624.*

[836] USGCRP, 2016: The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment

[837] Ebi, K.L., J.M. Balbus, G. Luber, A. Bole, A. Crimmins, G. Glass, S. Saha, M.M. Shimamoto, J. Trtanj, and J.L. White-Newsome, 2018: Human Health. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 539–571. doi: 10.7930/NCA4.2018.CH14.

[838] 74 FR 66496, December 15, 2009; 81 FR 54422, August 15, 2016.

susceptible to allergens, as well as health effects associated with heat waves, storms, and floods. Additional health concerns may arise in low-income households, especially those with children, if climate change reduces food availability and increases prices, leading to food insecurity within households.

The Impacts of Climate Change on Human Health [837] also found that some communities of color, low-income groups, people with limited English proficiency, and certain immigrant groups (especially those who are undocumented) live with many of the factors that contribute to their vulnerability to the health impacts of climate change. While difficult to isolate from related socioeconomic factors, race appears to be an important factor in vulnerability to climate-related stress, with elevated risks for mortality from high temperatures reported for Black or African American individuals compared to White individuals after controlling for factors such as air conditioning use. Moreover, people of color are disproportionately exposed to air pollution based on where they live, and disproportionately vulnerable due to higher baseline prevalence of underlying diseases such as asthma, so climate exacerbations of air pollution are expected to have disproportionate effects on these communities.

Native American Tribal communities possess unique vulnerabilities to climate change, particularly those impacted by degradation of natural and cultural resources within established reservation boundaries and threats to traditional subsistence lifestyles. Tribal communities whose health, economic well-being, and cultural traditions depend upon the natural environment will likely be affected by the degradation of ecosystem goods and services associated with climate change. The IPCC indicates that losses of customs and historical knowledge may cause communities to be less resilient or adaptable.[839] The NCA4 noted that while Indigenous peoples are diverse and will be impacted by the climate changes universal to all Americans, there are several ways in which climate change uniquely threatens Indigenous peoples' livelihoods and economies.[840] In addition, there can institutional barriers to their management of water, land, and other natural resources that could impede adaptive measures.

For example, Indigenous agriculture in the Southwest is already being adversely affected by changing patterns of flooding, drought, dust storms, and rising temperatures leading to increased soil erosion, irrigation water demand, and decreased crop quality and herd sizes. The Confederated Tribes of the Umatilla Indian Reservation in the Northwest have identified climate risks to salmon, elk, deer, roots, and huckleberry habitat. Housing and sanitary water supply infrastructure are vulnerable to disruption from extreme precipitation events.

NCA4 noted that Indigenous peoples often have disproportionately higher rates of asthma, cardiovascular disease, Alzheimer's, diabetes, and obesity, which can all contribute to increased vulnerability to climate-driven extreme heat and air pollution events. These factors also may be exacerbated by stressful situations, such as extreme weather events, wildfires, and other circumstances.

NCA4 and IPCC Fifth Assessment Report also highlighted several impacts specific to Alaskan Indigenous Peoples. Coastal erosion and permafrost thaw will lead to more coastal erosion, exacerbated risks of winter travel, and damage to buildings, roads, and other infrastructure—these impacts on archaeological sites, structures, and objects that will lead to a loss of cultural heritage for Alaska's Indigenous people. In terms of food security, the NCA4 discussed reductions in suitable ice conditions for hunting, warmer temperatures impairing the use of traditional ice cellars for food storage, and declining shellfish populations due to warming and acidification. While the NCA also noted that climate change provided more opportunity to hunt from boats later in the fall season or earlier in the spring, the assessment found that the net impact was an overall decrease in food security.

In addition, the U.S. Pacific Islands and the indigenous communities that live there are also uniquely vulnerable to the effects of climate change due to their remote location and geographic isolation. They rely on the land, ocean, and natural resources for their livelihoods, but face challenges in obtaining energy and food supplies that need to be shipped in at high costs. As a result, they face higher energy costs than the rest of the nation and depend on imported fossil fuels for electricity generation and diesel. These challenges exacerbate the climate impacts that the Pacific Islands are experiencing. NCA4 notes that Indigenous peoples of the Pacific are threatened by rising sea levels, diminishing freshwater availability, and negative effects to ecosystem services that threaten these individuals' health and well-being.

### 3. Criteria Pollutant and Air Toxics Impacts

In addition to climate change benefits, this proposed rule would also impact emissions of criteria and air toxic pollutants from vehicles and from upstream sources (*e.g.,* EGUs and refineries), as described in Section VII.A. We discuss near-roadway issues in Section VIII.I.3.i and upstream sources in Section VIII.I.3.ii.

### i. Near-Roadway Analysis

In this section, we review existing scholarly literature examining the potential for disproportionate exposure among people of color and people with low socioeconomic status (SES) living near or attending school near major roads. In addition, we provide three analyses: People living near roadways using the U.S. Census Bureau's American Housing Survey for calendar year 2009, children attending school near roadways using the U.S. Department of Education's database of school locations, and the analysis of people who live in close proximity to major truck routes which also carry light- and medium-duty vehicles, using data from the 2010 Decennial Census, the 2012 five-year American Community Survey, EPA's population analysis, and U.S. Department of Transportation Freight Analysis Framework, version 4.

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[839] Porter et al., 2014: Food security and food production systems.

[840] Jantarasami, L.C., R. Novak, R. Delgado, E. Marino, S. McNeeley, C. Narducci, J. Raymond-Yakoubian, L. Singletary, and K. Powys Whyte, 2018: Tribes and Indigenous Peoples. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 572–603. doi: 10.7930/NCA4.2018.CH15.

As discussed in Section II.C.7 of this document, concentrations of many air pollutants are elevated near high-traffic roadways. Several publications report nationwide analyses that compare the sociodemographic patterns of people who do or do not live near major roadways. Three of these studies found that people living near major roadways are more likely to be minorities or low in SES.[841] [842] [843] They also found that the outcomes of their analyses varied between regions within the U.S. However, only one such study looked at whether such conclusions were confounded by living in a location with higher population density and how demographics differ between locations nationwide.[843] In general, it found that higher density areas have higher proportions of low-income residents and people of color. In other publications based on a city, county, or state, the results are similar.

Locations in these studies include Los Angeles, CA; Seattle, WA; Wayne County, MI; Orange County, FL; and the State of California.[844] [845] [846] [847] [848] [849] [850] Such disparities may be due to multiple factors.[851] [852] [853] [854] [855]

People with low SES often live in neighborhoods with multiple stressors and health risk factors, including reduced health insurance coverage rates, higher smoking and drug use rates, limited access to fresh food, visible neighborhood violence, and elevated rates of obesity and some diseases such as asthma, diabetes, and ischemic heart disease. Although questions remain, several studies find stronger associations between traffic-related air pollution and health in locations with such chronic neighborhood stress, suggesting that populations in these areas may be more susceptible to the effects of air pollution.[856] [857] [858] [859]

We analyzed several national databases that allowed us to evaluate whether homes and schools were located near a major road and whether disparities in exposure may be occurring in these environments. The American Housing Survey (AHS) includes descriptive statistics of over 70,000 housing units across the nation. The survey is conducted every two years by the U.S. Census Bureau with road locations from the U.S. Census Bureau's TIGER database. The second database we analyzed was the U.S. Department of Education's Common Core of Data, which includes school location, enrollment by race, and the number of students eligible for free- and reduced-price school lunch for all public elementary and secondary schools and school districts nationwide. The third analysis uses data from USDOT's Freight Analysis Framework 4 (FAF4), in addition to the 2010 Decennial Census and EPA's population analysis for the conterminous United States (CONUS).

In analyzing the 2009 AHS, we focused on whether a housing unit was located within 300 feet, the distance provided in the AHS data, of a ''4-or-more lane highway, railroad, or airport.'' We analyzed whether there were differences between households in such locations compared with those in locations farther from these transportation facilities. We included other variables, such as land use category, region of country, and housing type. We found that homes with a non-White householder were 22–34 percent more likely to be located within 300 feet of these large transportation facilities than homes with White householders. Homes with a Hispanic householder were 17–33 percent more likely to be located within 300 feet of these large transportation facilities than homes with non-Hispanic householders. Households near large transportation facilities were, on average, lower in income and educational attainment and more likely to be a rental property and located in an urban area compared with households more distant from transportation facilities.

We examined the Common Core of Data from the U.S. Department of Education, to evaluate whether children who attend school in proximity to major roads are disproportionately represented by students of color or low SES students. To determine school proximities to major roadways, we used a geographic information system (GIS) to map each school and roadways based on the U.S. Census's TIGER roadway file. We found that students of color were overrepresented at schools within 200 meters of the largest roadways, and schools within 200 meters of the largest roadways had higher than expected numbers of students eligible for free or reduced-price lunches. For example, Black students represent 22 percent of students at schools located within 200 meters of a primary road, compared to 17 percent of students in all U.S. schools. Hispanic students represent 30 percent of students at schools located within 200 meters of a primary road, compared to 22 percent of students in all U.S. schools. In extended analyses of this data set, we found that students of

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[853] Lane, H.J.; Morello-Frosch, R.; Marshall, J.D.; Apte, J.S. (2022) Historical redlining is associated with present-day air pollution disparities in US Cities. Environ Sci & Technol Letters 9: 345–350. DOI: [Online at: *https://doi.org/10.1021/acs.estlett.1c01012*].

[854] Ware, L. (2021) Plessy's legacy: the government's role in the development and perpetuation of segregated neighborhoods. RSF: The Russel Sage Foundation Journal of the Social Sciences, 7:92–109. DOI: DOI: 10.7758/RSF.2021.7.1.06.

[855] Archer, D.N. (2020) ''White Men's Roads through Black Men's Homes'': advancing racial equity through highway reconstruction. Vanderbilt Law Rev 73: 1259.

[856] Clougherty, J.E.; Kubzansky, L.D. (2009) A framework for examining social stress and susceptibility to air pollution in respiratory health. Environ Health Perspect 117: 1351–1358. Doi:10.1289/ehp.0900612.

[857] Clougherty, J.E.; Levy, J.I.; Kubzansky, L.D.; Ryan, P.B.; Franco Suglia, S.; Jacobson Canner, M.; Wright, R.J. (2007) Synergistic effects of traffic-related air pollution and exposure to violence on urban asthma etiology. Environ Health Perspect 115: 1140–1146. doi:10.1289/ehp.9863.

[858] Finkelstein, M.M.; Jerrett, M.; DeLuca, P.; Finkelstein, N.; Verma, D.K.; Chapman, K.; Sears, M.R. (2003) Relation between income, air pollution and mortality: a cohort study. Canadian Med Assn J 169: 397–402.

[859] Shankardass, K.; McConnell, R.; Jerrett, M.; Milam, J.; Richardson, J.; Berhane, K. (2009) Parental stress increases the effect of traffic-related air pollution on childhood asthma incidence. Proc Natl Acad Sci 106: 12406–12411. doi:10.1073/pnas.0812910106.

color from nearly every race are more likely to attend school within 200 meters of the largest roads as compared with White students.[860] For example, American Indian/Alaska Native, Asian/Pacific Islander, Black, Hispanic, and multiracial students are at least 75 percent more likely than White students to attend school near primary roads, such as limited-access highways.[861] Students eligible for free or reduced-price lunches are also more likely to attend schools near major roads. The schools where we observed disparities of race and SES were mostly found in cities and large suburbs.

As described in Section II.C.8 of this Preamble, we recently conducted an analysis of the populations within the CONUS living in close proximity to FAF4 roads, which include many large highways and other routes where light- and medium-duty vehicles operate. Relative to the rest of the population, people living near these FAF4 roads are more likely to be people of color and have lower incomes than the general population. People living near FAF4 roads are also more likely to live in metropolitan areas. Even controlling for region of the country, county characteristics, population density, and household structure, race, ethnicity, and income are significant determinants of whether someone lives near a FAF4 road. Overall, there is substantial evidence that people who live or attend school near major roadways are more likely to be of a non-White race, Hispanic, and/or have a low SES. We expect communities near roads will benefit from the reduced tailpipe emissions of PM, $NO_X$, $SO_2$, NMOG, CO, and mobile source air toxics from light- and medium-duty vehicles in this proposal. EPA is considering how to better estimate the near-roadway air quality impacts of its regulatory actions and how those impacts are distributed across populations. EPA requests comment on the EJ analysis presented in this proposal.

#### ii. Upstream Source Impacts

In general, we expect that increases in emissions from EGUs and decreases in petroleum-sector emissions would lead to changes in exposure to criteria pollutants for people living in the communities near these facilities. Analyses of communities in close proximity to EGUs have found that a higher percentage of communities of color and low-income communities live near these sources when compared to national averages.[862] Analysis of populations near refineries also indicates there may be potential disparities in pollution-related health risk from that source.[863]

### *J. Additional Non-Monetized Considerations Associated With Benefits and Costs: Energy Efficiency Gap*

The topic of the ‘‘energy paradox’’ or ‘‘energy efficiency gap’’ has been extensively discussed in many previous vehicle GHG standards' analyses.[864] The idea of the energy efficiency gap is that existing technologies that reduce fuel consumption enough to pay for themselves in short periods were not widely adopted, even though conventional economic principles suggest that because the benefits to vehicle buyers would outweigh the costs to those buyers of the new technologies, automakers would provide them and people would buy them. However, as described in previous EPA GHG vehicle rules (most recently in the 2021 rule) engineering analyses identified technologies, such as downsized-turbocharged engines, gasoline direct injection, and improved aerodynamics, where the additional cost of the technology is quickly covered by the fuel savings it provides, but they were not widely adopted until after the issuance of EPA vehicle standards. As explained in detail in previous rulemakings, research suggests the presence of fuel-saving technologies does not lead to adverse effects on other vehicle attributes, such as performance and noise. Additionally, research shows that there are technologies that exist that provide improvements in both performance and fuel economy, or at least in improved fuel economy without hindering performance.

There are a number of hypotheses in the literature that attempt to explain the existence of the energy efficiency gap, including both consumer and producer side reasons.[865] For example, some researchers posit that consumers take up-front costs into account in purchase decisions more than future fuel savings, consumers may not fully understand potential cost savings, or they may not prioritize fuel consumption in their set of important attributes when starting the vehicle purchase process. On the producer side, explanations include the reasons related to large, fixed costs in switching to new technologies, or the uncertainty involved in technological innovation and adoption.

Part of the uncertainty surrounding the existence or reason behind the energy efficiency gap is that most of the technology applied to existing ICE vehicles that may have created possible unaccounted for effects was ‘‘invisible.’’ This is for a few reasons, including that the technology itself was not something the mainstream consumer would know about, or because it was applied to a vehicle at the same time as multiple other changes, therefore making it unclear to the consumer what changes in vehicle attributes, if any, could be attributed to a specific technology. Though there may still exist a slight gap in ICE vehicle purchases due to this uncertainty, it becomes less and less of an issue with the growing share of electric vehicles in the market, and changes in vehicle attributes due to the new technology are clearer. For more information, see DRIA Chapter 4.4.

## IX. Consideration of Potential Fuels Controls for a Future Rulemaking

The emissions standards for new vehicles (MY 2027 and later) proposed in this rule would achieve significant air quality benefits. However, there is an opportunity to further address PM emissions from the existing vehicle fleet, the millions of vehicles produced during the phase-in period, as well as nonroad engines, through changes in market fuel composition. Given the current population of vehicles and nonroad equipment, we expect that tens of millions of gasoline-powered sources will remain in use well into the 2030s.[866] [867] Although EPA has not undertaken sufficient analysis to propose changes to fuel requirements under CAA section 211(c) in this rulemaking, and considers such changes beyond the scope of this rulemaking, EPA has begun to consider the possibility of such changes and in this section, EPA requests comments on aspects of a possible future rulemaking aimed at further PM emission

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[860] U.S. EPA (2023) Extended Analyses of Students Attending Schools within 200 Meters of U.S. Primary and Secondary Roads. Memorandum to docket.

[861] These racial groups are those reported in reference 860.

[862] See 80 FR 64662, 64915–64916 (October 23, 2015).

[863] U.S. EPA (2014). Risk and Technology Review—Analysis of Socio-Economic Factors for Populations Living Near Petroleum Refineries. Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina. January.

[864] For two of the most recent examples, see 86 FR 74434, December 30, 2021, ‘‘Revised 2023 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions Standards’’ and 85 FR 24174, April 30, 2020, ‘‘The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks.’’

[865] Note that the literature surrounding the energy efficiency gap in LD vehicles is based on historical data, which is focused on ICE vehicles.

[866] USEPA, ‘‘Population and Activity of Onroad Vehicles,’’ November 2020. Document EPA–420–R–20–023.

[867] USEPA, ‘‘Nonroad Engine Population Growth Estimated in MOVES2014b,’’ July 2018. Document EPA–420–R–18–010.

reductions from these sources via gasoline fuel property standards. Such future fuel standards could be an important complement to EPA's proposed vehicle PM standards.

### *A. Impacts of High-Boiling Components on Emissions*

Numerous emission studies have associated high-boiling compounds in gasoline with increased tailpipe PM emissions.[868] [869] In addition, analysis of a large number of market fuel samples has shown that the high-boiling tail of gasoline contains a high proportion of aromatics, and that the heaviest few percent of this material has very high leverage on PM emissions.[870] [871] [872] [873] The combination of these facts underlies the rest of our discussion, specifically the ability to use high boiling point as a surrogate for heavy aromatic content and the high leverage such compounds have on PM emissions from gasoline vehicles and equipment.

#### 1. Predictive Fuel Parameters

Historically, PM emission predictors have been focused on total aromatics (*e.g.,* from ASTM method D1319) and heavy-end distillation parameters from ASTM D86, such as T90.[874] [875] The T90 parameter refers to the temperature at which 90 volume percent of the gasoline sample has been distilled. It has been used for decades as a simple measure of the boiling range of the heaviest 10 percent of the fuel, or essentially how much high-boiling material is present. For example, in the EPAct study results published by EPA in 2013, aromatics content and T90 were found to be statistically significant predictors of PM emissions across a large set of fuels and vehicles.[876]

The PM Index (PMI) parameter, first described in a 2010 publication, combines detailed fuel composition data (from ASTM D6730) with volatility and structural characteristics for all compounds identified in the fuel to predict its relative propensity to form PM.[877] The PMI and its variants have been shown to be the most robust type of fuel-based PM predictor to date, and illustrate that a small proportion of low-volatility aromatics in gasoline are responsible for a large share of PM emissions.[878] PMI has been used in several emission studies and modeling analyses correlating fuel parameters to PM,[879] [880] and our assessment of potential impacts of fuel formulation changes on PM emission inventories, presented in Section IX.7, rely heavily on PMI. However, the detailed fuel hydrocarbon analysis required to calculate PMI is costly and time-consuming. Therefore, it would be impractical to set PMI standards for market gasoline. We discuss alternative fuel parameters that could serve as an effective surrogate for PMI in Section IX.E.

#### 2. Onroad Emissions Impacts

We considered three large studies spanning a range of vehicle technologies to provide a quantitative estimate of the impact of PMI on PM emissions. The first is the EPAct/V2/E–89 study designed by EPA, CRC, and DOE/NREL and published in 2013, where 27 gasoline blends were tested in 15 vehicles from the 2008 model year.[881] These results reflect the performance of port-fuel-injected vehicles meeting the light duty Tier 2 emissions standards. While PMI was not originally a design parameter of the study, ASTM D6729 data was generated after test fuel production, which allowed the PMI analysis to be done later. During test fuel development, the distribution of C7/C8/C9/C10+ aromatics was controlled across the test fuels to uniform ratios approximating what is found in market fuel surveys. The test fuels spanned a PMI range of 0.7 to 2.2, and the study results indicate a change in PMI of 1 percent produces a PM emissions change of approximately 1 percent. PMI ranges for market fuels are shown in Section IX.B.2.

A second study providing relevant PM vs PMI data is CRC E–94–2, published in 2018.[882] Researchers tested 16 light duty vehicles spanning model years 2013–2017 and a range of engine technologies using eight fuels varying in PMI, ethanol, and anti-knock index (AKI, also called octane) level. These results showed a change in PM emissions of approximately 2 percent per 1 percent PMI over the range of 1.4 to 2.4 PMI.

A third and more recent study was jointly conducted by EPA, Environment and Climate Change Canada, and several automakers.[883] Ten high-sales vehicles of model years 2015–2022 were tested in the participants' labs using five test fuels spanning a PMI range of 1.5 to 2.4. This study was designed to assess the emissions impact of replacing a small portion of heavy aromatics in a high-PMI gasoline with alternative high-octane blendstocks (light aromatics, isoparaffins, and ethanol), which are the types of changes we would expect to occur if fuel producers need to comply with a new PMI limit. Aromatics profiles and other key parameters were carefully designed to represent market fuels. Results showed a change in PM emissions of approximately 1.5 percent for each 1 percent change in PMI over the full span of the study fuels, which falls between the results of the two earlier studies described here. Taken together these three studies suggest a range of 1–2 percent PM emissions increase for each percent PMI increase.

#### 3. Nonroad Emissions Impacts

A literature review for fuel impacts on nonroad gasoline engine (NRGE) emissions finds relatively few studies, and we are not aware of any that have specifically assessed effects of heavy

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[868] Coordinating Research Council, ''Evaluation and Investigation of Fuel Effects on Gaseous and Particulate Emissions on SIDI In-Use Vehicles,'' Report No. E–94–2, March 2016.

[869] USEPA ''Assessing the Effect of Five Gasoline Properties on Exhaust Emissions from Light-Duty Vehicles Certified to Tier 2 Standards: Analysis of Data from EPAct Phase 3 (EPAct/V2/E–89),'' April 2013. Document EPA–420–R–13–002.

[870] Chapman E., Winston-Galant M., Geng P., Latigo R., Boehman A., ''Alternative Fuel Property Correlations to the Honda Particulate Matter Index (PMI),'' SAE Technical Paper 2016–01–2550, 2016.

[871] Ben Amara A., Tahtouh T., Ubrich E., Starck L., Moriya H., Iida J., Koji N., ''Critical Analysis of PM Index and Other Fuel Indices: Impact of Gasoline Fuel Volatility and Chemical Composition,'' SAE Technical Paper 2018–01–1741, 2018.

[872] Sobotowski R.A., Butler A.D., Guerra Z., ''A Pilot Study of Fuel Impacts on PM Emissions from Light-duty Gasoline Vehicles,'' SAE Int. J. Fuels Lubr. 8(1):2015.

[873] Aikawa, K., Sakurai K., Jetter J.J., ''Development of a Predictive Model for Gasoline Vehicle Particulate Matter Emissions,'' SAE Technical Paper 2010–01–2115, 2010.

[874] Reference to ASTM D86, D1319, etc.

[875] Coordinating Research Council, ''An Improved Index for Particulate Matter Emissions (PME),'' Report No. RW–107–2, March 2021.

[876] USEPA ''Assessing the Effect of Five Gasoline Properties on Exhaust Emissions from Light-Duty Vehicles Certified to Tier 2 Standards: Analysis of Data from EPAct Phase 3 (EPAct/V2/E–89),'' April 2013. Document EPA–420–R–13–002.

[877] Aikawa, K., Sakurai K., Jetter J.J., ''Development of a Predictive Model for Gasoline Vehicle Particulate Matter Emissions,'' SAE Technical Paper 2010–01–2115, 2010.

[878] Coordinating Research Council, ''An Improved Index for Particulate Matter Emissions (PME),'' Report No. RW–107–2, March 2021.

[879] Butler A.D., Sobotowski R.A., Hoffman G.J., and Machiele, P., ''Influence of Fuel PM Index and Ethanol Content on Particulate Emissions from Light-Duty Gasoline Vehicles,'' SAE Technical Paper 2015–01–1072, 2015.

[880] Coordinating Research Council, ''Alternative Oxygenate Effects on Emissions,'' Report No. E–129–2, October 2022.

[881] USEPA ''Assessing the Effect of Five Gasoline Properties on Exhaust Emissions from Light-Duty Vehicles Certified to Tier 2 Standards: Analysis of Data from EPAct Phase 3 (EPAct/V2/E–89),'' April 2013. Document EPA–420–R–13–002.

[882] Coordinating Research Council, ''Evaluation and Investigation of Fuel Effects on Gaseous and Particulate Emissions on SIDI In-Use Vehicles,'' Report No. E–94–2, March 2016.

[883] USEPA, ''Exhaust Emission Impacts of Replacing Heavy Aromatic Hydrocarbons in Gasoline with Alternate Octane Sources,'' April 2023. Document EPA–420–R–23–008.

aromatics or high-boiling compounds on PM emissions. Work published in 2005 and 2006 examined small NRGE emissions on two fuels, one being a gasoline with T90, aromatics, and oxygen content typical of market fuel at that time, and the other an alkylate test fuel with no aromatics and significantly lower T90.[884, 885] For a 4-stroke engine, the results showed the alkylate fuel reduced PM by 28 percent to 59 percent, depending on the output power level. This type of engine is commonly found in larger portable equipment like lawnmowers, gensets, and plate compactors. The study also tested a 2-stroke engine, a design that has historically powered handheld devices like chainsaws and string trimmers. These are fueled by gasoline mixed with a small amount of lubricating oil, and as a result, have much higher emissions of PM and unburned hydrocarbons than 4-stroke engines (where oil is not involved in combustion). In the 2-stroke engine, the alkylate fuel reduced PM by 10 percent at a single, high-load test point. Overall, this engine had PM emissions roughly 100 times higher than the 4-stroke.

Sensitivity of PM emissions in NRGEs to fuel properties like aromatics content and T90 suggests that the fundamental mechanisms of particle formation described in the literature (*e.g.,* nucleation and growth arising from diffusion flames) is universal to gasoline combustion.[886] [887] Thus, we expect the effects of PMI observed in onroad vehicle studies to be broadly applicable to 4-stroke NRGEs. In addition, most nonroad engines rely on carburetors for fuel metering and in the absence of air-fuel-ratio feedback control tend to be calibrated to run with slightly over-fueled combustion to optimize power output and limit exhaust temperatures. This type of operation produces higher emissions related to incomplete combustion, including PM, and thus we might expect a significant impact of PMI. It is less clear how a reduction in PMI will affect emissions from 2-stroke gasoline engines, given their use of a fuel-oil mixture. We will be collecting additional data on the effects of PMI on NRGEs, and request comment on other data sources that may be relevant.

## *B. Survey of High-Boiling Materials in Market Gasoline*

Data on high-boiling materials (*e.g.,* in compliance data and other surveys) has historically been reported in terms of T90 from ASTM D86. This section discusses our assessment of the trends of T90 data over the past two decades, followed by a summary of available data for PMI.

### 1. T90 Levels

Figure 40 shows T90 trends by season over the past two decades. On an annual-average basis, the T90 of U.S. gasoline declined from around 325 °F prior to 2010 to around 315 °F after 2010.

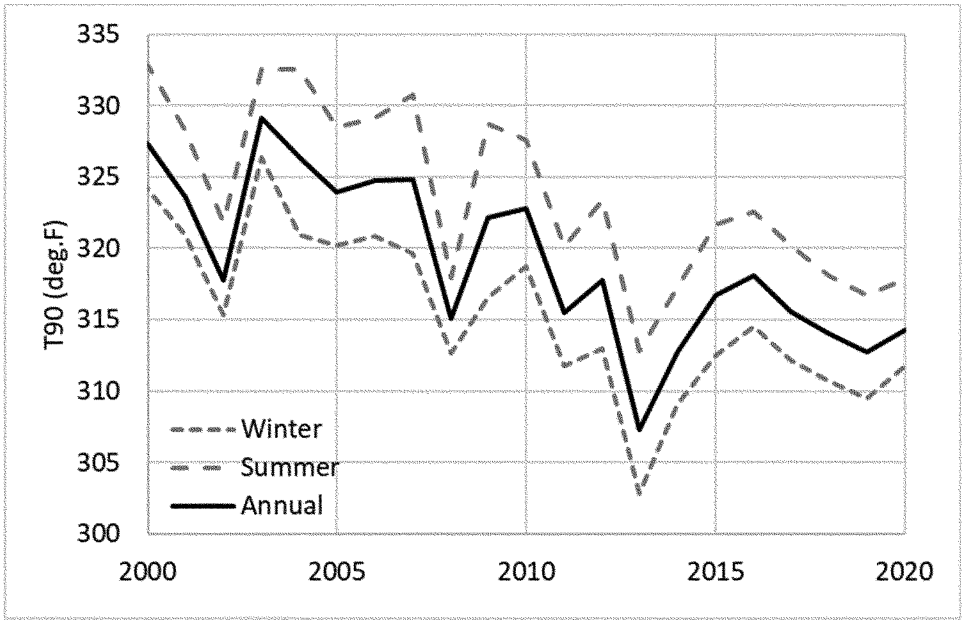

**Figure 40. Average gasoline T90 values by season 2000 – 2020.**

In any given year, there is significant variation in T90 levels across refineries, as well as between batches within each refinery. Thus, while the volume-weighted average T90 of U.S. gasoline was 313 °F in 2019, Figure 41 shows that the ranges for individual refineries ranged from 280 °F to 340 °F in 2019, and that individual gasoline batches could have much higher T90.

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[884] Timo Ålander, Eero Antikainen, Taisto Raunemaa, Esa Elonen, Aimo Rautiola & Keijo Torkkell (2005) Particle Emissions from a Small Two-Stroke Engine: Effects of Fuel, Lubricating Oil, and Exhaust Aftertreatment on Particle Characteristics, Aerosol Science and Technology, 39:2, 151–161.

[885] Timo Ålander. Carbon Composition and Volatility Characteristics of the Aerosol Particles Formed in Internal Combustion Engines. Kuopio Univ. Publ. C. Nat. and Environ. Sci. 192: 1–54 (2006).

[886] Das D.D., St. John P.C., McEnally C.S., Kim S., Pfefferle L.D., ‘‘Measuring and Predicting Sooting Tendencies of Oxygenates, Alkanes, Alkenes, Cycloalkenes, and Aromatics on a Unified Scale,’’ Combustion and Flame 190 (2018) 349–364.

[887] Calcote, H.F., Manos D.M., ‘‘Effect of Molecular Structure on Incipient Soot Formation,’’ Combust. Flame 49: 289–304 (1983).

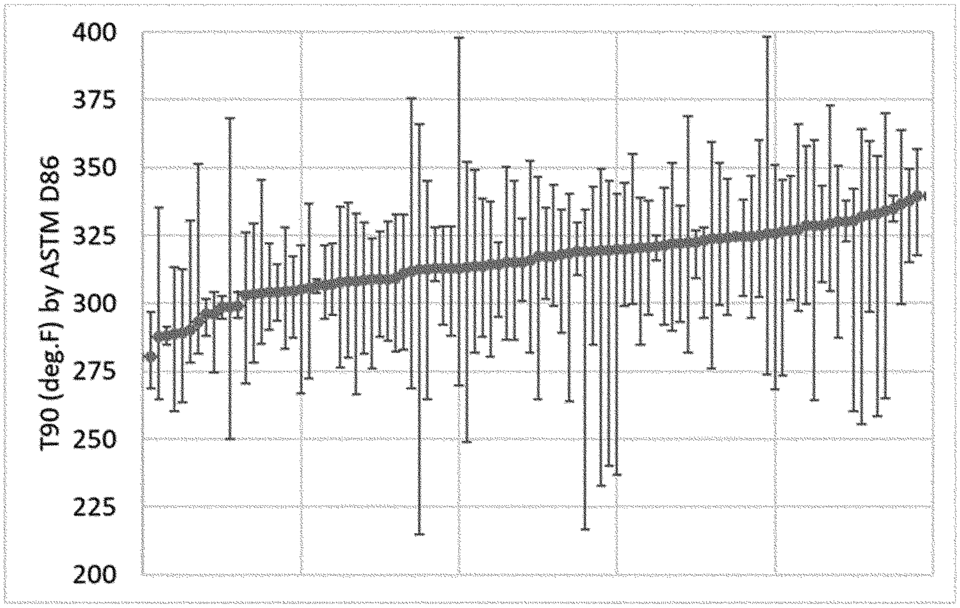

Figure 41. Volume-weighted T90 averages and batches by refinery for 2019.

A common thread across the market shifts in T90 has been a decreasing gasoline-to-distillate ratio (GDR) in the product slates produced by refineries. Changes in demand for gasoline relative to distillate products changes how refiners blend up their refinery streams. To accommodate a downward shift in GDR, the simplest process adjustment refiners can make is to undercut some heavy material from the gasoline blendstocks into diesel products. This has the effect of reducing the T90 of gasoline, consistent with the historical trends over the past two decades. Perhaps the most important factor affecting GDR was the influx of ethanol into gasoline. The increasing ethanol volume displaced a portion of petroleum, which caused refiners to move more of the midrange gasoline cut into the distillate pool. Ethanol's octane also allowed refiners to back out aromatic content. A second factor causing lower T90 values was the Tier 2 program, which reduced gasoline sulfur levels. Because some of the heavy gasoline blendstocks are high in sulfur, moving them into the distillate pool helped refiners comply with the gasoline sulfur standards and reduced T90 values at the same time. A third factor may have been the changes in U.S. crude slates as fracked oil came online after 2010. Fracked crudes tend to have lower density and less heavy material, which results in a lighter gasoline.

Figure 40 also shows seasonal variation, with winter T90 values around 8 degrees lower on average than summer. GDR is lower in the winter due to lower demand for gasoline and an increase in heating oil product demand. Another factor is higher gasoline volatility limits (*i.e.,* RVP) in the winter allowing refiners to blend more butanes and pentanes into gasoline, which displaces heavier blendstocks proportionally.

Any potential future gasoline standard that might place limits on high-boiling and/or heavy aromatic content of gasoline should then be placed in the context of future changes in gasoline production and the GDR. Looking at domestic petroleum consumption projections in EIA's 2022 Annual Energy Outlook, we would expect the GDR to decline by roughly 10 percent over the next two decades. This is not surprising, given that the decline in gasoline demand with electrification of light-duty and medium-duty vehicles and consumer nonroad equipment is expected to be faster than the decline in diesel demand for heavy duty trucks and equipment.[888] To the extent that U.S. refinery production shifts along with U.S. market demand, then the T90 level of gasoline would be expected to continue to decline in the future as well. However, fuel production is also significantly affected by imports and exports. We can assume refiners will continue to try to maintain or expand export markets as much as possible. For these reasons, we would not expect significant reductions below the current production GDR of 1.4 for a decade or more, and thus despite significant reductions in T90 levels over the last decade, the GDR would be expected to remain fairly constant in the future.

### 2. PMI Profile of Market Gasoline

Figure 42 shows the distribution of PMI now and roughly a decade ago. Given our assessment of T90 levels over time, it is not surprising to see a reduction in the median PMI of market gasoline. Regardless of this downward shift, the median PMI of market gasoline is nearly 1.6, and roughly 10 percent of gasoline remains above a PMI of 2.0. Thus, there remains considerable opportunity to reduce PM emissions by bringing PMI levels down, particularly in areas with the highest PMIs.

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[888] Root, T. (2021, June 30). ''Lawn care is going electric. And the revolution is here to stay.'' The Washington Post. Retrieved from *https://www.washingtonpost.com/climate-solutions/2021/06/30/electric-lawn-care/* on 12/15/2022.

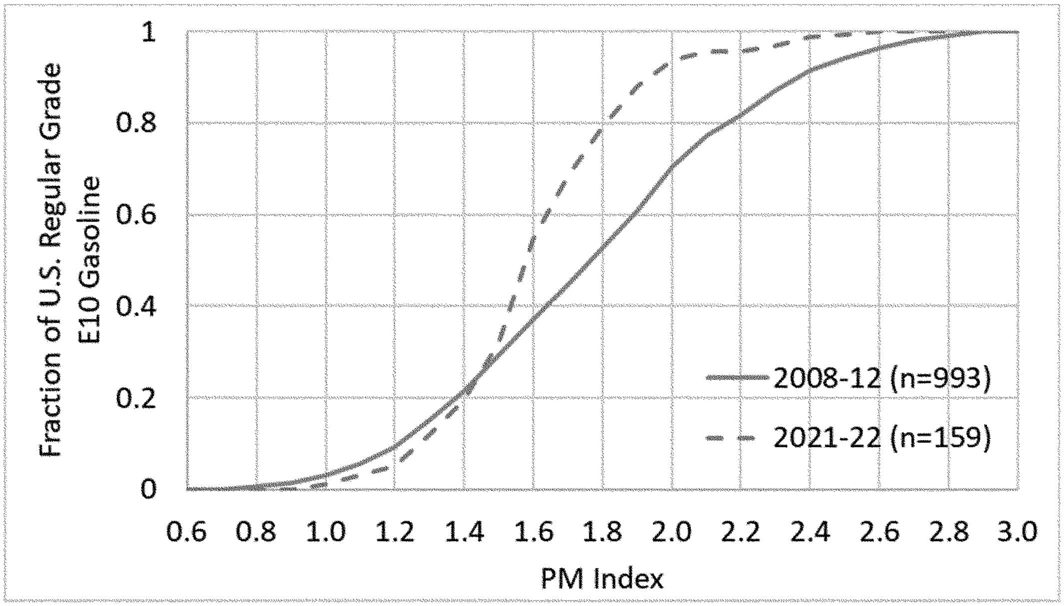

**Figure 42. PM index distribution in U.S. gasoline in 2008-12 and 2021-22.**

The specification for Tier 3 certification test gasoline includes a range for heavy (C10+) aromatics, which, along with the other specifications, results in a PMI value in the range of 1.6–1.7. This mirrors the median level in recent market surveys, though market fuels contain a wider range of compounds. Depending on the level of a potential limit on heavy material or PMI, the specifications for certification gasoline may nor may not need to be adjusted.

### *C. Sources of High-Boiling Compounds in Gasoline Production and How Reductions Might Occur*

#### 1. Refinery Units and Processes

There are primarily three refinery units that contribute high-boiling material to gasoline: The fluidized catalytic cracker (FCC), reformer, and coker. The FCC unit breaks down heavy crude fractions into lighter material spanning a wide boiling range, after which it is separated by distillation into the gasoline, diesel, and fuel oil product pools. The FCC produces the largest share of gasoline volume in most refineries, and for those processing highly aromatic crudes, the FCC can be a significant source of heavy aromatics. Lowering the boiling range of FCC output going into gasoline is likely to be the simplest way to reduce high-boiling material. Refiners commonly shift mid-boiling FCC output between gasoline and diesel seasonally to match product volume demands (see Section IX.C).

The reformer is typically the primary source of aromatics in a refinery's gasoline, including high-boiling aromatic material. This unit's purpose is to increase the octane of naphtha streams by converting paraffinic material into aromatics. The reformer output (reformate) may contain several percent of high-boiling alkylbenzenes and bi-cyclic compounds, depending on its operating conditions and the boiling range of the feed naphtha. Except for possible removal of light reformate to control gasoline benzene levels, all reformer output is typically routed to the gasoline pool. Thus, the simplest ways to reduce heavy aromatics in reformate are likely to be lowering the boiling range of the feed naphtha and/or reducing the severity (*i.e.,* target octane) of the output.

Refineries that process heavy crudes often have coker units, which are a type of cracking unit used to break down very heavy distillation residues. The coker output is typically hydrotreated to produce a stable naphtha. Depending on its boiling range and octane level, this material may be blended into gasoline, diesel, or sent to the reformer. Thus, the aromatic content and boiling range of the coker naphtha may also be a consideration for a refiner trying to reduce heavy aromatics in gasoline.

We reviewed gasoline aromatics and T90 values from refinery batch data, as well as public information on which types of chemical processing units are present in those refineries. This analysis suggested two refinery configurations that are likely to result in more heavy aromatics in gasoline. Refineries with coker units tend to have higher T90 levels, and because the coker cracks heavy aromatic material into the gasoline boiling range, we expect these refineries to produce higher-PMI gasoline. Second, are refineries with aromatic extraction units, which are used to produce benzene, toluene, and xylenes for sale as petrochemicals. These refineries are expected to run their reformers at increased severity to produce more aromatics overall. After extraction of the valuable light aromatics, we expect a higher proportion of heavy aromatics will remain to meet octane requirements of their gasoline output.

#### 2. Value of Aromatics for Octane Requirements

Reducing the content of high-boiling compounds in gasoline is made more complicated by the need to meet market octane requirements since these are generally aromatic-rich streams. Because of their high octane (>110 AKI), aromatics are among the most valuable compounds produced in refineries. If heavy aromatics were to be removed from gasoline, then not only their volume, but their octane would have to be replaced. One source for additional octane is via increased reformer severity or throughput to generate additional light aromatics. This action may require other adjustments to maintain compliance with gasoline benzene standards or rebalance naphtha streams. A refinery may also be able to increase high-octane isoparaffin production through additional alkylation and/or isomerization operations. Finally, a refinery may opt to further increase reliance on ethanol as a source of octane. We seek comment and data on how refinery operations might change with a limit on heavy aromatics and/or other high boiling gasoline components.

### *D. Methods of Compliance Determination*

Distillation by ASTM D86 has been part of EPA's gasoline compliance methods since the 1990s. As such, the equipment and expertise to run the method are widespread. An assessment of the correlation between PMI and four D86 distillation parameters (T70–T95) shows that T90 has the best correlation with PMI, but with only a modest correlation coefficient.[889] The results also indicate that a T90 limit of 330 °F, for example, would permit fuels with PMI over 2.3 in the market while prohibiting some others with PMI less than 2. A comparison of D86 results with those of DHA (such as ASTM D6730) illustrate that ASTM D86 does a relatively poor job of separating compounds by volatility and underestimates the final boiling point of the heavy tail.[890] These analyses indicate that ASTM D86 may lack the needed precision for PMI control.

Setting a standard for PMI itself would be ideal but quantifying the PMI of a fuel requires results from a DHA method such as ASTM D6730. This method runs for 2–3 hours and produces a chromatograph that must be interpreted by an experienced analyst, making it difficult to standardize and automate. There are a few alternative ASTM chromatography methods that are simpler and faster to run than DHA, which we believe may be better candidates for a PMI surrogate. ASTM D8071 uses a vacuum-UV (VUV) light source detector to produce results by molecular type and carbon number in about 35 minutes. It doesn't quantify individual species but is still useful for producing a good estimate of PMI without requiring the same analytical experience from the operator as ASTM D6730. However, it is relatively new and unfamiliar to many petroleum labs, and there isn't much VUV data on market fuels for use in correlating to PMI. Another method is ASTM D5769, which gives results for a range of aromatics species, but does not quantify other heavy material in the tail.

The most promising alternative is simulated distillation (SimDis) by ASTM D7096. Unlike ASTM D6730 or D8071, this method does not separate the constituents by molecular type but produces a profile of mass by boiling point that is sufficiently precise to quantify the heavy tail of a fuel sample. Given the data showing that the heavy tail of market gasoline is highly aromatic, this method can act as a promising surrogate for PMI. SimDis was developed in the 1980s to quickly assess the boiling point range of petroleum samples and has been in use in refinery process control for many years. In a lab setting, ASTM D7096 runs in about 15 minutes and can easily be incorporated into an automated workflow. Collaborative work between EPA, national lab, and auto industry partners over the past year has produced data evaluating the reproducibility ASTM D7096.[891] We believe those results support the potential use of this method for demonstrating compliance with a limit on high-boiling point compounds. We request comment on the suitability of these methods for compliance determination.

### *E. Structure and Costs of Standards*

#### 1. Statutory Authority

Section 211(c)(1)(A) of the CAA provides EPA broad authority to issue or revise regulations controlling fuel or fuel additives that cause or contribute to air pollution. This authority could be used to limit high-boiling aromatics on the basis that they contribute to PM emissions that endanger public health. It is worth noting that CAA section 211(c)(1)(A) requires the Administrator to consider other technologically or economically feasible means of achieving emissions standards under section 202. While the vehicle standards proposed in this notice under CAA section 202 authority would be very effective at controlling particular emissions from new vehicles, they would not address or be capable of addressing the in-use fleet. Other than potential controls on the heavy aromatic content of gasoline, EPA is not aware of any other practical means of significantly reducing PM emissions from the existing fleet. Past gasoline and diesel sulfur standards were put in place in part using CAA 211(c)(1)(A) authority to address the in-use fleet.[892] [893] We request comment on the appropriateness of EPA exercising these authorities to set limits on heavy aromatics and other high-boiling material in gasoline.

#### 2. Structure and Level of the Standard

We believe significant air quality improvements would be achieved through a fuel standard that would eliminate market gasoline with high PMI levels (*e.g.,* >2) and reduce the amount of heavy aromatics in gasoline overall. Such a regulatory program could be structured in a number of ways. Options include a per-gallon cap, a national annual average standard implemented along with an averaging, banking, and trading program (ABT), a facility maximum annual average standard, or some combination of these. A per-gallon cap would be the simplest form of control and the easiest to enforce. It would also guarantee that the benefits of the program are achieved in all areas of the country at all times and that gasoline is more uniform in quality. However, a per-gallon cap could also reduce flexibility for issues that arise in the course of gasoline production and thus carries greater potential for causing supply disruptions.

A national annual average standard would provide maximum flexibility for refiners, avoiding compliance issues during facility start-up/shutdown and maintenance periods that might disrupt gasoline supply. However, a national average standard could also increase regulatory burden associated with testing, recordkeeping, and reporting, because compliance determination requires tracking historical fuel batch data as well as credit balances. It may also fail to provide benefits in high-PMI areas where ongoing credit use is a long-term compliance strategy.

The gasoline benzene standard is an example of a hybrid approach.[894] It has a national average standard (0.62 volume percent) with ABT plus a maximum annual average for each production facility (1.3 volume percent without use of credits). It resulted in large reductions in average benzene levels across the country, while limiting the potential for locally-elevated exposures of people living in areas where high-benzene gasoline from a particular production facility would

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[889] See Docket Memo from Aron Butler, ''Supplemental Information Related to Potential Fuels Controls for Gasoline PM'', docket ID #EPA–HQ–OAR–2022–0829.

[890] Sobotowski, R., Butler, A., Loftis, K., and Wyborny, L., ''A Method of Assessing and Reducing the Impact of Heavy Gasoline Fractions on Particulate Matter Emissions from Light-Duty Vehicles,'' SAE Int. J. Fuels Lubr. 15(3):2022. See Figure 4b.

[891] USEPA, ''Assessment and Optimization of ASTM D7096 Simulated Distillation for Quantifying Heavy Hydrocarbons in Gasoline,'' April 2023. Document EPA–420–R–23–009.

[892] 72 FR 8428 (Feb. 26, 2007), ''Final Rule for Control of Hazardous Air Pollutants from Mobile Sources''.

[893] The gasoline and diesel standards were also put in place using 211(c)(1)(B) authority to enable vehicle emission control systems.

[894] 72 FR 8428 (Feb. 26, 2007), ''Final Rule for Control of Hazardous Air Pollutants from Mobile Sources''.

regularly be sold. Some type of a per-gallon cap or maximum facility average in addition to a national average may be similarly appropriate for PMI control.

Another reason to consider a more stringent upper limit on PMI is related to low-speed pre-ignition (LSPI), a type of abnormal combustion that causes a spike in cylinder pressure (known as knock) that can damage the engine over time. As vehicle manufacturers have moved toward turbocharged, downsized engines for increased fuel economy and reduced GHG emissions, LSPI has become a significant design limitation and there is evidence that higher-PMI fuels increase the likelihood of LSPI events.[895] We request comment on the impact of PMI on engine design and efficiency.

Of course, we understand that it may be difficult to comment on the various structures for a standard without having some idea of what the stringency of the standard might be. Their viability is in large part a function of the level of the standard. We do not have specific proposals at this time for the level of stringency associated with the various structures, but we offer the following as an example to help elucidate EPA's early thinking, which we hope will facilitate public comment. Were we to establish a facility maximum annual average SimDis T99 limit, 450 °F might be appropriate for preventing locally elevated PMI, while a national annual average T99 limit of 425 °F would provide PMI reductions in many areas and protection from potential PMI increases if crude or product slates change in the future. These T99 standards would allow 1 volume percent of a gasoline sample to exceed the specified temperature. We discuss this analysis in more detail in the cost and PM impacts discussion in the following section. A standard could also be set in terms of T98 or T97, which would allow 2 or 3 volume percent above the specified temperature, though reducing the T-number of the standard would introduce more uncertainty about how much high-PMI material remains in a complying batch.

In addition, we may consider setting seasonal standards for a couple of reasons. One is that gasoline has lower T90 and PMI in winter, so a refiner may produce relatively high PMI gasoline in summer but still comply with an annual average standard via a large shift in winter to undercutting heavy material into distillate products. Another reason is that PM emissions from gasoline vehicles are higher at cold temperatures.[896] We are collecting additional data on the effect of PMI on emissions at cold temperatures to assess the potential effectiveness of reducing wintertime PM emissions through a fuel control. We seek comment on the most appropriate structure and level of the standard, including annual averaging, caps, and the need for seasonal limits.

3. Cost and Impacts on Refining

Much of the material that comprises the heavy tail of gasoline, including aromatics that increase PMI, comes from a midrange ''swing cut'' of FCC naphtha that can be blended either into the heavy part of gasoline or the light part of diesel or other distillate products. Refiners routinely move this swing cut between products to balance their GDR to match market demands. If, however, refiners are required to limit the heavy aromatic content of their gasoline, we expect more swing cut material to move out of gasoline and into the distillate pool. Such a change requires refiners to make up for the loss of volume and octane-rich aromatics.

As outlined in Section IX.E, we believe the most efficient way to assess and potentially control PMI and/or heavy aromatics is via a chromatography method like SimDis. However, the refinery modeling tools that are available to assess costs and broad impacts of changes to gasoline specifications are built around D86 volatility parameters. Thus, our current cost assessment uses T90 as a proxy for a SimDis standard.

We used the Haverly LP refinery model to reduce the average T90 of U.S. gasoline by 15 °F in 5 °F steps.[897] Using a T90 versus PMI correlation developed from market fuel data, this T90 reduction span of 15 °F would correspond to a PMI change of about 0.5. To accomplish this, the model moved heavy gasoline blendstocks from the gasoline pool to the distillate pool. To make up for the lost gasoline volume and octane, the model increased the reformer severity, purchased and isomerized natural gas liquids, and produced more alkylate. The estimated costs for the 5 °F, 10 °F, and 15 °F reductions in T90 were 0.5, 2.2, and 3.0 cents per gallon, respectively. This includes the refining cost as well as fuel economy and distribution costs associated with a slight reduction in energy density of gasoline. We request comment on the suitability of the Haverly model for this work as well as the cost estimates themselves.

## *F. Estimated Emissions and Air Quality Impacts*

Changes in fuel composition resulting from new limits on PMI or other high-boiling components are expected to reduce tailpipe PM and may also impact secondary pollutants formed in the atmosphere. We can assess the magnitude of tailpipe PM reductions by applying the emission impacts observed in the vehicle studies discussed in Section VIII.A.2 to the PMI changes associated with the new standards. If a new standard achieved the 0.5 PMI reduction described in the refinery modeling scenarios, the vehicle studies indicate we would expect a per-vehicle tailpipe PM reduction of about 30 percent for typical in-use vehicles. We think a similar reduction may also occur for 4-stroke nonroad gasoline engines, as described in Section VIII.A.3. The impacts may be smaller for ''high-emitter'' vehicles (those with failing or malfunctioning emission controls) and 2-stroke nonroad engines, which would reduce the overall inventory impact. We request comment on potential emissions impacts for onroad and nonroad sources.

Mobile sources are an important contributor to secondary aerosols formed from nitrate, sulfate, and organic precursors.[898] [899] Studies have shown that secondary organic aerosol (SOA) formation from gasoline vehicle exhaust can exceed directly-emitted (tailpipe) PM emissions, and that changes to gasoline formulation can have impacts on SOA that are larger than the associated shifts in direct PM emissions.[900] [901] [902] [903] An analysis of

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[895] Swarts, A., and Kalaskar, V., ''Market Fuel Effects on Low Speed Preignition,'' *SAE Int J Adv & Curr Prac in Mobility* 3(5):2473–2483, 2021.

[896] Edward Nam, Sandeep Kishan, Richard W. Baldauf, Carl R. Fulper, Michael Sabisch, and James Warila. ''Temperature Effects on Particulate Matter Emissions from Light-Duty, Gasoline-Powered Motor Vehicles.'' Environmental Science & Technology 2010 44 (12), 4672–4677.

[897] See Docket Memo from Aron Butler, ''Supplemental Information Related to Potential Fuels Controls for Gasoline PM'', docket ID #EPA–HQ–OAR–2022–0829.

[898] Davidson, K., Fann, N., Zawacki, M., Fulcher, C., Baker, K. ''The recent and future health burden of the U.S. mobile sector apportioned by source,'' *Environ. Res. Lett.* 15. 2020.

[899] Zawacki, M., Baker, K., Phillips, S., Davidson, K., Wolfe, P. ''Mobile source contributions to ambient ozone and particulate matter in 2025'', Atmospheric Environment, Volume 188, 2018, Pages 129–141.

[900] Zhao Y., Lambe A.T., Saleh R., Saliba G., Robinson A.L., ''Secondary Organic Aerosol Production from Gasoline Vehicle Exhaust: Effects of Engine Technology, Cold Start, and Emission Certification Standard,'' Environ. Sci. Technol. 2018, 52, 1253–1261.

[901] Gentner D.R., Jathar S.H., Gordon T.D., Bahraini R., Day D.A., El Haddad I., Hayes P.L., Pieber S.M., Platt S.M., de Gouw J., Goldstein A.H., Harley R.A., Jimenez J.L., Prevot A.S.H., Robinson A.L., ''Review of Urban Secondary Aerosol Formation from Gasoline and Diesel Motor Vehicle

Continued

SOA yields for a range of hydrocarbon types and molecular weights indicates that the compounds with the highest potential for SOA formation in the exhaust, share components with the heavy tail in gasoline.[904] Changes to aromatic content may also affect $NO_X$ emissions, which can affect nitrate particle formation. EPA is conducting research to understand potential changes in emissions that may influence the formation of secondary PM. We request comment on the most appropriate data sources and methods to assess impacts on SOA and other secondary pollutants of gasoline PMI changes.

A reduction in gasoline PMI would be expected to reduce exposure to directly-emitted PM for those exposed to vehicle exhaust in close proximity to roadways. As described in Section II.C.8 of this Preamble, there is substantial evidence that people who live or attend school near major roadways are more likely to be people of color, and/or have a low socioeconomic status (SES). In addition, lower-SES neighborhoods are likely to have higher populations of vehicles with higher emissions than those in higher-SES neighborhoods.[905] [906]

## X. Statutory and Executive Order Reviews

### A. Executive Order 12866: ''Regulatory Planning and Review and Executive Order 13563: Improving Regulation and Regulatory Review''

This action is a significant regulatory action within the scope of section 3(f)(1) of E.O. 12866 that was submitted to OMB for review. Any changes made in response to Executive Order 12866 review have been documented in the docket. EPA prepared an analysis of the potential costs and benefits associated with this action. This analysis is in the Regulatory Impact Analysis, which can be found in the docket for this rule and is briefly summarized in Section VIII of this Preamble.

### B. Paperwork Reduction Act

The information collection activities in this proposed rule have been submitted for approval to the Office of Management and Budget (OMB) under the PRA. The Information Collection Request (ICR) document that the EPA prepared has been assigned EPA ICR number 2750.01. You can find a copy of the ICR in the docket for this rule, and it is briefly summarized here.

The Agency is proposing requirements for manufacturers to submit information to ensure compliance with the provisions in this proposed rule. This includes a variety of requirements for vehicle manufacturers. Section 208(a) of the CAA requires that vehicle manufacturers provide information the Administrator may reasonably require to determine compliance with the regulations; submission of the information is therefore mandatory. We will consider confidential all information meeting the requirements of section 208(c) of the CAA.

Many of the information activities associated with the proposed rule are covered by existing emission certification and reporting requirements for EPA's light-duty and medium-duty vehicle emission control program. Therefore, this ICR only covers the incremental burden associated with the updated regulatory requirements as described in this proposal.

The total annual reporting burden associated with this rule is about 44,947 hours and $26.240 million, based on a projection of 35 respondents. The estimated burden for vehicle manufacturers is a total estimate for new reporting requirements incremental to the current program. Burden means the total time, effort, or financial resources expended by persons to generate, maintain, retain, or disclose or provide information to or for a Federal agency. This includes the time needed to review instructions; modify existing technology and systems for the purposes of collecting, validating, and verifying newly required information, processing and maintaining information, and disclosing and providing information; adjust the existing ways to comply with any previously applicable instructions and requirements; train personnel to be able to respond to a collection of information; search data sources; complete and review the collection of information; and transmit or otherwise disclose the information.

*Respondents/affected entities:* Light and medium-duty vehicle manufacturers, alternative fuel converters, and independent commercial importers.

*Respondent's obligation to respond:* Manufacturers must respond as part of their annual model year vehicle certification under section 208(a) of the CAA which is required prior to enter vehicles into commerce. Participation in some programs is voluntary; but once a manufacturer has elected to participate, it must submit the required information.

*Estimated number of respondents:* 35.

*Frequency of response:* Annually or on occasion, depending on the type of response.

*Total estimated burden:* 44,947 hours (per year). Burden is defined at 5 CFR 1320.3(b).

*Total estimated cost:* $26,239,629 per year, includes an estimated $25,611,681 annualized capital or operation & maintenance costs.

An agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB control number. The OMB control numbers for the EPA's regulations are listed in 40 CFR part 9.

Submit your comments on the Agency's need for this information, the accuracy of the provided burden estimates and any suggested methods for minimizing respondent burden to the EPA using the docket identified at the beginning of this rule. You may also send your ICR-related comments to OMB's Office of Information and Regulatory Affairs using the interface at *www.reginfo.gov/public/do/PRAMain*. Find this particular information collection by selecting ''Currently under Review—Open''. Since OMB is required to make a decision concerning the ICR between 30 and 60 days after receipt, OMB must receive comments no later than July 5, 2023. The EPA will respond to any ICR-related comments in the final rule.

### C. Regulatory Flexibility Act

I certify that this action will not have a significant economic impact on a substantial number of small entities under the RFA.

EPA has focused its assessment of potential small business impacts on three key aspects of the proposed standards, including GHG emissions standards, criteria pollutant standards (including NMOG+$NO_X$ fleet-average standards and PM emissions standards),

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Emissions,'' Environ. Sci. Technol. 2017, 51, 1074–1093.

[902] Gordon, T.D., Presto, A.A., May, A.A., Nguyen, N.T., Lipsky, E.M., Donahue, N.M., Gutierrez, A., Zhang, M., Maddox, C., Rieger, P., Chattopadhyay, S., Maldonado, H., Maricq, M.M., and Robinson, A.L., ''Secondary organic aerosol formation exceeds primary particulate matter emissions for light-duty gasoline vehicles,'' Atmos. Chem. Phys., 14, 4661–4678.

[903] Peng J., Hu M., Du Z., Wang Y., Zheng J., Zhang W., Yang Y., Qin Y., Zheng R., Xiao Y., Wu Y., Lu S., Wu Z., Guo S., Mao H., Shuai S., ''Gasoline Aromatics: A Critical Determinant of Urban Secondary Organic Aerosol Formation,'' Atmos. Chem. Phys., 17, 10743–10752, 2017.

[904] Gentner D.R., *et al.,* ''Elucidating secondary organic aerosol from diesel and gasoline vehicles through detailed characterization of organic carbon emissions,'' PNAS 109 (2018) 18318–18323.

[905] Park, S.S.; Bijayan, A.; Mara, S.L.; Herner, J.D. (2016) ''Investigating the real-world emission characteristics of light-duty gasoline vehicles and their relationship to local socioeconomic conditions in three communities in Los Angeles, California.'' J Air & Waste Management Assoc 66: 1031–1044.

[906] Est, S. (2005) ''Equity implications of vehicle emission taxes.'' J Transport Econ & Policy 39: 1–24.

and EV battery warranty and durability. Details of EPA's No SISNOSE assessment are included in DRIA Chapter 12.

There are three types of small entities that could potentially be impacted by the proposed GHG standards: (1) Small entity vehicle manufacturers; (2) alternative fuel converters, which are companies that take a vehicle for which an OEM has already accounted for GHG compliance and convert it to operate on a cleaner fuel such as natural gas or propone; and (3) independent commercial importers (ICIs), which are firms that import vehicles from other countries for individual vehicle purchasers.

Under the current light-duty GHG program, small entities are exempt from the GHG standards. EPA is proposing to continue the current exemption for all three types of small entities, including small entity manufacturers, alternate fuel convertors, and ICIs. However, EPA is proposing to add some environmental protections for imported vehicles. EPA is also proposing to continue the current provision allowing small entity manufacturers to opt into the GHG program to earn credits to sell in the credit market. The small entity vehicle manufacturers in the market at this time produce only electric vehicles. EPA is requesting comment on the potential need for small entity light-duty and medium-duty manufacturers to have an annual production cap (*e.g.,* 200–500 vehicles per year) on vehicles eligible for the exemption. EPA believes that capping the number of vehicles exempted could be an appropriate protection for GHG emissions, while still allowing small entities to produce vehicles consistent with typical past annual sales.

Under existing EPA regulations, each ICI is currently limited to importing 50 vehicles per year. EPA is proposing to reduce the limit to 25 non-ZEV vehicles per year, which is well above historical sales, as a means of limiting the potential environmental impact of importing vehicles with potentially high GHG emissions. Importing of ZEVs would not count against the 25 vehicles limit. EPA believes this lower vehicle limit is important for capping the potential for high-emitting imported vehicles, because, unlike with criteria pollutant emissions, there are very limited add-on emissions control options for reducing the GHG emissions of an imported vehicle. EPA is proposing to ease the burden required for ICIs to certify EVs by removing the requirement to have a fuel economy label. Production EVs don't normally have their high voltage wiring accessible so it is not practical for ICIs to measure the energy in and out of the battery which is necessary when measuring energy for the fuel economy label.

EPA also has evaluated the potential impacts on small businesses for the proposed criteria pollutant emissions standards, including both the NMOG+ $NO_X$ standard and the PM standard. EPA's proposed NMOG+$NO_X$ standards should have no impact on the existing small entity manufacturers, which currently produce only electric vehicles. The proposed standards are expected to have minimal impact on both the alternate fuel converters and ICIs, as discussed in DRIA Chapter 12. EPA estimates that the proposed PM standard will have no significant financial impact on any of the three types of small entities. Existing small entity manufacturers all produce only EVs, which have no tailpipe emissions and therefore would be able to comply with the PM standard without any additional burden. Alternative fuel vehicles are exempted from doing any cold temperature testing under existing EPA regulations, and EPA is proposing to continue this exemption such that there would be no impact on alternative fuel converters. To minimize the testing burden on ICIs, EPA is proposing to exempt ICI from measuring PM during cold testing; ICIs would only need to comply with the new PM levels on the FTP75 and US06 tests.

The final aspect of the NPRM that could have potential impacts on small entities is battery durability (Section III.F.2). The current small entity manufacturers all have warranties that meet or exceed our proposed requirements for battery durability. EPA is proposing to exempt small entities from meeting the proposed battery durability requirements since the testing and reporting requirements would be an added financial burden that is not necessary given their current warranties.

### *D. Unfunded Mandates Reform Act*

This action contains no unfunded Federal mandate for State, local, or Tribal governments as described in UMRA, 2 U.S.C. 1531–1538, and does not significantly or uniquely affect small governments. This action imposes no enforceable duty on any State, local or Tribal government. This action contains Federal mandates under UMRA that may result in expenditures of $100 million or more for state, local, and Tribal governments, in the aggregate, or the private sector in any one year. Accordingly, the EPA has prepared a written statement of the costs and benefits associated with action as required under section 202 of UMRA. This is discussed Section VIII of this Preamble and Chapter 10 of the DRIA. This action is not subject to the requirement of section 203 of UMRA because it contains no regulatory requirements that might significantly or uniquely affect small governments.

### *E. Executive Order 13132: ''Federalism''*

This action does not have federalism implications. It will not have substantial direct effects on the states, on the relationship between the national government and the states, or on the distribution of power and responsibilities among the various levels of government.

### *F. Executive Order 13175: ''Consultation and Coordination With Indian Tribal Governments''*

This action does not have Tribal implications as specified in Executive Order 13175. Thus, Executive Order 13175 does not apply to this action. However, EPA has engaged with our Tribal stakeholders in the development of this rulemaking by offering a Tribal workshop and offering government-to-government consultation upon request.

### *G. Executive Order 13045: ''Protection of Children From Environmental Health Risks and Safety Risks''*

This action is subject to Executive Order 13045 because it is a significant regulatory action under section 3(f)(1) of Executive Order 12866, and EPA believes that the environmental health risks or safety risks of the pollutants addressed by this action may have a disproportionate effect on children. The 2021 Policy on Children's Health also applies to this action.[907] Accordingly, we have evaluated the environmental health or safety effects of air pollutants affected by this program on children. The results of this evaluation are described in Section II. The protection offered by these standards may be especially important for children because childhood represents a life stage associated with increased susceptibility to air pollutant-related health effects.

Children make up a substantial fraction of the U.S. population, and often have unique factors that contribute to their increased risk of experiencing a health effect from exposures to ambient air pollutants because of their continuous growth and development. Children are more susceptible than adults to many air pollutants because they have (1) a developing respiratory

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[907] U.S. Environmental Protection Agency (2021). 2021 Policy on Children's Health. Washington, DC. *https://www.epa.gov/system/files/documents/2021-10/2021-policy-on-childrens-health.pdf.*

system, (2) increased ventilation rates relative to body mass compared with adults, (3) an increased proportion of oral breathing, particularly in boys, relative to adults, and (4) behaviors that increase chances for exposure. Even before birth, the developing fetus may be exposed to air pollutants through the mother that affect development and permanently harm the individual when the mother is exposed.

Certain motor vehicle emissions present greater risks to children as well. Early lifestages (*e.g.,* children) are thought to be more susceptible to tumor development than adults when exposed to carcinogenic chemicals that act through a mutagenic mode of action.[908] Exposure at a young age to these carcinogens could lead to a higher risk of developing cancer later in life. Section II.C.8 describes a systematic review and meta-analysis conducted by the U.S. Centers for Disease Control and Prevention that reported a positive association between proximity to traffic and the risk of leukemia in children.

The adverse effects of individual air pollutants may be more severe for children, particularly the youngest age groups, than adults. As described in Section II, the Integrated Science Assessments for a number of pollutants affected by this rule, including those for $SO_2$, $NO_2$, PM, ozone and CO, describe children as a group with greater susceptibility. Section II.C.8 discusses a number of childhood health outcomes associated with proximity to roadways, including evidence for exacerbation of asthma symptoms and suggestive evidence for new onset asthma.

There is substantial evidence that people who live or attend school near major roadways are more likely to be people of color, Hispanic ethnicity, and/or low socioeconomic status. Within these highly exposed groups, children's exposure and susceptibility to health effects is greater than adults due to school-related and seasonal activities, behavior, and physiological factors.

Section VII of this Preamble presents the estimated emission reductions from this proposed rule, including substantial reductions in criteria air pollutants and mobile source air toxics which would reduce exposures for children, significantly reducing air pollution in close proximity to major roadways where ten million children attend school.

GHG emissions contribute to climate change and the GHG emissions reductions described in Section VI resulting from implementation of this proposed rule would further improve children's health. The assessment literature cited in EPA's 2009 and 2016 Endangerment Findings concluded that certain populations and life stages, including children, the elderly, and the poor, are most vulnerable to climate-related health effects. The assessment literature since 2016 strengthens these conclusions by providing more detailed findings regarding these groups' vulnerabilities and the projected impacts they may experience. These assessments describe how children's unique physiological and developmental factors contribute to making them particularly vulnerable to climate change. Impacts to children are expected from heat waves, air pollution, infectious and waterborne illnesses, and mental health effects resulting from extreme weather events. In addition, children are among those especially susceptible to most allergic diseases, as well as health effects associated with heat waves, storms, and floods. Additional health concerns may arise in low-income households, especially those with children, if climate change reduces food availability and increases prices, leading to food insecurity within households. More detailed information on the impacts of climate change to human health and welfare is provided in Section II of this Preamble.

Children are not expected to experience greater ambient concentrations of air pollutants than the general population. However, because of their greater susceptibility to air pollution, including the impacts of a changing climate, and their increased time spent outdoors, it is likely that these standards will have particular benefits for children's health.

### *H. Executive Order 13211: "Energy Effects"*

This action is not a "significant energy action" because it is not likely to have a significant adverse effect on the supply, distribution, or use of energy. EPA has outlined the energy effects in Table 9–7 of the Draft Regulatory Impact Analysis (DRIA), which is available in the docket for this action and is briefly summarized here.

This action reduces $CO_2$ for light-duty and medium-duty vehicles under revised GHG standards, which will result in significant reductions of the consumption of petroleum, will achieve energy security benefits, and have no adverse energy effects. Because the GHG emission standards result in significant fuel savings, this rule encourages more efficient use of fuels. Table 9–7 in the DRIA shows over 950 billion gallons of retail gasoline (about 18 billion barrels of oil) reduced through 2055.

### *I. National Technology Transfer and Advancement Act (NTTAA) and 1 CFR Part 51*

This rulemaking involves technical standards. Except for the standards discussed in this section, the standards included in the regulatory text as incorporated by reference were all previously approved for IBR and no change is included in this action.

In accordance with the requirements of 1 CFR 51.5, we are proposing to incorporate by reference the use of standards and test methods from the California Air Resources Board (CARB). The referenced standards and test methods may be obtained through the CARB website (*www.arb.ca.gov*) or by calling (916) 322–2884. We are incorporating by reference the following CARB documents:

| Standard or test method | Regulation | Summary |
|---|---|---|
| CARB's 2022 OBD regulation—13 CCR 1968.2, Malfunction and Diagnostic System Requirements—2004 and Subsequent Model-Year Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles and Engines; operative November 22, 2022. | 40 CFR 86.1 and 86.1806–27 ......................... | The CARB standards establish updated requirements for manufacturers to design their light-duty and medium-duty vehicles with onboard diagnostic systems that detect malfunctions in emission controls. These are newly referenced standards. |

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[908] U.S. Environmental Protection Agency (2005). Supplemental guidance for assessing susceptibility from early-life exposure to carcinogens. Washington, DC: Risk Assessment Forum. EPA/630/R–03/003F. *https://www3.epa.gov/airtoxics/childrens_supplement_final.pdf.*

| Standard or test method | Regulation | Summary |
|---|---|---|
| California 2026 and Subsequent Model Year Criteria Pollutant Exhaust Emission Standards and Test Procedures for Passenger Cars, Light-Duty Trucks, And Medium-Duty Vehicles (“CARB’s LMDV Test Procedures”); adopted August 25, 2022. | 40 CFR 1066.801 and 1066.1010 | The CARB regulation establishes test procedures for measuring emissions from light-duty and medium-duty vehicles that are not plug-in hybrid electric vehicles. These are newly referenced standards. |
| California Test Procedures for 2026 and Subsequent Model Year Zero-Emission Vehicles and Plug-In Hybrid Electric Vehicles, in the Passenger Car, Light-Duty Truck and Medium-Duty Vehicle Classes (“CARB’s PHEV Test Procedures”); adopted August 25, 2022. | 40 CFR 1066.801 and 1066.1010 | The CARB regulation establishes test procedures for measuring emissions from plug-in hybrid electric vehicles. These are newly referenced standards. |

In accordance with the requirements of 1 CFR 51.5, we are proposing to incorporate by reference the use of standards and test methods from the United Nations. The referenced standards and test methods may be obtained from the UN Economic Commission for Europe, Information Service at Palais des Nations, CH–1211 Geneva 10, Switzerland; *unece_info@un.org; www.unece.org*. We are incorporating by reference the following UN Economic Commission for Europe document:

| Standard or test method | Regulation | Summary |
|---|---|---|
| Addendum 22: United Nations Global Technical Regulation No. 22, United Nations Global Technical Regulation on In-vehicle Battery Durability for Electrified Vehicles, Adopted April 14, 2022. | 40 CFR 86.1 and 86.1815 | GTR 22 establishes design protocols and procedures for measuring durability and performance for batteries used with electric vehicles and plug-in hybrid-electric vehicles. |

### *J. Executive Order 12898: “Federal Actions To Address Environmental Justice in Minority Populations and Low-Income Populations”*

Executive Order 12898 (59 FR 7629, February 16, 1994) directs Federal agencies, to the greatest extent practicable and permitted by law, to make environmental justice part of their mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of their programs, policies, and activities on minority populations (people of color and/or indigenous peoples) and low-income populations.

EPA believes that the human health or environmental conditions that exist prior to this action result in or have the potential to result in disproportionate and adverse human health or environmental effects on people of color, low-income populations and/or indigenous peoples. EPA provides a summary of the evidence for potentially disproportionate and adverse effects among people of color and low-income populations in Sections II.C.8 and VIII.I of the Preamble for this rule.

EPA believes that this action is likely to reduce existing disproportionate and adverse effects on people of color, low-income populations and/or indigenous peoples. The air pollutant emission reductions proposed in this rule would improve air quality for the people who reside in close proximity to major roadways and who are disproportionately represented by people of color and people with low income, as described in Section II.C.8 and Section VIII.I of this Preamble. We expect that increases in criteria and toxic pollutant emissions from EGUs and reductions in petroleum-sector emissions could lead to changes in exposure to these pollutants for people living in the communities near these facilities. Analyses of communities in close proximity to these sources (such as EGUs and refineries) have found that a higher percentage of communities of color and low-income communities live near these sources when compared to national averages.

Section VIII.I.2 discusses the environmental justice issues associated with climate change. People of color, low-income populations and/or indigenous peoples may be especially vulnerable to the impacts of climate change. The GHG emission reductions from this proposal would contribute to efforts to reduce the probability of severe impacts related to climate change.

EPA is additionally identifying and addressing environmental justice concerns by providing fair treatment and meaningful involvement with Environment Justice groups in developing this proposed action and soliciting input for this notice of proposed rulemaking.

The information supporting this Executive Order review is contained in Sections II.C.8 and VIII.I of the Preamble for this rule, and all supporting documents have been placed in the public docket for this action.

## XI. Statutory Provisions and Legal Authority

Statutory authority for this proposed rule is found at 42 U.S.C. 7401–7675 and 49 U.S.C. 32901–23919q.

## List of Subjects

### *40 CFR Part 85*

Environmental protection, Confidential business information, Greenhouse gases, Imports, Labeling, Motor vehicle pollution, Reporting and recordkeeping requirements, Research, Warranties.

### *40 CFR Part 86*

Environmental protection, Administrative practice and procedure, Confidential business information, Incorporation by reference, Labeling, Motor vehicle pollution, Reporting and recordkeeping requirements.

### *40 CFR Part 600*

Environmental protection, Administrative practice and procedure, Electric power, Fuel economy, Labeling, Reporting and recordkeeping requirements.

### *40 CFR Part 1036*

Environmental protection, Administrative practice and procedure, Air pollution control, Confidential business information, Greenhouse gases, Labeling, Motor vehicle pollution, Reporting and recordkeeping requirements, Warranties.

*40 CFR Part 1037*

Environmental protection, Administrative practice and procedure, Air pollution control, Confidential business information, Labeling, Motor vehicle pollution, Reporting and recordkeeping requirements, Warranties.

*40 CFR Part 1066*

Environmental protection, Air pollution control, Incorporation by reference, Reporting and recordkeeping requirements.

**Michael S. Regan,**

*Administrator.*

For the reasons set out in the preamble, we are proposing to amend title 40, chapter I of the Code of Federal Regulations as set forth below.

## PART 85—CONTROL OF AIR POLLUTION FROM MOBILE SOURCES

■ 1. The authority citation for part 85 continues to read as follows:

**Authority:** 42 U.S.C. 7401–7671q.

■ 2. Amend § 85.505 by revising paragraph (f) to read as follows:

### § 85.505 Overview.

* * * * *

(f) If you have previously used small volume conversion manufacturer or qualified small volume test group/engine family procedures and you may exceed the volume thresholds using the sum described in § 85.535(f) to determine small volume status in 40 CFR 86.1838–01 or 1036.150(d), as appropriate, you must satisfy the requirements for conversion manufacturers who do not qualify for small volume exemptions or your exemption from tampering is no longer valid.

* * * * *

■ 3. Amend § 85.510 by revising paragraphs (b)(2)(i)(A) and (B), (b)(2)(ii), and (b)(6) through (11) to read as follows:

### § 85.510 Exemption provisions for new and relatively new vehicles/engines.

* * * * *

(b) * * *

(2) * * *

(i) * * *

(A) If criteria for small volume manufacturer or qualified small volume engine families are met as defined in 40 CFR 1036.150(d), you may combine heavy-duty engines using good engineering judgment into conversion engine families if the following criteria are satisfied instead of those specified in 40 CFR 1036.230.

(*1*) Same OEM.

(*2*) Same OBD group after MY 2013.

(*3*) Same service class (*e.g.,* light heavy-duty diesel engines, medium heavy-duty diesel engines, heavy heavy-duty diesel engines).

(*4*) Engine displacement is within 15% of largest displacement or 50 CID, whichever is larger.

(*5*) Same number of cylinders.

(*6*) Same arrangement of cylinders.

(*7*) Same combustion cycle.

(*8*) Same method of air aspiration.

(*9*) Same fuel type (*e.g.,* diesel/gasoline).

(*10*) Same fuel metering system (*e.g.,* mechanical direct or electronic direct injection).

(*11*) Same catalyst/filter construction (*e.g.,* metal vs. ceramic substrate).

(*12*) All converted engines are subject to the most stringent emission standards. For example, 2005 and 2007 heavy-duty diesel engines may be in the same family if they meet the most stringent (2007) standards.

(*13*) Same emission control technology (*e.g.,* internal or external EGR).

(B) EPA-established scaled assigned deterioration factors for both exhaust and evaporative emissions may be used for engines with over 10,000 miles if the criteria for small volume manufacturer or qualified small volume engine families are met as defined in 40 CFR 1036.150(d). This deterioration factor will be adjusted according to vehicle or engine miles of operation. The deterioration factor is intended to predict the engine's emission levels at the end of the useful life. EPA may adjust these scaled assigned deterioration factors if we find the rate of deterioration non-constant or if the rate differs by fuel type.

* * * * *

(ii) Conversion evaporative/refueling families are identical to the OEM evaporative/refueling families unless the OEM evaporative emission system is no longer functionally necessary. You must create any new evaporative families according to 40 CFR 86.1821.

* * * * *

(6) Durability testing is required unless the criteria for small volume manufacturer or qualified small volume test groups/engine families are met as defined in 40 CFR 86.1838–01 or 1036.150(d), as applicable.

(7) Conversion test groups/engine families for conversions to dual-fuel or mixed-fuel vehicles/engines cannot include vehicles/engines subject to different emission standards unless applicable exhaust and OBD demonstrations are also conducted for the original fuel(s) demonstrating compliance with the most stringent standard represented in the test group. However, for small volume conversion manufacturers and qualified small volume test groups/engine families the data generated from exhaust emission testing on the new fuel for dual-fuel or mixed-fuel test vehicles/engines may be carried over to vehicles/engines which otherwise meet the test group/engine family criteria and for which the test vehicle/engine data demonstrate compliance with the application vehicle/engine standard. Clean alternative fuel conversion evaporative families for dual-fuel or mixed-fuel vehicles may not include vehicles/engines which were originally certified to different evaporative emissions standards unless evaporative/refueling demonstrations are also conducted for the original fuel(s) demonstrating compliance with the most stringent standard represented in the evaporative/refueling family.

(8) The vehicle/engine selected for testing must qualify as a worst-case vehicle/engine under 40 CFR 86.1828–01 or 1036.235(a)(2), as applicable.

(9) The following requirements apply for OBD systems:

(i) The OBD system must properly detect and identify malfunctions in all monitored emission-related powertrain systems or components including any new monitoring capability necessary to identify potential emission problems associated with the new fuel.

(ii) Conduct OBD testing as needed to demonstrate that the vehicle/engine continues to comply with emission thresholds and other requirements that apply based on the original certification.

(iii) Submit the applicable OBD reporting information for vehicles as set forth in 40 CFR 86.1806–17. Submit the applicable OBD reporting information for engines as set forth in 40 CFR 86.010–18 or 1036.110, as appropriate. Submit the following statement of compliance if the OEM vehicles/engines were required to be OBD-equipped:

The test group/engine family converted to an alternative fuel has fully functional OBD systems and therefore meets the OBD requirements specified in [40 CFR part 86 or part 1036, as applicable] when operating on the alternative fuel.

(10) In lieu of specific certification test data, you may submit the following attestations for the appropriate statements of compliance, if you have

sufficient basis to prove the statement is valid.

(i) The test group/engine family converted to an alternative fuel has properly exercised the optional and applicable statements of compliance or waivers in the certification regulations. Attest to each statement or waiver in your application for certification.

(ii) The test group/engine family converted to dual-fuel or mixed-fuel operation retains all the OEM fuel system, engine calibration, and emission control system functionality when operating on the fuel with which the vehicle/engine was originally certified.

(iii) The test group/engine family converted to dual fuel or mixed-fuel operation retains all the functionality of the OEM OBD system (if so equipped) when operating on the fuel with which the vehicle/engine was originally certified.

(iv) The test group/engine family converted to dual-fuel or mixed-fuel operation properly purges hydrocarbon vapor from the evaporative emission canister when the vehicle/engine is operating on the alternative fuel.

(11) Certification fees apply as described in 40 CFR part 1027.

* * * * *

■ 4. Amend § 85.515 by revising paragraphs (b)(4), (6), and (8), (b)(9)(iii), (b)(10)(i), and (b)(10)(iii)(A) to read as follows:

### § 85.515 Exemption provisions for intermediate age vehicles/engines.

* * * * *

(b) * * *

(4) EPA-established scaled assigned deterioration factors for both exhaust and evaporative emissions may be used for vehicles/engines with over 10,000 miles if the criteria for small volume manufacturer or qualified small volume test groups/engine families are met as defined in 40 CFR 86.1838–01 or 40 CFR 1036.150(d), as appropriate. This deterioration factor will be adjusted according to vehicle/engine miles or hours of operation. The deterioration factor is intended to predict the vehicle/engine's emission level at the end of the useful life. EPA may adjust these scaled assigned deterioration factors if we find the rate of deterioration non-constant or if the rate differs by fuel type.

* * * * *

(6) Durability testing is required unless the criteria for small volume manufacturer or qualified small volume test groups/engine families are met as defined in 40 CFR 86.1838–01 or 40 CFR 1036.150(d), as applicable. Durability procedures for large volume conversion manufacturers of intermediate age light-duty and heavy-duty chassis certified vehicles that follow provisions in 40 CFR 86.1820–01 may eliminate precious metal composition and catalyst grouping statistic when creating clean alternative fuel conversion durability groupings.

* * * * *

(8) You must conduct all exhaust and all evaporative and refueling emissions testing with a worst-case vehicle/engine to show that the conversion test group/engine family complies with exhaust and evaporative/refueling emission standards, based on the certification procedures.

(9) * * *

(iii) In addition to conducting OBD testing described in this paragraph (b)(9), you must submit to EPA the following statement of compliance if the OEM vehicles/engines were required to be OBD-equipped:

The test group/engine family converted to an alternative fuel has fully functional OBD systems and therefore meets the OBD requirements specified in [40 CFR part 86 or part 1036, as applicable] when operating on the alternative fuel.

(10) * * *

(i) You must describe how your conversion system qualifies as a clean alternative fuel conversion. You must include emission test results from the required exhaust, evaporative emissions, and OBD testing, applicable exhaust and evaporative emissions standards and deterioration factors. You must also include a description of how the test vehicle/engine selected qualifies as a worst-case vehicle/engine under 40 CFR 86.1828–01 or 1036.235(a)(2), as applicable.

* * * * *

(iii) * * *

(A) The test group/engine family converted to an alternative fuel has properly exercised the optional and applicable statements of compliance or waivers in the certification regulations. Attest to each statement or waiver in your notification.

* * * * *

■ 5. Amend § 85.520 by revising paragraphs (b)(4), (b)(6)(i), and (b)(6)(iii)(A) to read as follows:

### § 85.520 Exemption provisions for outside useful life vehicles/engines.

* * * * *

(b) * * *

(4) The following requirements apply for OBD systems:

(i) The OBD system must properly detect and identify malfunctions in all monitored emission-related powertrain systems or components, including any new monitoring capability necessary to identify potential emission problems associated with the new fuel. These include but are not limited to: Fuel trim lean and rich monitors, catalyst deterioration monitors, engine misfire monitors, oxygen sensor deterioration monitors, EGR system monitors, if applicable, and evaporative system leak monitors, if applicable. No original OBD system monitor that is still applicable to the vehicle/engine may be aliased, removed, bypassed, or turned-off. No MILs shall be illuminated after the conversion. Readiness flags must be properly set for all monitors that identify any malfunction for all monitored components.

(ii) Subsequent to the vehicle/engine fuel conversion, you must clear all OBD codes and reset all OBD monitors to not-ready status using an OBD scan tool appropriate for the OBD system in the vehicle/engine in question. You must operate the vehicle/engine with the new fuel on representative road operation or chassis dynamometer/engine dynamometer testing cycles to satisfy the monitors' enabling criteria. When all monitors have reset to a ready status, you must submit an OBD scan tool report showing that with the vehicle/engine operating in the key-on/engine-on mode, all supported monitors have reset to a ready status and no emission related ''pending'' (or potential) or ''confirmed'' (or MIL-on) diagnostic trouble codes (DTCs) have been stored. The MIL must not be commanded ''On'' or be illuminated. A MIL check must also be conducted in a key-on/engine-off mode to verify that the MIL is functioning properly. You must include the VIN/EIN of the test vehicle/engine. If necessary, the OEM evaporative emission readiness monitor may remain unset for dedicated gaseous fuel conversion systems.

(iii) In addition to conducting OBD testing described in this paragraph (b)(4), you must submit to EPA the following statement of compliance if the OEM vehicles/engines were required to be OBD-equipped:

The test group/engine family converted to an alternative fuel has fully functional OBD systems and therefore meets the OBD requirements specified in [40 CFR part 86 or 40 CFR part 1036, as applicable] when operating on the alternative fuel.

* * * * *

(6) * * *

(i) You must describe how your conversion system complies with the good engineering judgment criteria in paragraph (b)(3) of this section and/or other requirements under this subpart or other applicable subparts such that the conversion system qualifies as a clean alternative fuel conversion. The submission must provide a level of technical detail sufficient for EPA to confirm the conversion system's ability to maintain or improve on emission levels in a worst-case vehicle/engine. The submission of technical information must include a complete characterization of exhaust and evaporative emissions control strategies, the fuel delivery system, durability, and specifications related to OBD system functionality. You must present detailed information to confirm the durability of all relevant new and existing components and to explain why the conversion system will not harm the emission control system or degrade the emissions. EPA may ask you to supply additional information, including test data, to support the claim that the conversion system does not increase emissions and involves good engineering judgment that is being applied for purposes of conversion to a clean alternative fuel.

* * * * *

(iii) * * *

(A) The test group/engine family converted to an alternative fuel has properly exercised the optional and applicable statements of compliance or waivers in the certification regulations. Attest to each statement or waiver in your notification.

* * * * *

### § 85.524 [Removed]

■ 6. Remove § 85.524.

■ 7. Amend § 85.535 by revising paragraph (f) to read as follows:

### § 85.535 Liability, recordkeeping, and end of year reporting.

* * * * *

(f) Clean alternative fuel conversion manufacturers must submit an end of the year sales report to EPA describing the number of clean alternative fuel conversions by fuel type(s) and vehicle test group/engine family by January 31 of the following year. The number of conversions is the sum of the calendar year intermediate age conversions, outside useful life conversions, and the same conversion model year certified clean alternative fuel conversions. The number of conversions will be added to any other vehicle and engine sales accounted for using 40 CFR 86.1838–01 or 1036.150(d), as appropriate to determine small volume manufacturer or qualified small volume test group/engine family status.

* * * * *

■ 8. Amend § 85.1503 by revising paragraphs (a) and (c) to read as follows:

### § 85.1503 General requirements for importation of nonconforming vehicles and engines.

(a) A nonconforming vehicle or engine offered for importation into the United States must be imported by an ICI who is a current holder of a valid certificate of conformity unless an exemption or exclusion is granted by the Administrator under § 85.1511 or the vehicle is eligible for entry under § 85.1512.

* * * * *

(c) In any one certificate year (*e.g.,* the current model year), an ICI may finally admit no more than the following numbers of nonconforming vehicles into the United States under the provisions of §§ 85.1505 and 85.1509, except as allowed by paragraph (e) of this section:

(1) [Reserved]

(2) A total of 25 light-duty vehicles, light-duty trucks, and medium-duty passenger vehicles. This limit does not apply for electric vehicles.

(3) 50 highway motorcycles.

* * * * *

■ 9. Amend § 85.1509 by:

■ a. Revising paragraph (a) introductory text.

■ b. Removing and reserving paragraphs (b) through (f).

■ c. Removing the paragraph heading from paragraphs (j), (k) introductory text, and (l).

The revision reads as follows:

### § 85.1509 Final admission of modification and test vehicles.

(a) A motor vehicle or motor vehicle engine may be imported under this section by a certificate holder possessing a currently valid certificate of conformity only if—

* * * * *

■ 10. Amend § 85.1510 by revising paragraphs (d)(1) and (f) to read as follows:

### § 85.1510 Maintenance instructions, warranties, emission labeling and fuel economy requirements.

* * * * *

(d) * * *

(1) The certificate holder shall affix a fuel economy label that complies with the requirements of 40 CFR part 600, subpart D. The requirement for fuel economy labels does not apply for electric vehicles.

* * * * *

(f) *Corporate Average Fuel Economy (CAFE).* Certificate holders shall comply with any applicable CAFE requirements of the Energy Policy and Conservation Act, 15 U.S.C. 2001 *et seq.,* and 40 CFR part 600, for all vehicles imported under §§ 85.1505 and 85.1509.

■ 11. Amend § 85.1515 by revising paragraphs (a)(2)(i)(A) and (B), (c)(2)(ix) and (x), and (c)(3), (5), (6), and (8) to read as follows:

### § 85.1515 Emission standards and test procedures applicable to imported nonconforming motor vehicles and motor vehicle engines.

(a) * * *

(2) * * *

(i) * * *

(A) Cold temperature CO, NMHC, NMOG+NO$_x$, and PM emission standards specified in 40 CFR 86.1811.

(B) SFTP emission standards specified in 40 CFR 86.1811 and 86.1816 for all pollutants, and separate emission standards that apply for US06 and SC03 duty cycles.

* * * * *

(c) * * *

(2) * * *

(ix) Nonconforming vehicles subject to the provisions of 40 CFR part 86, subpart S, originally manufactured in OP years 2022 through 2029 must meet the Tier 3 exhaust emission standards in 40 CFR 86.1811–17 and 86.1816–18, the Tier 3 evaporative emission standards in 40 CFR 86.1813–17, and the refueling emission standards in 40 CFR 86.1813–17(b).

(x) Nonconforming vehicles subject to the provisions of 40 CFR part 86, subpart S, originally manufactured in OP years 2030 and later must meet the Tier 4 exhaust emission standards in 40 CFR 86.1811–27, the Tier 3 evaporative emission standards in 86.1813–17, and the refueling emission standards in 40 CFR 86.1813–17(b).

(3) The following provisions apply for Tier 2 vehicles certified to standards under 40 CFR 86.1811–04:

(i) As an option to the requirements of paragraph (c)(2) of this section, independent commercial importers may elect to meet lower bins in Tables S04–1 and S04–2 of 40 CFR 86.1811–04 than specified in paragraph (c)(2) of this section and bank or sell NOx credits as permitted in 40 CFR 86.1860–04 and 40 CFR 86.1861–04. An ICI may not meet higher bins in Tables S04–1 and S04–2 of 40 CFR 86.1811–04 than specified in paragraph (c)(2) of this section unless it demonstrates to the Administrator at the time of certification that it has obtained appropriate and sufficient NO$_x$ credits from another manufacturer, or has generated them in a previous model year or in the current model year and not transferred them to another manufacturer or used them to address other vehicles as permitted in 40 CFR 86.1860–04 and 40 CFR 86.1861–04.

(ii) Where an ICI desires to obtain a certificate of conformity using a bin higher than specified in paragraph (c)(2) of this section but does not have sufficient credits to cover vehicles produced under such certificate, the Administrator may issue such certificate if the ICI has also obtained a certificate of conformity for vehicles certified using a bin lower than that required under paragraph (c)(2) of this section. The ICI may then produce vehicles to the higher bin only to the extent that it has generated sufficient credits from vehicles certified to the lower bin during the same model year.

* * * * *

(5) Except for the situation where an ICI desires to bank, sell or use $NO_x$ credits as described in paragraph (c)(3) of this section, the requirements of 40 CFR 86.1811 related to fleet average standards and requirements to comply with such standards do not apply to vehicles modified under this subpart.

(6) ICIs using Tier 2 bins higher than those specified in paragraph (c)(2) of this section must monitor their production so that they do not produce more vehicles certified to the standards of such bins than their available credits can cover. ICIs must not have a credit deficit at the end of a model year and are not permitted to use the deficit carryforward provisions provided in 40 CFR 86.1860–04(e).

* * * * *

(8) The following provisions apply for cold temperature emission standards:

(i) Nonconforming LDV/LLDTs originally manufactured in OP years 2010 and later must meet the cold temperature emission standards in 40 CFR 86.1811. ICIs may comply with the cold temperature PM standard based on an engineering evaluation.

(ii) Nonconforming HLDTs and MDPVs originally manufactured in OP years 2012 and later must meet the cold temperature emission standards in 40 CFR 86.1811. ICIs may comply with the cold temperature PM standard based on an engineering evaluation.

(iii) ICIs, which qualify as small-volume manufacturers, are exempt from the cold temperature NMHC phase-in intermediate percentage requirements described in 40 CFR 86.1811–10(g)(3). See 40 CFR 86.1811–04(k)(5)(vi) and (vii).

(iv) The provisions of this paragraph (c)(8)(iv) apply for Tier 2 vehicles. As an alternative to the requirements of paragraphs (c)(8)(i) and (ii) of this section, ICIs may elect to meet a cold temperature NMHC family emission level below the cold temperature NMHC fleet average standards specified in Table S10–1 of 40 CFR 86.1811–10 and bank or sell credits as permitted in 40 CFR 86.1864–10. An ICI may not meet a higher cold temperature NMHC family emission level than the fleet average standards in Table S10–1 of 40 CFR 86.1811–10 as specified in paragraphs (c)(8)(i) and (ii) of this section, unless it demonstrates to the Administrator at the time of certification that it has obtained appropriate and sufficient NMHC credits from another manufacturer, or has generated them in a previous model year or in the current model year and not traded them to another manufacturer or used them to address other vehicles as permitted in 40 CFR 86.1864–10.

* * * * *

■ 12. Amend § 85.1702 by revising paragraph (a)(3), adding paragraph (a)(6), and adding a reserved paragraph (b).

The revision and addition read as follows:

### § 85.1702 Definitions.

(a) * * *

(3) *Pre-certification vehicle* means an uncertified vehicle that a certificate holder employs in fleets from year to year in the ordinary course of business for product development, production method assessment, and market promotion, but not involving lease or sale.

* * * * *

(6) *Certificate holder* has the meaning given in 40 CFR 1068.30.

* * * * *

■ 13. Revise § 85.2101 to read as follows:

### § 85.2101 General applicability.

(a) Sections 85.2101 through 85.2111 are applicable to all 1981 and later model year vehicles subject to standards under 40 CFR part 86, subpart S.

(b) References in this subpart to engine families and emission control systems shall be deemed to apply to durability groups and test groups as applicable.

■ 14. Amend § 85.2102 by revising paragraph (a) introductory text and paragraphs (a)(10) and (11) to read as follows:

### § 85.2102 Definitions.

(a) As used in §§ 85.2101 through 85.2111 all terms not defined herein shall have the meaning given them in the Act. All terms additionally not defined in the Act shall have the meaning given in 40 CFR 86.1803, 1065.1001, or 1068.30:

* * * * *

(10) *Useful life* means that period established under 40 CFR 86.1805.

(11) *Vehicle* means any vehicle subject to standards under 40 CFR part 86, subpart S.

* * * * *

■ 15. Revise § 85.2103 to read as follows:

### § 85.2103 Emission performance warranty.

(a) The manufacturer of each vehicle to which this subpart applies must provide a written commitment to meet warranty requirements as described in this section.

(b) The manufacturer must remedy a nonconformity identified in paragraph (c) of this section throughout the warranty period specified in § 85.2108 at no cost to the owner if such nonconformity results or will result in the vehicle owner having to bear any penalty or other sanction (including the denial of the right to use the vehicle) under local, State, or Federal law.

(c) The following failures qualify as a nonconformity for purposes of the warranty requirements of this subpart:

(1) A vehicle fails to conform at any time during its useful life to the applicable emission standards or family emission limits as determined by an EPA-approved emission test.

(2) An electric vehicle or a plug-in hybrid electric vehicle fails to meet the Minimum Performance Requirement for useable battery energy under 40 CFR 86.1815 for the specified period as determined by the vehicle's State of Health Monitor, if applicable.

(d) The warranty periods under this section apply based on the vehicle's age in years and on the vehicle's odometer reading. The warranty period expires based on the specified age or mileage, whichever comes first. The warranty period for a particular vehicle begins on the date the vehicle is delivered to its ultimate purchaser or, if the vehicle is first placed in service as a ''demonstrator'' or ''company'' car prior to delivery, on the date it is first placed in service.

(e) The following warranty periods apply for light-duty vehicles, light-duty trucks, and medium-duty passenger vehicles:

(1) The following specified major emission control components have a warranty period of eight years or 80,000 miles:

(i) Catalytic converters and SCR catalysts, and related components.

(ii) Particulate filters and particulate traps, used with both spark-ignition and compression-ignition engines.

(iii) Components related to exhaust gas recirculation with compression-ignition engines.

(iv) Emission control module.

(v) Batteries serving as a Renewable Energy Storage System for electric vehicles and plug-in hybrid electric vehicles, along with related powertrain components.

(2) Nonconformities other than those identified in paragraph (e)(1) of this section have a warranty period of two years or 24,000 miles.

(f) The following warranty periods apply for medium-duty vehicles:

(1) The specific major emission control components identified in paragraph (e)(1) of this section have a warranty period of eight years or 80,000 miles.

(2) Nonconformities other than those identified in paragraph (f)(1) of this section have a warranty period of five years or 50,000 miles.

■ 16. Amend § 85.2104 by revising paragraphs (d), (e), (f), (g) introductory text, (g)(1) and (g)(2) introductory text to read as follows:

### § 85.2104 Owners' compliance with instructions for proper maintenance and use.

* * * * *

(d) the time/mileage interval for scheduled maintenance services shall be the service interval specified for the part in the written instructions for proper maintenance and use. However, in the case of certified parts having a maintenance or replacement interval different from that specified in the written instructions for proper maintenance and use, the time/mileage interval shall be the service interval for which the part was certified.

(e) The owner may perform maintenance or have maintenance performed more frequently than required in the maintenance instructions.

(f) Written instruction for proper use of electric vehicles and plug-in hybrid electric vehicles may identify certain behaviors or vehicle operating modes expected to unreasonably or artificially shorten battery durability. For example, exceeding a vehicle's towing capacity might be considered improper use. However, the manufacturer should not consider actions to be improper use if the vehicle can be designed to prevent the targeted behaviors or operating modes. Evidence of compliance with the requirement to properly use vehicles under this paragraph (f) is generally limited to onboard data logging, though manufacturers may also request vehicle owners to make a statement regarding specific behaviors or vehicle operating modes.

(g) Except as provided in paragraph (h) of this section, a manufacturer may deny an emission performance warranty claim on the basis of noncompliance with the written instructions for proper maintenance and use if and only if:

(1) An owner is not able to comply with a request by a manufacturer for evidence pursuant to paragraph (c) or (f) of this section; or

(2) Notwithstanding the evidence presented pursuant to paragraph (c) of this section, the manufacturer is able to prove that the vehicle failed because:

* * * * *

■ 17. Amend § 85.2105 by revising paragraph (b)(3) to read as follows:

### § 85.2105 Aftermarket parts.

* * * * *

(b) * * *

(3) List all objective evidence as defined in § 85.2102 that was used in the determination to deny warranty. This evidence must be made available to the vehicle owner or EPA upon request.

* * * * *

■ 18. Amend § 85.2109 by revising paragraph (a)(2) to read as follows:

### § 85.2109 Inclusion of warranty provisions in owners' manuals and warranty booklets.

(a) * * *

(2) A list of all items which are covered by the emission performance warranty for the full useful life of the vehicle. This list shall contain all specified major emission control components. All items listed pursuant to this subsection shall be described in the same manner as they are likely to be described on a service facility work receipt for that vehicle; and

* * * * *

■ 19. Revise § 85.2110 to read as follows:

### § 85.2110 Submission of owners' manuals and warranty statements to EPA.

(a) The manufacturer of each vehicle to which this subpart applies must send to EPA an owner's manual and warranty booklet (if applicable) in electronic format for each model vehicle that completely and accurately represent the warranty terms for that vehicle.

(1) The owner's manuals and warranty booklets should be received by EPA 60 days prior to the introduction of the vehicle for sale.

(2) If the manuals and warranty booklets are not in their final format 60 days prior to the introduction of the vehicle for sale, a manufacturer may submit the most recent draft at that time, provided that the manufacturer promptly submits final versions when they are complete.

(b) All materials described in paragraph (a) of this section shall be sent to the Designated Compliance Officer as specified at 40 CFR 1068.30 (Attention: Warranty Booklet).

## PART 86—CONTROL OF EMISSIONS FROM NEW AND IN-USE HIGHWAY VEHICLES AND ENGINES

■ 20. The authority citation for part 86 continues to read as follows:

**Authority:** 42 U.S.C. 7401–7671q.

■ 21. Amend § 86.1 by:

■ a. Adding introductory text.

■ b. Revising paragraphs (a) and (d)(2).

■ c. Removing and reserving paragraphs (d)(3) and (4).

■ d. Revising paragraph (e)(2).

■ e. Removing and reserving paragraph (g)(4).

■ f. Revising paragraph (g)(8).

■ g. Removing and reserving paragraphs (g)(10), (11), (13), and (14).

■ h. Revising paragraphs (g)(15) through (19), (21), (22), and (25).

The addition and revisions read as follows:

### § 86.1 Incorporation by reference.

Certain material is incorporated by reference into this part with the approval of the Director of the Federal Register under 5 U.S.C. 552(a) and 1 CFR part 51. To enforce any edition other than that specified in this section, EPA must publish a document in the **Federal Register** and the material must be available to the public. All approved incorporation by reference (IBR) material is available for inspection at EPA and at the National Archives and Records Administration (NARA). Contact EPA at: U.S. EPA, Air and Radiation Docket Center, WJC West Building, Room 3334, 1301 Constitution Ave. NW, Washington, DC 20004; *www.epa.gov/dockets;* (202) 202–1744. For information on inspecting this material at NARA, visit *www.archives.gov/federal-register/cfr/ibr-locations.html* or email *fr.inspection@nara.gov*. The material may be obtained from the following sources:

(a) UN Economic Commission for Europe, Information Service, Palais des Nations, CH–1211 Geneva 10, Switzerland; *unece_info@un.org; www.unece.org:*

(1) Addendum 22: United Nations Global Technical Regulation, No. 22, United Nations Global Technical Regulation on In-vehicle Battery Durability for Electrified Vehicles, Adopted April 14, 2022, (''GTR No. 22''); IBR approved for § 86.1815.

(2) [Reserved]

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(d) * * *

(2) California Regulatory Requirements known as Onboard Diagnostics II (OBD–II), Title 13, Motor Vehicles, Division 3, Air Resources

Board, Chapter 1, Motor Vehicle Pollution Control Devices, Article 2, Approval of Motor Vehicle Pollution Control Devices (New Vehicles), § 1968.2 Malfunction and Diagnostic System Requirements—2004 and Subsequent Model-Year Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles and Engines; operative November 22, 2022; IBR approved for § 86.1806–27(a).

* * * * *

(e) * * *

(2) ISO 15765–4:2005(E), Road Vehicles—Diagnostics on Controller Area Networks (CAN)—Part 4: Requirements for emissions-related systems, January 15, 2005, IBR approved for § 86.010–18(k).

* * * * *

(g) * * *

(8) SAE J1930, Electrical/Electronic Systems Diagnostic Terms, Definitions, Abbreviations, and Acronyms—Equivalent to ISO/TR 15031–2: April 30, 2002, Revised April 2002, IBR approved for § 86.010–18(k).

* * * * *

(15) SAE J1939–71, Vehicle Application Layer (Through February 2007), Revised January 2008, IBR approved for § 86.010–38(j).

(16) SAE J1939–73, Application Layer—Diagnostics, Revised September 2006, IBR approved for §§ 86.010–18(k); 86.010–38(j).

(17) SAE J1939–81, Network Management, Revised May 2003, IBR approved for § 86.010–38(j).

(18) SAE J1962, Diagnostic Connector Equivalent to ISO/DIS 15031–3; December 14, 2001, Revised April 2002, IBR approved for § 86.010–18(k).

(19) SAE J1978, OBD II Scan Tool—Equivalent to ISO/DIS 15031–4; December 14, 2001, Revised April 2002, IBR approved for § 86.010–18(k).

* * * * *

(21) SAE J1979, (R) E/E Diagnostic Test Modes, Revised May 2007, IBR approved for § 86.010–18(k).

(22) SAE J2012, (R) Diagnostic Trouble Code Definitions Equivalent to ISO/DIS 15031–6: April 30, 2002, Revised April 2002, IBR approved for § 86.010–18(k).

* * * * *

(25) SAE J2403, Medium/Heavy-Duty E/E Systems Diagnosis Nomenclature—Truck and Bus, Revised August 2007, IBR approved for §§ 86.010–18(k); 86.010–38(j).

* * * * *

### § 86.113–04 [Amended]

■ 22. Amend § 86.113–04 by removing and reserving paragraph (a)(2)(i).

■ 23. Add § 86.113–27 to read as follows:

### § 86.113–27 Fuel specifications.

Use the fuels specified in 40 CFR part 1065 to perform valid tests, as follows:

(a) For service accumulation, use the test fuel or any commercially available fuel that is representative of the fuel that in-use vehicles will use.

(b) For diesel-fueled engines, use the ultra low-sulfur diesel fuel specified in 40 CFR part 1065.703 for emission testing.

(c) The following fuel requirements apply for gasoline-fueled engines:

(1) Use the appropriate E10 fuel specified in 40 CFR part 1065.710(b) to demonstrate compliance with all exhaust, evaporative, and refueling emission standards under subpart S of this part.

(2) For vehicles certified for 50-state sale, you may instead use California Phase 3 gasoline (E10) as adopted in California's LEV III program as follows:

(i) You may use California Phase 3 gasoline (E10) as adopted in California's LEV III program for exhaust emission testing.

(ii) If you certify vehicles to LEV III evaporative emission standards with California Phase 3 gasoline (E10), you may use that collection of data to certify to evaporative emission standards. For evaporative emission testing with California test fuels, perform tests based on the test temperatures specified by the California Air Resources Board. Note that this paragraph (c)(2)(ii) does not apply for refueling, spitback, high-altitude, or leak testing.

(iii) If you certify using fuel meeting California's specifications, we may perform testing with E10 test fuel meeting either California or EPA specifications.

(d) Interim test fuel specifications apply for model years 2027 through 2029 as described in 40 CFR 600.117.

(e) Additional test fuel specifications apply as specified in subpart S of this part.

■ 24. Amend § 86.132–96 by revising paragraphs (a), (b), (f), (g), (h) introductory text, and (j) introductory text to read as follows:

### § 86.132–96 Vehicle preconditioning.

(a) Prepare the vehicle for testing as described in this section. Store the vehicle before testing in a way that prevents fuel contamination and preserves the integrity of the fuel system. The vehicle shall be moved into the test area and the following operations performed.

(b)(1) *Gasoline- and Methanol-Fueled Vehicles.* Drain the fuel tank(s) and fill with test fuel, as specified in § 86.113, to the ''tank fuel volume'' defined in § 86.082–2. Install the fuel cap(s) within one minute after refueling.

(2) *Gaseous-Fueled Vehicles.* Fill fuel tanks with fuel that meets the specifications in § 86.113. Fill the fuel tanks to a minimum of 85 percent of service pressure for natural gas-fueled vehicles or a minimum of 85 percent of available fill volume for liquefied petroleum gas-fueled vehicles. Prior draining of the fuel tanks is not required if the fuel in the tanks already meets the specifications in § 86.113.

* * * * *

(f) Drain and then fill the vehicle's fuel tank(s) with test fuel, as specified in § 86.113, to the ''tank fuel volume'' defined in § 86.082–2. Refuel the vehicle within 1 hour after completing the preconditioning drive. Install fuel cap(s) within 1 minute after refueling. Park the vehicle within five minutes after refueling. However, for the following vehicles omit this refueling event and instead drive the vehicle off the dynamometer and park it within five minutes after the preconditioning drive:

(1) Diesel-fueled vehicles.

(2) Gaseous-fueled vehicles.

(3) Fuel economy data vehicles.

(4) In-use vehicles subject to testing under § 86.1845.

(g) The vehicle shall be soaked for not less than 12 hours nor more than 36 hours before the cold start exhaust emission test. The soak period starts at the end of the refueling event, or at the end of the previous drive if there is no refueling.

(h) During the soak period for the three-diurnal test sequence described in § 86.130–96, precondition any evaporative canisters as described in this paragraph (h); however, canister preconditioning is not required for fuel economy data vehicles. For vehicles with multiple canisters in a series configuration, the set of canisters must be preconditioned as a unit. For vehicles with multiple canisters in a parallel configuration, each canister must be preconditioned separately. If production evaporative canisters are equipped with a functional service port designed for vapor load or purge steps, the service port shall be used during testing to precondition the canister. In addition, for model year 1998 and later vehicles equipped with refueling canisters, these canisters shall be preconditioned for the three-diurnal test sequence according to the procedure in paragraph (j)(1) of this section. If a vehicle is designed to actively control evaporative or refueling emissions without a canister, the manufacturer shall devise an appropriate preconditioning procedure, subject to the approval of the Administrator.

* * * * *

(j) During the soak period for the supplemental two-diurnal test sequence described in § 86.130–96, precondition any evaporative canisters using one of the methods described in this paragraph (j); however, canister preconditioning is not required for fuel economy data vehicles. For vehicles with multiple canisters in a series configuration, the set of canisters must be preconditioned as a unit. For vehicles with multiple canisters in a parallel configuration, each canister must be preconditioned separately. In addition, for model year 1998 and later vehicles equipped with refueling canisters, these canisters shall be preconditioned for the supplemental two-diurnal test sequence according to the procedure in paragraph (j)(1) of this section. Canister emissions are measured to determine breakthrough. Breakthrough is here defined as the point at which the cumulative quantity of hydrocarbons emitted is equal to 2 grams.

* * * * *

### §§ 86.165–12 and 86.1801–01 [Removed]

■ 25. Remove §§ 86.165–12 and 86.1801–01.

■ 26. Amend § 86.1801–12 by revising paragraphs (a)(2)(ii), (a)(3)(i) and (ii), (h), (i), (j)(1) introductory text, and (k) and adding paragraph (l) to read as follows:

### § 86.1801–12 Applicability.

(a) * * *

(2) * * *

(ii) Starting in model year 2030, the provisions of this subpart do not apply for vehicles above 22,000 pounds GCWR. The provisions of this subpart are optional for those vehicles in model years 2027 through 2029 as described in paragraph (l) of this section.

* * * * *

(3) * * *

(i) Heavy duty vehicles above 14,000 pounds GVWR may be optionally certified to the exhaust emission standards in this subpart, including the greenhouse gas emission standards, if they are properly included in a test group with similar vehicles at or below 14,000 pounds GVWR. Emission standards apply to these vehicles as if they were Class 3 heavy-duty vehicles. The work factor for these vehicles may not be greater than the largest work factor that applies for vehicles in the test group that are at or below 14,000 pounds GVWR (see § 86.1819–14). Starting in model year 2030, this option no longer applies for vehicles above 22,000 pounds GCWR.

(ii) Incomplete heavy-duty vehicles at or below 14,000 pounds GVWR may be optionally certified to the exhaust emission standards in this subpart that apply for heavy-duty vehicles. Starting in model year 2030, this option no longer applies for vehicles above 22,000 pounds GCWR.

* * * * *

(h) *Applicability of provisions of this subpart to light-duty vehicles, light-duty trucks, medium-duty passenger vehicles, and heavy-duty vehicles.* Numerous sections in this subpart provide requirements or procedures applicable to a ''vehicle'' or ''vehicles.'' Unless otherwise specified or otherwise determined by the Administrator, the term ''vehicle'' or ''vehicles'' in those provisions apply equally to light-duty vehicles (LDVs), light-duty trucks (LDTs), medium-duty passenger vehicles (MDPVs), and heavy-duty vehicles (HDVs), as those terms are defined in § 86.1803–01. Note that this subpart also identifies heavy-duty vehicles at or below 14,000 pounds GVWR that are not medium-duty passenger vehicles as medium-duty vehicles.

(i) *Types of pollutants.* Emission standards and related requirements apply for different types of pollutants as follows:

(1) *Criteria pollutants.* Criteria pollutant standards apply for $NO_X$, HC, PM, and CO, including exhaust, evaporative, and refueling emission standards. These pollutants are sometimes described collectively as ''criteria pollutants'' because they are either criteria pollutants under the Clean Air Act or precursors to the criteria pollutants ozone and PM.

(2) *Greenhouse gas emissions.* This subpart contains standards and other regulations applicable to the emission of the air pollutant defined as the aggregate group of six greenhouse gases: carbon dioxide, nitrous oxide, methane, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride.

(3) *Nomenclature.* Numerous sections in this subpart refer to requirements relating to ''exhaust emissions.'' Unless otherwise specified or otherwise determined by the Administrator, the term ''exhaust emissions'' refers at a minimum to emissions of all pollutants described by emission standards in this subpart, including carbon dioxide ($CO_2$), nitrous oxide ($N_2O$), and methane ($CH_4$).

(j) * * *

(1) Manufacturers that qualify as a small business under the Small Business Administration regulations in 13 CFR part 121 are exempt from certain standards and associated provisions as specified in §§ 86.1815, 86.1818, and 86.1819 and in 40 CFR part 600. This exemption applies to both U.S.-based and non-U.S.-based businesses. The following categories of businesses (with their associated NAICS codes) may be eligible for exemption based on the Small Business Administration size standards in 13 CFR 121.201:

* * * * *

(k) *Conditional exemption from greenhouse gas emission standards.* Manufacturers may request a conditional exemption from compliance with the emission standards described in § 86.1818–12(c) through (e) and associated provisions in this part and in part 600 of this chapter for model years 2012 through 2016. For the purpose of determining eligibility the sales of related companies shall be aggregated according to the provisions of § 86.1838–01(b)(3) or, if a manufacturer has been granted operational independence status under § 86.1838–01(d), eligibility shall be based on that manufacturer's vehicle production.

(1) [Reserved]

(2) *Maintaining eligibility for exemption from greenhouse gas emission standards.* To remain eligible for exemption under this paragraph (k) the manufacturer's average sales for the three most recent consecutive model years must remain below 5,000. If a manufacturer's average sales for the three most recent consecutive model years exceeds 4,999, the manufacturer will no longer be eligible for exemption and must meet applicable emission standards according to the provisions in this paragraph (k)(2).

(i) If a manufacturer's average sales for three consecutive model years exceeds 4,999, and if the increase in sales is the result of corporate acquisitions, mergers, or purchase by another manufacturer, the manufacturer shall comply with the emission standards described in § 86.1818–12(c) through (e), as applicable, beginning with the first model year after the last year of the three consecutive model years.

(ii) If a manufacturer's average sales for three consecutive model years exceeds 4,999 and is less than 50,000, and if the increase in sales is solely the result of the manufacturer's expansion in vehicle production, the manufacturer shall comply with the emission standards described in § 86.1818–12(c) through (e), as applicable, beginning with the second model year after the last year of the three consecutive model years.

(iii) If a manufacturer's average sales for three consecutive model years exceeds 49,999, the manufacturer shall comply with the emission standards described in § 86.1818–12 (c) through (e), as applicable, beginning with the first model year after the last year of the three consecutive model years.

(l) *Transition to GHG standards for high-GCWR vehicles.* If manufacturers certify all their engines installed in model year 2027 vehicles with GCWR above 22,000 pounds under 40 CFR part 1036, instead of waiting until model year 2030, the vehicles in which those engines are installed may demonstrate compliance with the appropriate $CO_2$ target values specified for model year 2026 in § 86.1819–14(k)(4)(i). See 40 CFR 1036.635.

■ 27. Amend § 86.1803–01 by:

■ a. Revising the definition of ''Banking''.

■ b. Removing the definitions of ''Durability useful life'', ''Fleet average cold temperature NMHC standard'', and ''Fleet average $NO_X$ standard''.

■ c. Adding definitions of ''Incomplete vehicle'' and ''Light-duty program vehicle'' in alphabetical order.

■ d. Revising the definitions of ''Light-duty truck'' and ''Medium-duty passenger vehicle (MDPV)''.

■ e. Adding definitions of ''Normal operation'' and ''Rechargeable Energy Storage System (RESS)'', and ''Revoke'' in alphabetical order.

■ f. Revising the definition of ''Supplemental FTP (SFTP)''.

■ g. Adding definitions of ''Suspend'', ''Tier 4'', and ''United States'' in alphabetical order.

■ h. Removing the definition of ''Useful life''.

■ i. Adding a definition of ''void'' in alphabetical order.

The revisions and additions read as follows:

### § 86.1803–01 Definitions.

* * * * *

*Banking* means the retention of emission credits by the manufacturer generating the emission credits, for use in future model year certification programs as permitted by regulation.

* * * * *

*Incomplete vehicle* has the meaning given in 40 CFR 1037.801.

* * * * *

*Light-duty program vehicle* means any medium-duty passenger vehicle and any vehicle subject to standards under this subpart that is not a heavy-duty vehicle. This definition generally applies only for model year 2027 and later vehicles.

*Light-duty truck* has one of the following meanings:

(1) Except as specified in paragraph (2) of this definition, *Light-duty truck* means any motor vehicle that is not a heavy-duty vehicle, but is:

(i) Designed primarily for purposes of transportation of property or is a derivation of such a vehicle; or

(ii) Designed primarily for transportation of persons and has a capacity of more than 12 persons; or

(iii) Available with special features enabling off-street or off-highway operation and use.

(2) For vehicles subject to Tier 4 standards, *Light-duty truck* has the meaning given for ''Light truck'' in 40 CFR 600.002.

* * * * *

*Medium-duty passenger vehicle (MDPV)* has one of the following meanings:

(1) Except as specified in paragraph (2) of this definition, *Medium-duty passenger vehicle* means any heavy-duty vehicle (as defined in this subpart) with a gross vehicle weight rating (GVWR) of less than 10,000 pounds that is designed primarily for the transportation of persons. The MDPV definition does not include any vehicle which:

(i) Is an ''incomplete truck'' as defined in this subpart; or

(ii) Has a seating capacity of more than 12 persons; or

(iii) Is designed for more than 9 persons in seating rearward of the driver's seat; or

(iv) Is equipped with an open cargo area (for example, a pick-up truck box or bed) of 72.0 inches in interior length or more. A covered box not readily accessible from the passenger compartment will be considered an open cargo area for purposes of this definition.

(2) Starting with model year 2027, or earlier at the manufacturer's discretion, *Medium-duty passenger vehicle* means any heavy-duty vehicle subject to standards under this subpart that is designed primarily for the transportation of persons, with seating rearward of the driver, except that the MDPV definition does not include any vehicle that

(i) Is an ''incomplete truck'' as defined in this subpart; or

(ii) Has a seating capacity of more than 12 persons; or

(iii) Is designed for more than 9 persons in seating rearward of the driver's seat; or

(iv) Is equipped with an open cargo area (for example, a pick-up truck box or bed) with an interior length of 72.0 inches or more for vehicles above 9,899 pounds GVWR with a work factor above 5,000 pounds. A covered box not readily accessible from the passenger compartment will be considered an open cargo area for purposes of this definition.

(v) Is equipped with an open cargo area of 94.0 inches in interior length or more for vehicles at or below 9,899 pounds GVWR and for vehicles with a work factor at or below 5,000 pounds.

*Medium-duty vehicle* means any heavy-duty vehicle subject to standards under this subpart, excluding medium-duty passenger vehicles. This definition generally applies only for model year 2027 and later vehicles.

* * * * *

*Normal operation* means any vehicle operating modes meeting all the following conditions:

(1) Any engine and vehicle settings that are within the physically adjustable range for any adjustable parameters.

(2) Any operator demand that is allowable for engine and vehicle calibrations that are available to the operator for vehicle operation within the manufacturer's specifications fuel and load (GVWR and GCWR).

(3) Any ambient conditions during any season for operation on public roads in the United States.

* * * * *

*Rechargeable Energy Storage System (RESS)* has the meaning given in 40 CFR 1065.1001. For electric vehicles and hybrid electric vehicles, this may also be referred to as a Rechargeable Electrical Energy Storage System.

* * * * *

*Revoke* has the meaning given in 40 CFR 1068.30.

* * * * *

*Supplemental FTP (SFTP)* means the test procedures designed to measure emissions during aggressive and microtransient driving over the US06 cycle and during driving while the vehicle's air conditioning system is operating over the SC03 cycle as described in § 86.1811–17.

*Suspend* has the meaning given in 40 CFR 1068.30.

* * * * *

*Tier 4* means relating to the Tier 4 emission standards described in §§ 86.1811–27. Note that a Tier 4 vehicle continues to be subject to Tier 3 evaporative emission standards.

* * * * *

*United States* has the meaning given in 40 CFR 1068.30.

* * * * *

*Void* has the meaning given in 40 CFR 1068.30.

* * * * *

### §§ 86.1805–04 and 86.1805–12 [Removed]

■ 28. Remove §§ 86.1805–04 and 86.1805–12.

■ 29. Amend § 86.1805–17 by revising paragraphs (c) and (d) and removing paragraph (f). The revisions read as follows:

**§ 86.1805–17 Useful life.**

* * * * *

(c) *Cold temperature emission standards.* The cold temperature NMHC emission standards in § 86.1811–17 apply for a useful life of 10 years or 120,000 miles for LDV and LLDT, and 11 years or 120,000 miles for HLDT and HDV. The cold temperature CO emission standards in § 86.1811 apply for a useful life of 5 years or 50,000 miles.

(d) *Criteria pollutants.* The useful life provisions of this paragraph (d) apply for all emission standards not covered by paragraph (b) or (c) of this section. This paragraph (d) applies for the cold temperature emission standards in § 86.1811–27(c). Except as specified in paragraph (f) of this section and in §§ 86.1811, 86.1813, and 86.1816, the useful life for LDT2, HLDT, MDPV, and HDV is 15 years or 150,000 miles. The useful life for LDV and LDT1 is 10 years or 120,000 miles. Manufacturers may optionally certify LDV and LDT1 to a useful life of 15 years or 150,000 miles, in which case the longer useful life would apply for all the standards and requirements covered by this paragraph (d).

* * * * *

**§ 86.1806–05 [Removed]**

■ 30. Remove § 86.1806–05.

■ 31. Amend § 86.1806–17 by revising paragraphs (b)(4)(ii) and (e) to read as follows:

**§ 86.1806–17 Onboard diagnostics.**

* * * * *

(b) * * *

(4) * * *

(ii) Design your vehicles to display information related to engine derating and other inducements in the cab as specified in 40 CFR 1036.110(c)(1).

* * * * *

(e) Onboard diagnostic requirements apply for alternative-fuel conversions as described in 40 CFR part 85, subpart F.

* * * * *

■ 32. Add § 86.1806–27 to read as follows:

**§ 86.1806–27 Onboard diagnostics.**

Model year 2027 and later vehicles must have onboard diagnostic (OBD) systems as described in this section. OBD systems must generally detect malfunctions in the emission control system, store trouble codes corresponding to detected malfunctions, and alert operators appropriately. Vehicles may optionally comply with the requirements of this section instead of the requirements of § 86.1806–17 before model year 2027.

(a) Vehicles must comply with the 2022 OBD requirements adopted for California as described in this paragraph (a). California's 2022 OBD–II requirements are part of Title 13, section 1968.2 of the California Code of Regulations, approved on November 22, 2022 (incorporated by reference, see § 86.1). We may approve your request to certify an OBD system meeting a later version of California's OBD requirements if you demonstrate that it complies with the intent of this section. The following clarifications and exceptions apply for vehicles certified under this subpart:

(1) For vehicles not certified in California, references to vehicles meeting certain California Air Resources Board emission standards are understood to refer to the corresponding EPA emission standards for a given family, where applicable. Use good engineering judgment to correlate the specified standards with the bin standards that apply under this subpart.

(2) Vehicles must comply with OBD requirements throughout the useful life as specified in § 86.1805. If the specified useful life is different for evaporative and exhaust emissions, the useful life specified for evaporative emissions applies for monitoring related to fuel-system leaks and the useful life specified for exhaust emissions applies for all other parameters.

(3) The purpose and applicability statements in 13 CCR 1968.2(a) and (b) do not apply.

(4) The anti-tampering provisions in 13 CCR 1968.2(d)(1.4) do not apply.

(5) The requirement to verify proper alignment between the camshaft and crankshaft described in 13 CCR 1968.2(e)(15.2.1)(C) applies only for vehicles equipped with variable valve timing.

(6) The deficiency provisions described in paragraph (c) of this section apply instead of 13 CCR 1968.2(k).

(7) [Reserved]

(8) Apply thresholds for exhaust emission malfunctions from Tier 4 vehicles based on the thresholds calculated for the corresponding bin standards in the California LEV III program as prescribed for the latest model year in 13 CCR 1968.2(d). For example, for Tier 4 Bin 10 standards, apply the threshold that applies for the LEV standards. For cases involving Tier 4 standards that have no corresponding bin standards from the California LEV III program, use the next highest LEV III bin. For example, for Tier 4 Bin 50 standards, apply the threshold that applies for the ULEV standards. You may apply thresholds that are more stringent than we require under this paragraph (a)(8).

(9) Apply thresholds as specified in 40 CFR 1036.110(b)(5) for engines certified to emission standards under 40 CFR part 1036.

(b) For vehicles with installed compression-ignition engines that are subject to standards and related requirements under 40 CFR 1036.104 and 1036.111, you must comply with the following additional requirements:

(1) Make parameters related to engine derating and other inducements available for reading with a generic scan tool as specified in 40 CFR 110(b)(9)(vi).

(2) Design your vehicles to display information related to engine derating and other inducements in the cab as specified in 40 CFR 1036.110(c)(1).

(c) You may ask us to accept as compliant a vehicle that does not fully meet specific requirements under this section. Such deficiencies are intended to allow for minor deviations from OBD standards under limited conditions. We expect vehicles to have functioning OBD systems that meet the objectives stated in this section. The following provisions apply regarding OBD system deficiencies:

(1) Except as specified in paragraph (d) of this section, we will not approve a deficiency that involves the complete lack of a major diagnostic monitor, such as monitors related to exhaust aftertreatment devices, oxygen sensors, air-fuel ratio sensors, $NO_X$ sensors, engine misfire, evaporative leaks, and diesel EGR (if applicable).

(2) We will approve a deficiency only if you show us that full compliance is infeasible or unreasonable considering any relevant factors, such as the technical feasibility of a given monitor, or the lead time and production cycles of vehicle designs and programmed computing upgrades.

(3) Our approval for a given deficiency applies only for a single model year, though you may continue to ask us to extend a deficiency approval in renewable one-year increments. We may approve an extension if you demonstrate an acceptable level of effort toward compliance and show that the necessary hardware or software modifications would pose an unreasonable burden.

(d) For alternative-fuel vehicles, manufacturers may request a waiver from specific requirements for which monitoring may not be reliable for operation with the alternative fuel. However, we will not waive requirements that we judge to be feasible for a particular manufacturer or vehicle model.

(e) OBD-related requirements for alternative-fuel conversions apply as described in 40 CFR part 85, subpart F.

(f) You may ask us to waive certain requirements in this section for emergency vehicles. We will approve your request for an appropriate duration if we determine that the OBD requirement in question could harm system performance in a way that would impair a vehicle's ability to perform its emergency functions.

(g) The following interim provisions describe an alternate implementation schedule for the requirements of this section in certain circumstances:

(1) Manufacturers may delay complying with all the requirements of this section, and instead meet all the requirements that apply under § 86.1806–17 for any vehicles above 6,000 pounds GVWR that are not yet subject to all the Tier 4 standards in § 86.1811.

(2) Except as specified in this paragraph (g)(2), small-volume manufacturers may delay complying with all the requirements of this section until model year 2030, and instead meet all the requirements that apply under § 86.1806–17 during those years.

(3) Manufacturers may disregard the requirements of this section that apply above 8,500 pounds GVWR before model year 2019 and instead meet all the requirements that apply under § 86.1806–05. This also applies for model year 2019 vehicles from a test group with vehicles that have a Job 1 date on or before March 3, 2018 (see 40 CFR 85.2304).

(h) Manufacturers must meet the following requirements to monitor PM filters installed on vehicles with spark-ignition engines:

(1) For vehicles that have hardware dedicated to active regeneration strategies, such as secondary air or fuel injection or burners in the exhaust stream, monitor those systems for proper performance. Meet requirements for comprehensive monitoring in 13 CCR 1968.2(e)(15) for injectors, valves, sensors, pumps, and other individual components associated with such active regeneration systems.

(2) Systems must detect malfunctions as follows:

(i) The system must detect a malfunction before filtering decreases to the point that PM emissions exceed 10 mg/mile over the FTP. If there is no failure or deterioration of the PM filter that could cause a vehicle to exceed the specified PM emission level, the system must detect a malfunction if the PM filter allows free flow of exhaust through the PM filter assembly where 30 percent or less of the normal filtration is occurring; this may occur if someone tampers with the PM filter assembly by damaging it or replacing it with a straight pipe or if the PM filter substrate degrades to allow exhaust gases to bypass the filter.

(ii) The system must detect a malfunction before PM filter regeneration frequency increases to the point that HC, CO, or $NO_X$ emissions exceed 1.5 times the applicable FTP standard. If there is no failure or deterioration that could cause a vehicle to exceed the specified emission level, the system must detect a malfunction when PM filter regeneration frequency exceeds the manufacturer's specified design limits for allowable regeneration frequency.

(iii) The system must detect a malfunction if regeneration does not properly restore the PM filter when regeneration is designed to occur based on the manufacturer's specified conditions.

(3) Manufacturers must define monitoring conditions for malfunctions under paragraph (h)(2) of this section in accordance with 13 CCR 1968.2(d)(3.1) and (d)(3.2), except that monitoring of malfunctions under paragraph (h)(2)(i) and (ii) of this section must occur every time the monitoring conditions are met during the driving cycle. The required minimum ratio for gasoline particulate filters is 0.150. Manufacturers must track and report the in-use performance of PM filter monitors in accordance with 13 CCR 1968.2(d)(3.2.2). Separately track all monitors detecting malfunctions and report malfunctions as a single set of values as specified in 13 CCR 1968.2(d)(5.2.1)(B), except that manufacturers may need to report malfunctions separately for vehicles using SAE J1979–2 as specified in 13 CCR 1968.2(d)(5.1.3) and (5.2.2).

(4) Manufacturers must meet general requirements for MIL illumination and fault code storage for all the malfunctions in paragraph (h)(2) of this section in accordance with 13 CCR 1968.2(d)(2).

### § 86.1807–01 [Amended]

■ 33. Amend § 86.1807–01 by removing and reserving paragraph (d).

### § 86.1808–01 [Amended]

■ 34. Amend § 86.1808–01 by removing and reserving paragraph (e).

### §§ 86.1809–01 and 86.1809–10 [Removed]

■ 35. Remove §§ 86.1809–01 and 86.1809–10.

■ 36. Revise § 86.1809–12 to read as follows:

### § 86.1809–12 Prohibition of defeat devices.

(a) No new vehicle shall be equipped with a defeat device.

(b) EPA may test or require testing on any vehicle at a designated location, using driving cycles and conditions that may reasonably be expected to be encountered in normal operation and use, for the purposes of investigating a potential defeat device.

(c) For cold temperature CO, NMHC, and NMOG+$NO_X$ emission control, EPA will use a guideline to determine the appropriateness of the CO emission control and the NMHC or NMOG+$NO_X$ emission control at ambient temperatures between 25 °F (the upper bound of the range for cold temperature testing) and 68 °F (the lower bound of the FTP test temperature range). The guideline for CO and NMOG+$NO_X$ emission congruity across the intermediate temperature range is the linear interpolation between the CO or NMOG+$NO_X$ standard applicable at 25 °F and the corresponding standard applicable at 68 °F. The guideline for NMHC emission congruity across the intermediate temperature range is the linear interpolation between the NMHC FEL pass limit (*e.g.,* 0.3499 g/mi for a 0.3 g/mi FEL) applicable at 20 °F and the Tier 2 NMOG standard or the Tier 3 or Tier 4 NMOG+$NO_X$ bin standard to which the vehicle was certified at 68 °F, where the intermediate temperature NMHC level is rounded to the nearest 0.01 g/mile for comparison to the interpolated line. The following provisions apply for vehicles that exceed the specified emission guideline during intermediate temperature testing:

(1) If the CO emission level is greater than the 20 °F emission standard, the vehicle will automatically be considered to be equipped with a defeat device without further investigation. If the intermediate temperature NMHC or NMOG+$NO_X$ emission level, rounded to the nearest 0.01 g/mile or the nearest 10 mg/mile, is greater than the 20 °F FEL pass limit, the vehicle will be presumed to have a defeat device unless the manufacturer provides evidence to EPA's satisfaction that the cause of the test result in question is not due to a defeat device.

(2) If the conditions in paragraph (c)(1) of this section do not apply, EPA may investigate the vehicle design for the presence of a defeat device under paragraph (d) of this section.

(d) The following provisions apply for vehicle designs EPA designates for investigation as possible defeat devices:

(1) The manufacturer must show to EPA's satisfaction that the vehicle design does not incorporate strategies that unnecessarily reduce emission

control effectiveness exhibited during the certification test procedures specified in this subpart, the fuel economy test procedures in 40 CFR part 600, or the air conditioning efficiency test in 40 CFR 1066.845, when the vehicle is operated under conditions that may reasonably be expected to be encountered in normal operation and use.

(2) EPA has determined that it is not necessary for spark-ignition engines that control air-fuel ratios at or near stoichiometry to use commanded enrichment to maintain power or to protect the engine or its aftertreatment components from damage. This determination is effective for all vehicles certified to Tier 4 standards. This paragraph (d)(2) does not apply for the following examples of commanded enrichment:

(i) Engine starting.

(ii) Catalyst rewetting after deceleration fuel cutoff.

(iii) Limp-home operation when the check engine light is on.

(iv) Intrusive OBD monitoring.

(3) The following information requirements apply:

(i) Upon request by EPA, the manufacturer must provide an explanation containing detailed information regarding test programs, engineering evaluations, design specifications, calibrations, on-board computer algorithms, and design strategies incorporated for operation both during and outside of the Federal emission test procedures.

(ii) For purposes of investigation of possible cold temperature CO, NMHC, or NMOG+$NO_X$ defeat devices under this paragraph (d), the manufacturer must provide an explanation to show to EPA's satisfaction that CO emissions and NMHC or NMOG+$NO_X$ emissions are reasonably controlled in reference to the linear guideline across the intermediate temperature range.

(e) For each test group the manufacturer must submit an engineering evaluation with the Part II certification application demonstrating to EPA's satisfaction that a discontinuity in emissions of non-methane organic gases, particulate matter, carbon monoxide, carbon dioxide, oxides of nitrogen, nitrous oxide, methane, and formaldehyde measured on the Federal Test Procedure (40 CFR 1066.801(c)(1)) and on the Highway Fuel Economy Test Procedure (40 CFR 1066.801(c)(5)) does not occur in the temperature range of 20 to 86 °F.

■ 37. Amend § 86.1810–17 by revising paragraphs (g) and (h)(1) to read as follows:

### § 86.1810–17 General requirements.

* * * * *

(g) The cold temperature standards in this subpart refer to test procedures set forth in subpart C of this part and 40 CFR part 1066, subpart H. All other emission standards in this subpart rely on test procedures set forth in subpart B of this part and 40 CFR part 1066, subpart H. These procedures rely on the test specifications in 40 CFR parts 1065 and 1066 as described in subparts B and C of this part.

(h) * * *

(1) For criteria exhaust emissions, we may identify the worst-case fuel blend for testing in addition to what is required for gasoline-fueled vehicles. The worst-case fuel blend may be the fuel specified in 40 CFR 1065.725, or it may consist of a combination of the fuels specified in 40 CFR 1065.710(b) and 1065.725. We may waive testing with the worst-case blended fuel for US06 and/or SC03 duty cycles; if we waive only SC03 testing for Tier 3 vehicles, substitute the SC03 emission result using the standard test fuel for gasoline-fueled vehicles to calculate composite SFTP emissions.

* * * * *

■ 38. Amend § 86.1811–17 by revising paragraphs (b)(8)(iii)(B), (d) introductory text, and (g)(2)(ii) to read as follows:

### § 86.1811–17 Exhaust emission standards for light-duty vehicles, light-duty trucks and medium-duty passenger vehicles.

* * * * *

(b) * * *

(8) * * *

(iii) * * *

(B) You may continue to use the E0 test fuel specified in § 86.113 as described in 40 CFR 600.117.

* * * * *

(d) *Special provisions for Otto-cycle engines.* The following special provisions apply for vehicles with Otto-cycle engines:

* * * * *

(g) * * *

(2) * * *

(ii) The manufacturer must calculate its fleet average cold temperature NMHC emission level(s) as described in § 86.1864–10(b).

* * * * *

■ 39. Add § 86.1811–27 to read as follows:

### § 86.1811–27 Criteria exhaust emission standards.

(a) *Applicability and general provisions.* This section describes criteria exhaust emission standards that apply for model year 2027 and later vehicles.

(1) A vehicle meeting all the requirements of this section is considered a Tier 4 vehicle meeting the Tier 4 standards.

(2) See § 86.1813 for evaporative and refueling emission standards.

(3) See § 86.1818 for greenhouse gas emission standards.

(b) *Exhaust emission standards over bin driving cycles.* Exhaust emissions may not exceed standards over bin driving cycles, as follows:

(1) Measure emissions using the chassis dynamometer procedures of 40 CFR part 1066, as follows:

(i) Establish appropriate load settings based on loaded vehicle weight for light-duty program vehicles and adjusted loaded vehicle weight for medium-duty vehicles (see § 86.1803).

(ii) Emission standards under this paragraph (b) apply for all the following driving cycles unless otherwise specified:

| The driving cycle . . . | is identified in . . . |
|---|---|
| (A) FTP | 40 CFR 1066.801(c)(1). |
| (B) US06 | 40 CFR 1066.801(c)(2). |
| (C) SC03 | 40 CFR 1066.801(c)(3). |
| (D) HFET | 40 CFR 1066.801(c)(5). |
| (E) ACC II—Mid-temperature intermediate soak | 40 CFR 1066.801(c)(8). |
| (F) ACC II—Early driveaway | 40 CFR 1066.801(c)(9). |
| (G) ACC II High-load PHEV engine starts | 40 CFR 1066.801(c)(10). |

(iii) Hydrocarbon emission standards are expressed as NMOG; however, for certain vehicles you may measure exhaust emissions based on nonmethane hydrocarbon instead of NMOG as described in 40 CFR 1066.635.

(iv) Measure emissions from hybrid electric vehicles (including plug-in hybrid electric vehicles) as described in 40 CFR part 1066, subpart F, except that these procedures do not apply for plug-in hybrid electric vehicles during charge-depleting operation.

(2) Fully phased-in standards apply as specified in the following table:

TABLE 1 TO PARAGRAPH (b)(2)—FULLY PHASED-IN TIER 4 CRITERIA EXHAUST EMISSION STANDARDS

| | NMOG+NO$_X$ (mg/mile) [a] | PM (mg/mile) [b] | CO (g/mile) [c] | Formaldehyde (mg/mile) [d] |
|---|---|---|---|---|
| Light-duty program vehicles | 12 | 0.5 | 1.7 | 4 |
| Medium-duty vehicles | 60 | 0.5 | 3.2 | 6 |

[a] The NMOG+NO$_X$ standards apply on a fleet-average basis using discrete bin standards as described in paragraphs (b)(4) and (6) of this section. The specified fleet-average standards apply for model year 2032 and later vehicles; see paragraph (b)(6) of this section for fleet-average NMOG+NO$_X$ standards that apply for model years 2027 through 2031.

[b] PM standards under this paragraph (b) apply only for the FTP and US06 driving cycles.

[c] CO standards do not apply for the ACC II driving cycles specified in paragraph (b)(1)(ii)(E) through (G) of this section.

[d] Formaldehyde standards apply only for the FTP driving cycle.

(3) The FTP standards specified in this paragraph (b) apply equally for testing at low-altitude conditions and high-altitude conditions. The US06, SC03, and HFET standards apply only for testing at low-altitude conditions.

(4) The NMOG + NO$_X$ emission standard is based on a fleet average for a given model year.

(i) You must specify a family emission limit (FEL) for each test group based on the FTP emission standard corresponding to each named bin. The FEL serves as the emission standard for the test group with respect to all specified driving cycles. Calculate your fleet-average emission level as described in § 86.1860 to show that you meet the specified fleet-average standard. For multi-fueled vehicles, calculate fleet-average emission levels based only on emission levels for testing with gasoline or diesel fuel. You may generate emission credits for banking and trading, and you may use banked or traded credits as described in § 86.1861 for demonstrating compliance with the NMOG + NO$_X$ fleet-average emission standard. You comply with the fleet-average emission standard for a given model year if you have enough credits to show that your fleet-average emission level is at or below the applicable standard.

(ii) Select one of the identified values from table 2 of this section for demonstrating that your fleet-average emission level complies with the NMOG+NO$_X$ fleet-average emission standard. These FEL values define emission bins that also determine corresponding emission standards for NMOG+NO$_X$ emission standards for ACC II driving cycles, as follows:

TABLE 2 TO PARAGRAPH (b)(4)(ii)—TIER 4 NMOG+NO$_X$ BIN STANDARDS

[mg/mile]

| FEL name | FTP, US06, SC03, HFET | ACC II—Mid-temperature intermediate soak (3–12 hours) | ACC II—Mid-temperature intermediate soak (40 minutes) [a] | ACC II—Mid-temperature intermediate soak (10 minutes) | ACC II—Early driveaway [b] | ACC II—High-power PHEV engine starts [b c] |
|---|---|---|---|---|---|---|
| Bin 160 [d] | 160 | | | | | |
| Bin 125 [d] | 125 | | | | | |
| Bin 70 | 70 | 70 | 54 | 35 | 82 | 200 |
| Bin 60 | 60 | 60 | 46 | 30 | 72 | 175 |
| Bin 50 | 50 | 50 | 38 | 25 | 62 | 150 |
| Bin 40 | 40 | 40 | 31 | 20 | 52 | 125 |
| Bin 30 | 30 | 30 | 23 | 15 | 42 | 100 |
| Bin 20 | 20 | 20 | 15 | 10 | 32 | 67 |
| Bin 10 | 10 | 10 | 8 | 5 | 22 | 34 |
| Bin 0 | 0 | 0 | 0 | 0 | 0 | |

[a] Calculate the bin standard for a soak time between 10 and 40 minutes based on a linear interpolation between the corresponding bin values for a 10-minute soak and a 40-minute soak. Similarly, calculate the bin standard for a soak time between 40 minutes and 3 hours based on a linear interpolation between the corresponding bin values for a 40-minute soak and a 3-hour soak.

[b] Qualifying vehicles are exempt from standards for early driveaway and high-power PHEV engine starts as described in paragraph (b)(5) of this section.

[c] Alternative standards apply for high-power PHEV engine starts for model years 2027 and 2028 as described in paragraph (b)(6)(v) of this section.

[d] Bin 160 and Bin 125 apply only for medium-duty vehicles.

(5) Qualifying vehicles are exempt from certain ACC II bin standards as follows:

(i) Vehicles are exempt from the ACC II bin standards for early driveaway if the vehicle prevents engine starting during the first 20 seconds of a cold-start FTP test interval and the vehicle does not use an electrically heated catalyst or other technology to precondition the engine or emission controls such that NMOG+NO$_X$ emissions would be higher during the first 505 seconds of the early driveaway driving cycle compared to the first 505 seconds of the conventional FTP driving cycle.

(ii) Vehicles are exempt from the ACC II bin standards for high-power PHEV engine starts if their all-electric range on the cold-start US06 driving cycles is at or above 10 miles for model years 2027 and 2028, and at or above 40 miles for model year 2029 and later.

(6) The Tier 4 standards phase in over several years, as follows:

(i) *NMOG+NO$_X$ fleet average standards for light-duty program vehicles.* Include all light-duty program vehicles at or below 6,000 pounds GVWR in the calculation to comply with the Tier 4 fleet average NMOG+NO$_X$ standard. You must meet all the other Tier 4 requirements with 40 and 80 percent of your projected nationwide sales in model years 2027 and 2028, respectively. A vehicle counts toward meeting the phase-in percentage only if it meets all the requirements of this section. NMOG+NO$_X$ fleet average standards apply as follows for model year 2027 through 2031 light-duty program vehicles:

TABLE 3 TO PARAGRAPH (b)(6)(i)—DECLINING FLEET AVERAGE NMOG+NO$_X$ STANDARDS FOR LIGHT-DUTY PROGRAM VEHICLES

| Model year | Fleet average NMOG+NO$_X$ standard (mg/mile) |
|---|---|
| 2027 | 22 |
| 2028 | 20 |
| 2029 | 18 |
| 2030 | 16 |
| 2031 | 14 |

(ii) *Default phase-in for vehicles above 6,000 pounds GVWR.* The default approach for phasing in the Tier 4 standards for vehicle above 6,000 pounds GVWR is for all those vehicles to meet the Tier 4 standards of this section starting in model year 2030. Manufacturers using this default phase-in for medium-duty vehicles may not use credits generated from Tier 3 medium-duty vehicles for demonstrating compliance with the Tier 4 NMOG+NO$_X$ standards under this paragraph (b).

(iii) *Alternative early phase-in for vehicles above 6,000 pounds GVWR.* Manufacturers may use the following alternative early phase-in provisions to transition to the Tier 4 exhaust emission standards on an earlier schedule for vehicles above 6,000 pounds GVWR.

(A) If you select the alternative early phase-in for light-duty program vehicles above 6,000 pounds GVWR, you must demonstrate that you meet the phase-in requirements in paragraph (b)(6)(i) of this section based on all your light-duty program vehicles.

(B) If you select the alternative early phase-in for medium-duty vehicles, include all medium-duty vehicles at or below 22,000 pounds GCWR in the calculation to comply with the Tier 4 fleet average NMOG+NO$_X$ standard. You must meet all the other Tier 4 requirements with 40 and 80 percent of a manufacturer's projected nationwide sales in model years 2027 and 2028, respectively. A vehicle counts toward meeting the phase-in percentage only if it meets all the requirements of this section. Medium-duty vehicles complying with the alternative early phase-in are subject to the following NMOG+NO$_X$ fleet-average standards for model years 2027 through 2031:

TABLE 4 TO PARAGRAPH (b)(6)(iii)(B)—DECLINING FLEET AVERAGE NMOG+NO$_X$ STANDARDS FOR MEDIUM-DUTY VEHICLES

| Model year | Fleet average NMOG+NO$_X$ standard (mg/mile) |
|---|---|
| 2027 | 160 |
| 2028 | 140 |
| 2029 | 120 |
| 2030 | 100 |
| 2031 | 80 |

(iv) *Interim Tier 4 vehicles.* Vehicles not meeting all the requirements of this section during the phase-in are considered ''interim Tier 4 vehicles''. Interim Tier 4 vehicles are subject to all the requirements of this subpart that apply for Tier 3 vehicles except for the fleet average NMOG+NO$_X$ standards in §§ 86.1811–17 and 86.1816–18. Interim Tier 4 vehicles may certify using all available NMOG+NO$_X$ bins under §§ 86.1811–17 and 86.1816–18. Note that manufacturers complying with the default phase-in specified in paragraph (b)(6)(ii) of this section for vehicles above 6,000 pounds GVWR will need to meet a Tier 3 fleet average NMOG+NO$_X$ standard in model years 2027 through 2029, in addition to the Tier 4 fleet average for vehicles at or below 6,000 pounds GVWR in those same years.

(v) *Phase-in for high-power PHEV engine starts.* The following bin standards apply for high-power PHEV engine starts in model years 2027 and 2028 instead of the analogous standards specified in paragraph (b)(4)(ii) of this section:

TABLE 5 TO PARAGRAPH (b)(6)(v)—MODEL YEAR 2027 AND 2028 BIN STANDARDS FOR HIGH-POWER PHEV ENGINE STARTS

| FEL name | ACC II—High-power PHEV engine starts (mg/mile) |
|---|---|
| Bin 70 | 320 |
| Bin 60 | 280 |
| Bin 50 | 240 |
| Bin 40 | 200 |
| Bin 30 | 150 |
| Bin 20 | 100 |
| Bin 10 | 50 |

(vi) *MDPV.* Any vehicle that becomes an MDPV as a result of the revised definition in § 86.1803 starting in model 2027 remains subject to the heavy-duty Tier 3 standards in § 86.1816–18 under the default phase-in specified in paragraph (b)(6)(ii) of this section for model years 2027 through 2029.

(vii) Keep records as needed to show that you meet the requirements specified in this paragraph (b) for phasing in standards and for complying with declining fleet-average average standards.

(c) *Exhaust emission standards for cold temperature testing.* Exhaust emissions may not exceed standards for cold temperature testing, as follows:

(1) Measure emissions as described in paragraph (b)(1) of this section, but use the driving cycle identified in 40 CFR 1066.801(c)(5).

(2) The standards apply to gasoline-fueled and diesel-fueled vehicles, except as specified. Multi-fuel, bi-fuel or dual-fuel vehicles must comply with requirements using only gasoline and diesel fuel, as applicable. Testing with other fuels such as a high-level ethanol-gasoline blend is not required.

(3) Vehicles must meet the following standards:

(i) The NMOG+NO$_X$ fleet-average standard is a 300 mg/mile. Calculate fleet-average emission levels as described in § 86.1864.

(ii) The PM standard is 0.5 mg/mile.

(iii) The CO standard is 10.0 g/mile.

(4) The CO standard applies at both low-altitude and high-altitude conditions. The NMOG+NO$_X$ and PM standards apply only at low-altitude conditions. However, manufacturers must submit an engineering evaluation indicating that common calibration approaches are utilized at high altitudes. Any deviation from low altitude emission control practices must be included in the auxiliary emission control device (AECD) descriptions submitted at certification. Any AECD

specific to high altitude must require engineering emission data for EPA evaluation to quantify any emission impact and validity of the AECD.

(d) *Special provisions for spark-ignition engines.* The following A/C-on specific calibration provisions apply for vehicles with spark-ignition engines:

(1) A/C-on specific calibrations (*e.g.,* air-fuel ratio, spark timing, and exhaust gas recirculation) that differ from A/C-off calibrations may be used for a given set of engine operating conditions (*e.g.,* engine speed, manifold pressure, coolant temperature, air charge temperature, and any other parameters). Such calibrations must not unnecessarily reduce emission control effectiveness during A/C-on operation when the vehicle is operated under conditions that may reasonably be expected during normal operation and use. If emission control effectiveness decreases as a result of such calibrations, the manufacturer must describe in the Application for Certification the circumstances under which this occurs and the reason for using these calibrations.

(2) For AECDs involving commanded enrichment, these AECDs must not operate differently for A/C-on operation than for A/C-off operation. This includes both the sensor inputs for triggering enrichment and the degree of enrichment employed.

■ 40. Amend § 86.1813–17 by revising paragraphs (a)(2)(i) introductory text, (b)(1)(i), and (g)(2)(ii)(B) to read as follows:

### § 86.1813–17 Evaporative and refueling emission standards.

* * * * *

(a) * * *

(2) * * *

(i) The emission standard for the sum of diurnal and hot soak measurements from the two-diurnal test sequence and the three-diurnal test sequence is based on a fleet average in a given model year. You must specify a family emission limit (FEL) for each evaporative family. The FEL serves as the emission standard for the evaporative family with respect to all required diurnal and hot soak testing. Calculate your fleet-average emission level as described in § 86.1860 based on the FEL that applies for low-altitude testing to show that you meet the specified standard. For multi-fueled vehicles, calculate fleet-average emission levels based only on emission levels for testing with gasoline. You may generate emission credits for banking and trading, and you may use banked or traded credits for demonstrating compliance with the diurnal plus hot soak emission standard for vehicles required to meet the Tier 3 standards, other than gaseous-fueled or electric vehicles, as described in § 86.1861 starting in model year 2017. You comply with the emission standard for a given model year if you have enough credits to show that your fleet-average emission level is at or below the applicable standard. You may exchange credits between or among evaporative families within an averaging set as described in § 86.1861. Separate diurnal plus hot soak emission standards apply for each evaporative/refueling emission family as shown for high-altitude conditions. The sum of diurnal and hot soak measurements may not exceed the following Tier 3 standards:

* * * * *

(b) * * *

(1) * * *

(i) Refueling standards apply starting with model year 2027 for incomplete vehicles certified under 40 CFR part 1037 and in model year 2030 for incomplete vehicles certified under this subpart, unless the manufacturer complies with the alternate phase-in specified in paragraph (b)(1)(iii) of this section. If you do not meet the alternative phase-in requirement for model year 2026, you must certify all your incomplete heavy-duty vehicles above 14,000 pounds GVWR to the refueling standard in model year 2027.

(ii) Refueling standards are optional for incomplete heavy-duty vehicles at or below 14,000 pounds GVWR through model year 2029, unless the manufacturer uses the alternate phase-in specified in paragraph (b)(1)(iii) of this section to meet standards together for heavy-duty vehicles above and below 14,000 pounds GVWR.

* * * * *

(g) * * *

(2) * * *

(ii) * * *

(B) All the vehicles meeting the leak standard must also meet the Tier 3 evaporative emission standards. Through model year 2026, all vehicles meeting the leak standard must also meet the OBD requirements in § 86.1806–17(b)(1).

* * * * *

■ 41. Add § 86.1815 to read as follows:

### § 86.1815 Battery-related requirements for electric vehicles and plug-in hybrid electric vehicles.

Electric vehicles and plug-in hybrid electric vehicles must meet requirements related to batteries serving as a Rechargeable Energy Storage System from GTR No. 22 (incorporated by reference, see § 86.1). The requirements of this section apply starting in model year 2027 for vehicles at or below 6,000 pounds GVWR. These requirements apply vehicles above 6,000 pounds GVWR if they are certified to Tier 4 NMOG+$NO_X$ standards under § 86.1811–27, not later than model year 2030. The following clarifications and adjustments to GTR No. 22 apply for vehicles subject to this section:

(a) Manufacturers must install a customer-accessible display that monitors, estimates, and communicates the vehicle's State of Certified Energy (SOCE) and include information in the application for certification as described in § 86.1844. Manufacturers that qualify as small businesses under § 86.1801–12(j)(1) must meet the requirements of this paragraph (a) but are not subject to the requirements in paragraphs (c) through (g) of this section; however, small businesses may trade credits they generate from electric vehicles and plug-in hybrid electric vehicles for a given model year only if they meet requirements in paragraphs (c) through (g) of this section.

(b) Requirements in GTR No. 22 related to State of Certified Range do not apply.

(c) Evaluate SOCE for electric vehicles based on measured Useable Battery Energy (UBE) values over the Multi-Cycle Range and Energy Consumption Test described in 40 CFR 600.116–12(a). For medium-duty vehicles, perform testing with test weight set to Adjusted Loaded Vehicle Weight. Use good engineering judgment to evaluate SOCE for plug-in hybrid electric vehicles using the procedures specified in 40 CFR 600.116–12.

(d) In-use vehicles must display SOCE values that are accurate within 5 percent of measured values as calculated in GTR No. 22.

(e) Batteries installed in light-duty program vehicles must meet a Minimum Performance Requirement such that measured usable battery energy is at least 80 percent of the vehicle's certified usable battery energy after 5 years or 62,000 miles, and at least 70 percent of certified usable battery energy at 8 years or 100,000 miles.

(f) Manufacturers must perform testing and submit reports as follows:

(1) Perform Part A testing to verify that SOCE monitors meet accuracy requirements as described in § 86.1845. Test the number of vehicles and determine a pass or fail result as specified in Section 6.3 of GTR No. 22.

(2) Perform Part B verification for each battery durability family included in a monitor family subject to Part A testing to verify that batteries have SOCE meeting the Minimum Performance Requirement. Determine

performance by reading SOCE monitors with a physical inspection, remote inspection using wireless technology, or any other appropriate means.

(i) Randomly select test vehicles from at least 10 different U.S. states or territories, with no more than 20 percent of selected vehicles coming from any one state or territory. Select vehicles to represent a wide range of climate conditions and operating characteristics.

(ii) Select at least 500 test vehicles per year from each battery durability family, except that we may approve your request to select fewer vehicles for a given battery durability family based on limited production volumes. If you test fewer than 500 vehicles, you may exclude up to 5 percent of the tested vehicles to account for the limited sample size. Test vehicles may be included from year to year, or test vehicles may change over the course of testing for the battery durability family.

(iii) A battery durability family passes if 90 percent or more of sampled vehicles have reported values above the Minimum Performance Requirement.

(iv) Continue testing for eight years after the end of production for vehicles included in the battery durability family. Note that testing will typically require separate testing from multiple model years in a given calendar year.

(3) You may request our approval to group monitors and batteries differently, or to adjust testing specifications. Submit your request with your proposed alternative specifications, along with technical justification. In the case of broadening the scope of a monitor family, include data demonstrating that differences within the proposed monitor family do not cause error in estimating SOCE.

(4) Submit electronic reports to document the results of testing as described in § 86.1847.

(g) If vehicles do not comply with monitor accuracy requirements under this section, the recall provisions in 40 CFR part 85, subpart S, apply for each affected monitor family. If vehicles do not comply with battery durability requirements under this section, the manufacturer must adjust all credit balances to account for the nonconformity (see § 86.1850–01).

■ 42. Amend § 86.1818–18 by revising paragraph (a) introductory text to read as follows:

### § 86.1816–18 Emission standards for heavy-duty vehicles.

(a) *Applicability and general provisions.* This section describes Tier 3 exhaust emission standards for complete heavy-duty vehicles. These standards are optional for incomplete heavy-duty vehicles and for heavy-duty vehicles above 14,000 pounds GVWR as described in § 86.1801. Greenhouse gas emission standards are specified in § 86.1818 for MDPV and in § 86.1819 for other HDV. See § 86.1813 for evaporative and refueling emission standards. This section starts to apply in model year 2018, except that the provisions may apply to vehicles before model year 2018 as specified in paragraph (b)(11) of this section. This section applies for model year 2027 and later vehicles only as specified in § 86.1811–27. Separate requirements apply for MDPV as specified in § 86.1811. See subpart A of this part for requirements that apply for incomplete heavy-duty vehicles and for heavy-duty engines certified independent of the chassis. The following general provisions apply:

* * * * *

### §§ 86.1817–05 and 86.1817–08 [Removed]

■ 43. Remove §§ 86.1817–05 and 86.1817–08.

■ 44. Amend § 86.1818–12 by:

■ a. Revising paragraphs (a)(1), (b) introductory text, and (c).

■ b. Removing and reserving paragraph (e).

■ c. Revising paragraphs (f) introductory text, (g) introductory text, (g)(1) introductory text, (g)(2) introductory text, (g)(4)(i)(B), (g)(4)(iv)(B), (g)(5) and (6), and (h).

The revisions read as follows:

### § 86.1818–12 Greenhouse gas emission standards for light-duty vehicles, light-duty trucks, and medium-duty passenger vehicles.

(a) * * *

(1) The greenhouse gas standards and related requirements in this section apply to 2012 and later model year LDV, LDT, and MDPV, including multi-fuel vehicles, vehicles fueled with alternative fuels, hybrid electric vehicles, plug-in hybrid electric vehicles, electric vehicles, and fuel cell vehicles. Unless otherwise specified, multi-fuel vehicles must comply with all requirements established for each consumed fuel. Manufacturers that qualify as a small business according to the requirements of § 86.1801–12(j) are exempt from the emission standards in this section.

* * * * *

(b) *Definitions.* The following definitions apply for this section:

* * * * *

(c) *Fleet average $CO_2$ standards.* Fleet average $CO_2$ standards apply as follows for passenger automobiles and light trucks:

(1) Each manufacturer must comply with separate fleet average $CO_2$ standards for passenger automobiles and light trucks. To calculate the fleet average $CO_2$ standards for passenger automobiles for a given model year, multiply each $CO_2$ target value by the production volume of passenger automobiles for the corresponding model type-footprint combination, then sum those products and divide the sum by the total production volume of passenger automobiles in that model year. Repeat this calculation using production volumes of light trucks to determine the separate fleet average $CO_2$ standards for light trucks. Round the resulting fleet average $CO_2$ emission standards to the nearest whole gram per mile. Averaging calculations and other compliance provisions apply as described in § 86.1865.

(2) A $CO_2$ target value applies for each unique combination of model type and footprint. The $CO_2$ target serves as the emission standard that applies throughout the useful life for each vehicle. Determine the $CO_2$ target values from the following table, or from paragraph (h) of this section for model year 2031 and earlier vehicles:

TABLE 1 TO PARAGRAPH (c)(2)—FOOTPRINT-BASED $CO_2$ TARGET VALUES

| Vehicle type | Footprint cutpoints ($ft^2$) | | $CO_2$ target value (g/mile) | | |
|---|---|---|---|---|---|
| | Low | High | Below low cutpoint | Between cutpoints [a] | Above high cutpoint |
| Passenger automobile | 45 | 56 | 71.8 | $0.35 \times f + 56.2$ | 75.6 |
| Light truck | 45 | 70.0 | 75.7 | $1.38 \times f + 13.8$ | 110.1 |

[a] Calculate the $CO_2$ target value for vehicles between the footprint cutpoints as shown, using vehicle footprint, *f*, and rounding the result to the nearest 0.1 g/mile.

* * * * *

(f) *Nitrous oxide ($N_2O$) and methane ($CH_4$) exhaust emission standards for passenger automobiles and light trucks.* Each manufacturer's fleet of combined passenger automobiles and light trucks must comply with $N_2O$ and $CH_4$ standards using either the provisions of paragraph (f)(1), (2), or (3) of this section. Except with prior EPA approval, a manufacturer may not use the provisions of both paragraphs (f)(1) and (2) of this section in a model year. For example, a manufacturer may not use the provisions of paragraph (f)(1) of this section for their passenger automobile fleet and the provisions of paragraph (f)(2) for their light truck fleet in the same model year. The manufacturer may use the provisions of both paragraphs (f)(1) and (3) of this section in a model year. For example, a manufacturer may meet the $N_2O$ standard in paragraph (f)(1)(i) of this section and an alternative $CH_4$ standard determined under paragraph (f)(3) of this section.

* * * * *

(g) *Alternative fleet average standards for manufacturers with limited sales.* Manufacturers meeting the criteria in this paragraph (g) may request alternative fleet average $CO_2$ standards for model year 2031 and earlier vehicles.

(1) *Eligibility for alternative standards.* Eligibility as determined in this paragraph (g) shall be based on the total nationwide sales of combined passenger automobiles and light trucks. The terms ''sales'' and ''sold'' as used in this paragraph (g) shall mean vehicles produced for sale in the states and territories of the United States. For the purpose of determining eligibility the sales of related companies shall be aggregated according to the provisions of § 86.1838–01(b)(3), or, if a manufacturer has been granted operational independence status under § 86.1838–01(d), eligibility shall be based on that manufacturer's vehicle sales. To be eligible for alternative standards established under this paragraph (g), the manufacturer's average sales for the three most recent consecutive model years must remain below 5,000. If a manufacturer's average sales for the three most recent consecutive model years exceeds 4999, the manufacturer will no longer be eligible for exemption and must meet applicable emission standards starting with the model year according to the provisions in this paragraph (g)(1).

* * * * *

(2) *Requirements for new entrants into the U.S. market.* New entrants are those manufacturers without a prior record of automobile sales in the United States and without prior certification to greenhouse gas emission standards in § 86.1818–12. In addition to the eligibility requirements stated in paragraph (g)(1) of this section, new entrants must meet the following requirements:

* * * * *

(4) * * *

(i) * * *

(B) Vehicle models and projections of sales volumes for each model year.

* * * * *

(iv) * * *

(B) Information regarding ownership relationships with other manufacturers, including details regarding the application of the provisions of § 86.1838–01(b)(3) regarding the aggregation of sales of related companies.

(5) *Alternative standards.* Alternative standards apply as follows:

(i) Where EPA has exercised its regulatory authority to administratively specify alternative standards, those alternative standards approved for model year 2021 continue to apply through model year 2024. Starting in model year 2025, manufacturers must certify to the standards in paragraph (h) of this section on a delayed schedule, as follows:

| In model year . . . | Manufacturers must certify to the standards that would otherwise apply in . . . |
|---|---|
| (A) 2025 | 2023 |
| (B) 2026 | 2023 |
| (C) 2027 | 2025 |
| (D) 2028 | 2025 |
| (E) 2029 | 2027 |
| (F) 2030 | 2028 |
| (G) 2031 | 2030 |

(ii) EPA may approve a request from other manufacturers for alternative fleet average $CO_2$ standards under this paragraph (g). The alternative standards for those manufacturers will apply by model year as specified in paragraph (g)(5)(i) of this section.

(6) *Restrictions on credit trading.* Manufacturers subject to alternative standards approved by the Administrator under this paragraph (g) may not trade credits to another manufacturer. Transfers between car and truck fleets within the manufacturer are allowed, and the carry-forward provisions for credits and deficits apply. Manufacturers may generate credits in a given model year for trading to another manufacturer by certifying to the standards in paragraph (h) of this section for the current model year across the manufacturer's full product line. A manufacturer certifying to the standards in paragraph (h) of this section will no longer be eligible to certify to the alternative standards under this paragraph (g) in later model years.

(7) Starting in model year 2032, all manufacturers must certify to the standards in paragraph (c) of this section.

(h) *Historical and interim standards.* The following $CO_2$ target values apply for model year 2031 and earlier vehicles:

(1) $CO_2$ target values apply as follows for passenger automobiles:

TABLE 2 TO PARAGRAPH (h)(1)—HISTORICAL AND INTERIM $CO_2$ TARGET VALUES FOR PASSENGER AUTOMOBILES

| Model year | Footprint cutpoints ($ft^2$) | | $CO_2$ target value (g/mile) | | |
|---|---|---|---|---|---|
| | Low | High | Below low cutpoint | Between cutpoints [a] | Above high cutpoint |
| 2012 | 41 | 56 | 244.0 | $4.72 \times f + 50.5$ | 315.0 |
| 2013 | 41 | 56 | 237.0 | $4.72 \times f + 43.3$ | 307.0 |
| 2014 | 41 | 56 | 228.0 | $4.72 \times f + 34.8$ | 299.0 |
| 2015 | 41 | 56 | 217.0 | $4.72 \times f + 23.4$ | 288.0 |
| 2016 | 41 | 56 | 206.0 | $4.72 \times f + 12.7$ | 277.0 |
| 2017 | 41 | 56 | 195.0 | $4.53 \times f + 8.9$ | 263.0 |
| 2018 | 41 | 56 | 185.0 | $4.35 \times f + 6.5$ | 250.0 |
| 2019 | 41 | 56 | 175.0 | $4.17 \times f + 4.2$ | 238.0 |
| 2020 | 41 | 56 | 166.0 | $4.01 \times f + 1.9$ | 226.0 |
| 2021 | 41 | 56 | 161.8 | $3.94 \times f + 0.2$ | 220.9 |

TABLE 2 TO PARAGRAPH (h)(1)—HISTORICAL AND INTERIM $CO_2$ TARGET VALUES FOR PASSENGER AUTOMOBILES—Continued

| Model year | Footprint cutpoints ($ft^2$) | | $CO_2$ target value (g/mile) | | |
|---|---|---|---|---|---|
| | Low | High | Below low cutpoint | Between cutpoints [a] | Above high cutpoint |
| 2022 | 41 | 56 | 159.0 | $3.88 \times f - 0.1$ | 217.3 |
| 2023 | 41 | 56 | 145.6 | $3.56 \times f - 0.4$ | 199.1 |
| 2024 | 41 | 56 | 138.6 | $3.39 \times f - 0.4$ | 189.5 |
| 2025 | 41 | 56 | 130.5 | $3.26 \times f - 3.2$ | 179.4 |
| 2026 | 41 | 56 | 114.3 | $3.11 \times f - 13.1$ | 160.9 |
| 2027 | 42 | 56 | 130.9 | $0.64 \times f + 104.0$ | 139.8 |
| 2028 | 43 | 56 | 114.1 | $0.56 \times f + 90.2$ | 121.3 |
| 2029 | 44 | 56 | 96.9 | $0.47 \times f + 76.3$ | 102.5 |
| 2030 | 45 | 56 | 89.5 | $0.43 \times f + 70.1$ | 94.2 |
| 2031 | 45 | 56 | 81.2 | $0.39 \times f + 63.6$ | 85.5 |

[a] Calculate the $CO_2$ target value for vehicles between the footprint cutpoints as shown, using vehicle footprint, *f,* and rounding the result to the nearest 0.1 g/mile.

(2) $CO_2$ target values apply as follows for light trucks:

TABLE 3 TO PARAGRAPH (h)(2)—HISTORICAL AND INTERIM $CO_2$ TARGET VALUES FOR LIGHT TRUCKS

| Model year | Footprint cutpoints ($ft^2$) | | $CO_2$ target value (g/mile) | | |
|---|---|---|---|---|---|
| | Low | High | Below low cutpoint | Between cutpoints [a] | Above high cutpoint |
| 2012 | 41 | 66.0 | 294.0 | $4.04 \times f + 128.6$ | 395.0 |
| 2013 | 41 | 66.0 | 284.0 | $4.04 \times f + 118.7$ | 385.0 |
| 2014 | 41 | 66.0 | 275.0 | $4.04 \times f + 109.4$ | 376.0 |
| 2015 | 41 | 66.0 | 261.0 | $4.04 \times f + 95.1$ | 362.0 |
| 2016 | 41 | 66.0 | 247.0 | $4.04 \times f + 81.1$ | 348.0 |
| 2017 | 41 | 50.7 | 238.0 | $4.87 \times f + 38.3$ | ...................... |
| 2017 | 50.8 | 66.0 | ...................... | $4.04 \times f + 80.5$ | 347.0 |
| 2018 | 41 | 60.2 | 227.0 | $4.76 \times f + 31.6$ | ...................... |
| 2018 | 60.3 | 66.0 | ...................... | $4.04 \times f + 75.0$ | 342.0 |
| 2019 | 41 | 66.4 | 220.0 | $4.68 \times f + 27.7$ | 339.0 |
| 2020 | 41 | 68.3 | 212.0 | $4.57 \times f + 24.6$ | 337.0 |
| 2021 | 41 | 68.3 | 206.5 | $4.51 \times f + 21.5$ | 329.4 |
| 2022 | 41 | 68.3 | 203.0 | $4.44 \times f + 20.6$ | 324.1 |
| 2023 | 41 | 74.0 | 181.1 | $3.97 \times f + 18.4$ | 312.1 |
| 2024 | 41 | 74.0 | 172.1 | $3.77 \times f + 17.4$ | 296.5 |
| 2025 | 41 | 74.0 | 159.3 | $3.58 \times f + 12.5$ | 277.4 |
| 2026 | 41 | 74.0 | 141.8 | $3.41 \times f + 1.9$ | 254.4 |
| 2027 | 42 | 73.0 | 133.0 | $2.56 \times f + 25.6$ | 212.3 |
| 2028 | 43 | 72.0 | 117.5 | $2.22 \times f + 22.2$ | 181.7 |
| 2029 | 44 | 71.0 | 101.0 | $1.87 \times f + 18.7$ | 151.5 |
| 2030 | 45 | 70.0 | 94.4 | $1.72 \times f + 17.2$ | 137.3 |
| 2031 | 45 | 70.0 | 85.6 | $1.56 \times f + 15.6$ | 124.5 |

[a] Calculate the $CO_2$ target value for vehicles between the footprint cutpoints as shown, using vehicle footprint, *f,* and rounding the result to the nearest 0.1 g/mile.

■ 45. Amend § 86.1819–14 by:

■ a. Revising the introductory text and paragraphs (a)(1) and (2), (d)(10)(i), (d)(13), (d)(15)(viii), (d)(17) introductory text, (d)(17)(i), (h), (j) introductory text, and (j)(1).

■ b. Adding paragraph (j)(4).

■ c. Removing and reserving paragraphs (k)(1) through (3).

■ d. Revising paragraphs (k)(4), (5), and (7).

■ e. Removing paragraph (k)(10).

The revisions and addition read as follows:

### § 86.1819–14 Greenhouse gas emission standards for heavy-duty vehicles.

This section describes exhaust emission standards for $CO_2$, $CH_4$, and $N_2O$ for medium-duty vehicles. The standards of this section apply for model year 2014 and later vehicles that are chassis-certified with respect to criteria pollutants under this subpart S. Additional heavy-duty vehicles may be subject to the standards of this section as specified in paragraph (j) of this section. Any heavy-duty vehicles not subject to standards under this section are instead subject to greenhouse gas standards under 40 CFR part 1037, and engines installed in these vehicles are subject to standards under 40 CFR part 1036. If you are not the engine manufacturer, you must notify the engine manufacturer that its engines are subject to 40 CFR part 1036 if you intend to use their engines in vehicles that are not subject to standards under this section. Vehicles produced by small businesses may be exempted from the standards of this section as described in paragraph (k)(5) of this section.

(a) * * *

(1) Calculate a work factor, *WF,* for each vehicle subconfiguration (or group of subconfigurations as allowed under paragraph (a)(4) of this section), rounded to the nearest pound, using the following equation:

$$WF = 0.75 \times (GVWR—Curb\ Weight + xwd) + 0.25 \times (GCWR—GVWR)$$

Where:

*xwd* = 500 pounds if the vehicle has four-wheel drive or all-wheel drive; *xwd* = 0 pounds for all other vehicles.

*GCWR* = the gross combination weight rating as declared by the manufacturer. Starting in model year 2030, set *GCWR* to 22,000 for any vehicle with GCWR above 22,000 pounds.

(2) Using the appropriate work factor, calculate a target value for each vehicle subconfiguration (or group of subconfigurations as allowed under paragraph (a)(4) of this section) you produce using the following equation, or the phase-in provisions in paragraph (k)(4) of this section for model year 2031 and earlier vehicles, rounding to the nearest whole g/mile:

$$CO_2\ Target = 0.0221 \times WF + 170$$

* * * * *

(d) * * *

(10) * * *

(i) Use either the conventional-fueled $CO_2$ emission rate or a weighted average of your emission results as specified in 40 CFR 600.510–12(k) for light-duty trucks.

* * * * *

(13) This paragraph (d)(13) applies for $CO_2$ reductions resulting from technologies that were not in common use before 2010 that are not reflected in the specified test procedures. While you are not required to prove that such technologies were not in common use with heavy-duty vehicles before model year 2010, we will not approve your request if we determine they do not qualify. These may be described as off-cycle or innovative technologies. Through model year 2026 we may allow you to generate emission credits consistent with the provisions of § 86.1869–12(c) and (d). The 5-cycle methodology is not presumed to be preferred over alternative methodologies described in § 86.1869–12(d).

* * * * *

(15) * * *

(viii) Total and percent leakage rates under paragraph (h) of this section (through model year 2026 only).

* * * * *

(17) You may calculate emission rates for weight increments less than the 500-pound increment specified for test weight. This does not change the applicable test weights.

(i) Use the ADC equation in paragraph (g) of this section to adjust your emission rates for vehicles in increments of 50, 100, or 250 pounds instead of the 500 pound test-weight increments. Adjust emissions to the midpoint of each increment. This is the equivalent emission weight. For example, vehicles with a test weight basis of 11,751 to 12,250 pounds (which have an equivalent test weight of 12,000 pounds) could be regrouped into 100-pound increments as follows:

TABLE 1 TO PARAGRAPH (k)(17)(i)—EXAMPLE OF TEST-WEIGHT GROUPINGS

| Test weight basis | Equivalent emission weight | Equivalent test weight |
|---|---|---|
| 11,751–11,850 | 11,800 | 12,000 |
| 11,851–11,950 | 11,900 | 12,000 |
| 11,951–12,050 | 12,000 | 12,000 |
| 12,051–12,150 | 12,100 | 12,000 |
| 12,151–12,250 | 12,200 | 12,000 |

* * * * *

(h) *Air conditioning leakage.* Loss of refrigerant from your air conditioning systems may not exceed a total leakage rate of 11.0 grams per year or a percent leakage rate of 1.50 percent per year, whichever is greater. This applies for all refrigerants. Calculate the total leakage rate in g/year as specified in § 86.1867–12(a). Calculate the percent leakage rate as: [total leakage rate (g/yr)] ÷ [total refrigerant capacity (g)] × 100. Round your percent leakage rate to the nearest one-hundredth of a percent. For purpose of this requirement, ‘‘refrigerant capacity’’ is the total mass of refrigerant recommended by the vehicle manufacturer as representing a full charge. Where full charge is specified as a pressure, use good engineering judgment to convert the pressure and system volume to a mass. The leakage standard in this paragraph (h) no longer applies starting with model year 2027.

* * * * *

(j) *GHG certification of additional vehicles under this subpart.* You may certify certain complete or cab-complete vehicles to the GHG standards of this section. Starting in model year 2027, certain high-GCWR vehicles may also be subject to the GHG standards of this section. All vehicles optionally certified under this paragraph (j) are deemed to be subject to the GHG standards of this section. Note that for vehicles above 14,000 pounds GVWR and at or below 26,000 pounds GVWR, GHG certification under this paragraph (j) does not affect how you may or may not certify with respect to criteria pollutants.

(1) For GHG compliance, you may certify any complete or cab-complete spark-ignition vehicles above 14,000 pounds GVWR and at or below 26,000 pounds GVWR to the GHG standards of this section even though this section otherwise specifies that you may certify vehicles to the GHG standards of this section only if they are chassis-certified for criteria pollutants. Starting in model year 2027, this paragraph (j)(1) also applies for vehicles at or below 14,000 pounds GVWR with GCWR above 22,000 pounds with installed engines that have been certified under 40 CFR part 1036 as described in 40 CFR 1036.635.

* * * * *

(4) Vehicles above 22,000 pounds GCWR may be subject to the GHG standards of this section as described in 40 CFR 1036.635.

(k) * * *

(4) *Historical and interim standards.* The following $CO_2$ target values apply for model year 2031 and earlier vehicles:

(i) $CO_2$ target values apply as follows for model years 2014 through 2026, except as specified in paragraph (k)(4)(ii) of this section:

TABLE 2 TO PARAGRAPH (k)(4)(i)—$CO_2$ TARGET VALUES FOR MODEL YEARS 2014 THROUGH 2026

| Model year | $CO_2$ target (g/mile) | |
|---|---|---|
| | Spark-ignition | Compression-ignition |
| 2014 | 0.0482 × WF + 371 | 0.0478 × WF + 368 |
| 2015 | 0.0479 × WF + 369 | 0.0474 × WF + 366 |
| 2016 | 0.0469 × WF + 362 | 0.0460 × WF + 354 |
| 2017 | 0.0460 × WF + 354 | 0.0445 × WF + 343 |
| 2018–2020 | 0.0440 × WF + 339 | 0.0416 × WF + 320 |
| 2021 | 0.0429 × WF + 331 | 0.0406 × WF + 312 |
| 2022 | 0.0418 × WF + 322 | 0.0395 × WF + 304 |
| 2023 | 0.0408 × WF + 314 | 0.0386 × WF + 297 |
| 2024 | 0.0398 × WF + 306 | 0.0376 × WF + 289 |
| 2025 | 0.0388 × WF + 299 | 0.0367 × WF + 282 |
| 2026 | 0.0378 × WF + 291 | 0.0357 × WF + 275 |

(ii) The following optional alternative $CO_2$ target values apply for model years 2014 through 2020:

TABLE 3 TO PARAGRAPH (k)(4)(ii)—ALTERNATIVE $CO_2$ TARGET VALUES FOR MODEL YEARS 2014 THROUGH 2020

| Model year | $CO_2$ target (g/mile) | |
|---|---|---|
| | Spark-ignition | Compression-ignition |
| 2014 | 0.0482 × WF + 371 | 0.0478 × WF + 368 |
| 2015 | 0.0479 × WF + 369 | 0.0474 × WF + 366 |
| 2016–2018 | 0.0456 × WF + 352 | 0.0440 × WF + 339 |
| 2019–2020 | 0.0440 × WF + 339 | 0.0416 × WF + 320 |

(iii) $CO_2$ target values apply as follows for all engine types for model years 2027 through 2031:

TABLE 4 TO PARAGRAPH (k)(4)(iii)—$CO_2$ TARGET VALUES FOR MODEL YEARS 2027 THROUGH 2031

| Model year | $CO_2$ target (g/mile) |
|---|---|
| 2027 | 0.0348 × WF + 268 |
| 2028 | 0.0339 × WF + 261 |
| 2029 | 0.0310 × WF + 239 |
| 2030 | 0.0280 × WF + 216 |
| 2031 | 0.0251 × WF + 193 |

(5) *Provisions for small manufacturers.* Standards apply on a delayed schedule for manufacturers meeting the small business criteria specified in 13 CFR 121.201 (NAICS code 336111); the employee and revenue limits apply to the total number employees and total revenue together for affiliated companies. Qualifying small manufacturers are not subject to the greenhouse gas standards of this section for vehicles with a date of manufacture before January 1, 2022, as specified in 40 CFR 1037.150(c). In addition, small manufacturers producing vehicles that run on any fuel other than gasoline, E85, or diesel fuel may delay complying with every later standard under this part by one model year through model year 2026. For model year 2027 and later, qualifying small manufacturers remain subject to the model year 2026 greenhouse gas standards; however, small manufacturers may trade emission credits generated in a given model year only by certifying to standards that apply for that model year.

* * * * *

(7) *Advanced-technology credits.* Provisions for advanced-technology credits apply as described in 40 CFR 1037.615. If you generate credits from Phase 1 vehicles certified with advanced technology (in model years 2014 through 2020), you may multiply these credits by 1.50. If you generate credits from model year 2021 through 2026 vehicles certified with advanced technology, you may multiply these credits by 3.5 for plug-in hybrid electric vehicles, 4.5 for electric vehicles, and 5.5 for fuel cell vehicles. Advanced-technology credits from Phase 1 vehicles may be used to show compliance with any standards of this part or 40 CFR part 1036 or part 1037, subject to the restrictions in 40 CFR 1037.740. Similarly, you may use up to 60,000 Mg per year of advanced-technology credits generated under 40 CFR 1036.615 or 1037.615 (from Phase 1 vehicles) to demonstrate compliance with the $CO_2$ standards in this section. Include vehicles generating credits in separate fleet-average calculations (and exclude them from your conventional fleet-average calculation). You must first apply these advanced-technology vehicle credits to any deficits for other

vehicles in the averaging set before applying them to other averaging sets.

* * * * *

■ 46. Amend § 86.1820–01 by revising paragraphs (b) introductory text and (b)(7) and adding paragraph (b)(8) to read as follows:

### § 86.1820–01 Durability group determination.

* * * * *

(b) To be included in the same durability group, vehicles must be identical in all the respects listed in paragraphs (b)(1) through (7) of this section and meet one of the criteria specified in paragraph (b)(8) of this section:

* * * * *

(7) Type of particulate filter (none, catalyzed, noncatalyzed).

(8) The manufacturer must choose one of the following two criteria:

(i) Grouping statistic:

(A) Vehicles are grouped based upon the value of the grouping statistic determined using the following equation:

$$GS = [(\text{Cat Vol})/(\text{Disp})] \times \text{Loading Rate}$$

Where:

GS = Grouping Statistic used to evaluate the range of precious metal loading rates and relative sizing of the catalysts compared to the engine displacement that are allowable within a durability group. The grouping statistic shall be rounded to a tenth of a gram/liter.

Cat Vol = Total volume of the catalyst(s) in liters. Include the volume of any catalyzed particulate filters.

Disp = Displacement of the engine in liters.

Loading rate = The mass of total precious metal(s) in the catalyst (or the total mass of all precious metal(s) of all the catalysts if the vehicle is equipped with multiple catalysts) in grams divided by the total volume of the catalyst(s) in liters. Include the mass of precious metals in any catalyzed particulate filters.

(B) Engine-emission control system combinations which have a grouping statistic which is either less than 25 percent of the largest grouping statistic value, or less than 0.2 g/liter (whichever allows the greater coverage of the durability group) shall be grouped into the same durability group.

(ii) The manufacturer may elect to use another procedure which results in at least as many durability groups as required using criteria in paragraph (b)(8)(i) of this section providing that only vehicles with similar emission deterioration or durability are combined into a single durability group.

* * * * *

### § 86.1823–01 [Removed]

■ 47. Remove § 86.1823–01.

■ 48. Amend § 86.1823–08 by revising paragraph (f)(1)(iii), adding paragraph (f)(1)(iv), and revising paragraph (n) to read as follows:

### § 86.1823–08 Durability demonstration procedures for exhaust emissions.

* * * * *

(f) * * *

(1) * * *

(iii) For Tier 3 vehicles, the DF calculated by these procedures will be used for determining full and intermediate useful life compliance with FTP exhaust emission standards, SFTP exhaust emission standards, and cold CO emission standards. At the manufacturer's option and using procedures approved by the Administrator, a separate DF may be calculated exclusively using cold CO test data to determine compliance with cold CO emission standards. Also, at the manufacturer's option and using procedures approved by the Administrator, a separate DF may be calculated exclusively using US06 and/or air conditioning (SC03) test data to determine compliance with the SFTP emission standards.

(iv) For Tier 4 vehicles, the DF calculated by these procedures may be used for determining compliance with all the standards identified in § 86.1811–27. At the manufacturer's option and using procedures approved by the Administrator, manufacturers may calculate a separate DF for the following standards and driving schedules:

(A) Testing to determine compliance with cold temperature emission standards.

(B) US06 testing.

(C) SC03 testing.

(D) HFET.

(E) Mid-temperature intermediate soak testing.

(F) Early driveaway testing.

(G) High-power PHEV engine starts.

* * * * *

(n) *Emission component durability.* The manufacturer shall use good engineering judgment to determine that all emission-related components are designed to operate properly for the full useful life of the vehicles in actual use.

### §§ 86.1824–01 and 86.1824–07 [Removed]

■ 49. Remove §§ 86.1824–01 and 86.1824–07.

■ 50. Amend § 86.1824–08 by revising paragraphs (c)(1) and (k) to read as follows:

### § 86.1824–08 Durability demonstration procedures for evaporative emissions.

* * * * *

(c) * * *

(1) Mileage accumulation must be conducted using the SRC or any road cycle approved under the provisions of § 86.1823–08(e)(1).

* * * * *

(k) *Emission component durability.* The manufacturer shall use good engineering judgment to determine that all emission-related components are designed to operate properly for the full useful life of the vehicles in actual use.

### § 86.1825–01 [Removed]

■ 51. Remove § 86.1825–01.

■ 52. Amend § 86.1825–08 by revising the introductory text and paragraphs (c)(1) and (h) to read as follows:

### § 86.1825–08 Durability demonstration procedures for refueling emissions.

The durability-related requirements of this section apply for vehicles subject to refueling standards under this subpart. Refer to the provisions of §§ 86.1801 and 86.1813 to determine applicability of the refueling standards to different classes of vehicles. Diesel-fueled vehicles be exempt from the requirements of this section under § 86.1829.

* * * * *

(c) * * *

(1) Mileage accumulation must be conducted using the SRC or a road cycle approved under the provisions of § 86.1823–08(e)(1).

* * * * *

(h) *Emission component durability.* The manufacturer shall use good engineering judgment to determine that all emission-related components are designed to operate properly for the full useful life of the vehicles in actual use.

* * * * *

■ 53. Amend § 86.1827–01 by revising paragraph (a)(5) to read as follows:

### § 86.1827–01 Test group determination.

* * * * *

(a) * * *

(5) Subject to the same emission standards (except for $CO_2$), or FEL in the case of cold temperature NMHC or NMOG+NOx standards, except that a manufacturer may request to group vehicles into the same test group as vehicles subject to more stringent standards, so long as all the vehicles within the test group are certified to the most stringent standards applicable to any vehicle within that test group. Light-duty trucks and light-duty vehicles may be included in the same test group if all vehicles in the test group are subject to the same emission standards, with the exception of the $CO_2$ standard.

* * * * *

■ 54. Amend § 86.1828–01 by revising paragraphs (a), (b)(1), (c), (e), and (f) and removing paragraph (g).

The revisions read as follows:

### § 86.1828–01 Emission data vehicle selection.

(a) *Criteria exhaust testing.* Within each test group, the vehicle configuration shall be selected which is expected to be worst-case for exhaust emission compliance on candidate in-use vehicles, considering all criteria exhaust emission constituents, all exhaust test procedures, and the potential impact of air conditioning on test results. Starting with Tier 4 vehicles, include consideration of cold temperature testing. See paragraph (c) of this section for cold temperature testing with vehicles subject to Tier 3 standards. The selected vehicle will include an air conditioning engine code unless the worst-case vehicle configuration selected is not available with air conditioning. This vehicle configuration will be used as the EDV calibration.

(b) * * *

(1) The vehicle configuration expected to exhibit the highest evaporative and/or refueling emission on candidate in-use vehicles shall be selected for each evaporative/refueling family and evaporative refueling emission system combination from among the corresponding vehicles selected for testing under paragraph (a) of this section. Separate vehicles may be selected to be tested for evaporative and refueling testing.

* * * * *

(c) *Cold temperature testing—Tier 3.* For vehicles subject to Tier 3 standards, select test vehicles for cold temperature testing as follows:

(1) For cold temperature CO exhaust emission compliance for each durability group, the vehicle expected to emit the highest CO emissions at 20 degrees F on candidate in-use vehicles shall be selected from the test vehicles selected in accordance with paragraph (a) of this section.

(2) For cold temperature NMHC exhaust emission compliance for each durability group, the manufacturer must select the vehicle expected to emit the highest NMHC emissions at 20 °F on candidate in-use vehicles from the test vehicles specified in paragraph (a) of this section. When the expected worst-case cold temperature NMHC vehicle is also the expected worst-case cold temperature CO vehicle as selected in paragraph (c)(1) of this section, then cold temperature testing is required only for that vehicle; otherwise, testing is required for both the worst-case cold temperature CO vehicle and the worst-case cold temperature NMHC vehicle.

* * * * *

(e) *Alternative configurations.* The manufacturer may use good engineering judgment to select an equivalent or worst-case configuration in lieu of testing the vehicle selected in paragraphs (a) through (c) of this section. Carryover data satisfying the provisions of § 86.1839 may also be used in lieu of testing the configuration selected in paragraphs (a) through (c) of this section.

(f) *Good engineering judgment.* The manufacturer shall use good engineering judgment in making selections of vehicles under this section.

### § 86.1829–01 [Removed]

■ 55. Remove § 86.1829–01.

■ 56. Amend § 86.1829–15 by revising paragraphs (a), (b), (d)(1) introductory text, (d)(6), and (f) to read as follows:

### § 86.1829–15 Durability and emission testing requirements; waivers.

* * * * *

(a) Durability requirements apply as follows:

(1) One durability demonstration is required for each durability group. The configuration of the DDV is determined according to § 86.1822. The DDV shall be tested and accumulate service mileage according to the provisions of §§ 86.1823, 86.1824, 86.1825, and 86.1831. Small-volume manufacturers and small-volume test groups may optionally use the alternative durability provisions of § 86.1838.

(2) The following durability testing requirements apply for electric vehicles and plug-in hybrid electric vehicles:

(i) Manufacturers must perform monitor accuracy testing on in-use vehicles as described in § 86.1845–04(g) for each monitor family. Carryover provisions apply as described in § 86.1839–01(c).

(ii) Manufacturers must perform battery durability testing as described in § 86.1815(f)(2).

(b) The manufacturer must test EDVs as follows to demonstrate compliance with emission standards:

(1) Except as specified in this section, test one EDV in each test group using the test procedures specified in this subpart to demonstrate compliance with other exhaust emission standards.

(2) Test one EDV in each durability group using the test procedures in 40 CFR part 1066 to demonstrate compliance with cold temperature exhaust emission standards.

(3) Test one EDV in each test group to each of the three discrete mid-temperature intermediate soak standards identified in § 86.1811–27.

(4) Test one EDV in each evaporative/refueling family and evaporative/refueling emission control system combination using the test procedures in subpart B of this part to demonstrate compliance with evaporative and refueling emission standards.

* * * * *

(d) * * *

(1) For vehicles subject to the Tier 3 p.m. standards in § 86.1811–17 (not the Tier 4 p.m. standards in § 86.1811–27), a manufacturer may provide a statement in the application for certification that vehicles comply with applicable PM standards instead of submitting PM test data for a certain number of vehicles. However, each manufacturer must test vehicles from a minimum number of durability groups as follows:

* * * * *

(6) Manufacturers may provide a statement in the application for certification that vehicles comply with the mid-temperature intermediate soak standards for soak times not covered by testing.

* * * * *

(f) For electric vehicles and fuel cell vehicles, manufacturers may provide a statement in the application for certification that vehicles comply with all the emission standards and related requirements of this subpart instead of submitting test data. Tailpipe emissions of regulated pollutants from vehicles powered solely by electricity are deemed to be zero.

■ 57. Amend § 86.1834–01 by revising paragraph (h) to read as follows:

### § 86.1834–01 Allowable maintenance.

* * * * *

(h) When air conditioning exhaust emission tests are required, the manufacturer must document that the vehicle's air conditioning system is operating properly and in a representative condition. Required air conditioning system maintenance is performed as unscheduled maintenance and does not require the Administrator's approval.

■ 58. Amend § 86.1835–01 by revising paragraphs (a)(1)(i), (a)(4), (b)(1), and (d) introductory text to read as follows:

### § 86.1835–01 Confirmatory certification testing.

(a) * * *

(1) * * *

(i) The Administrator may adjust or cause to be adjusted any adjustable parameter of an emission-data vehicle which the Administrator has determined to be subject to adjustment for certification testing in accordance with § 86.1833–01(a)(1), to any setting within the physically adjustable range of that parameter, as determined by the Administrator in accordance with § 86.1833–01(a)(3), prior to the performance of any tests to determine whether such vehicle or engine conforms to applicable emission standards, including tests performed by the manufacturer. However, if the idle speed parameter is one which the Administrator has determined to be subject to adjustment, the Administrator shall not adjust it to a setting which causes a higher engine idle speed than would have been possible within the physically adjustable range of the idle speed parameter on the engine before it accumulated any dynamometer service, all other parameters being identically adjusted for the purpose of the comparison. The Administrator, in making or specifying such adjustments, will consider the effect of the deviation from the manufacturer's recommended setting on emissions performance characteristics as well as the likelihood that similar settings will occur on in-use light-duty vehicles, light-duty trucks, or complete heavy-duty vehicles. In determining likelihood, the Administrator will consider factors such as, but not limited to, the effect of the adjustment on vehicle performance characteristics and surveillance information from similar in-use vehicles.

* * * * *

(4) Retesting for fuel economy reasons or for compliance with greenhouse gas exhaust emission standards in § 86.1818–12 may be conducted under the provisions of 40 CFR 600.008–08.

(b) * * *

(1) If the Administrator determines not to conduct a confirmatory test under the provisions of paragraph (a) of this section, manufacturers will conduct a confirmatory test at their facility after submitting the original test data to the Administrator under either of the following circumstances:

(i) The vehicle configuration has previously failed an emission standard.

(ii) The test exhibits high emission levels determined by exceeding a percentage of the standards specified by the Administrator for that model year.

* * * * *

(d) *Conditional certification.* Upon request of the manufacturer, the Administrator may issue a conditional certificate of conformity for a test group which has not completed the Administrator testing required under paragraph (a) of this section. Such a certificate will be issued based upon the condition that the confirmatory testing be completed in an expedited manner and that the results of the testing be in compliance with all standards and procedures.

* * * * *

■ 59. Amend § 86.1838–01 by revising paragraph (b)(1)(i), the paragraph (b)(2)heading, and paragraph (b)(2)(i) to read as follows:

### § 86.1838–01 Small-volume manufacturer certification procedures.

* * * * *

(b) * * *

(1) * * *

(i) Optional small-volume manufacturer certification procedures apply for vehicles produced by manufacturers with the following number of combined sales of vehicles subject to standards under this subpart in all states and territories of the United States in the model year for which certification is sought, including all vehicles and engines imported under the provisions of 40 CFR 85.1505 and 85.1509:

(A) At or below 5,000 units for the Tier 3 standards described in §§ 86.1811–17, 86.1813–17, and 86.1816–18 and the Tier 4 standards described in § 86.1811–27. This volume threshold applies for phasing in the Tier 3 and Tier 4 standards and for determining the corresponding deterioration factors.

(B) No small-volume sales threshold applies for the heavy-duty greenhouse gas standards; alternative small-volume criteria apply as described in § 86.1819–14(k)(5).

(C) At or below 15,000 units for all other requirements. See § 86.1845 for separate provisions that apply for in-use testing.

* * * * *

(2) *Small-volume test groups and small-volume monitor families.* (i) If the aggregated sales in all states and territories of the United States, as determined in paragraph (b)(3) of this section are equal to or greater than 15,000 units, then the manufacturer (or each manufacturer in the case of manufacturers in an aggregated relationship) will be allowed to certify a number of units under the small-volume test group certification procedures in accordance with the criteria identified in paragraphs (b)(2)(ii) through (iv) of this section. Similarly, the manufacturer will be exempt from Part A testing for monitor accuracy as described in § 86.1845–04(g) in accordance with the criteria identified in paragraphs (b)(2)(ii) through (iv) of this section for individual monitor families with aggregated sales up to 5,000 units in the current model year.

* * * * *

■ 60. Amend § 86.1839–01 by revising paragraph (a) and adding paragraph (c) to read as follows:

### § 86.1839–01 Carryover of certification and battery monitoring data.

(a) In lieu of testing an emission-data or durability vehicle selected under § 86.1822, § 86.1828, or § 86.1829, and submitting data therefrom, a manufacturer may submit exhaust emission data, evaporative emission data and/or refueling emission data, as applicable, on a similar vehicle for which certification has been obtained or for which all applicable data required under § 86.1845 has previously been submitted. To be eligible for this provision, the manufacturer must use good engineering judgment and meet the following criteria:

(1) In the case of durability data, the manufacturer must determine that the previously generated durability data represent a worst case or equivalent rate of deterioration for all applicable emission constituents compared to the configuration selected for durability demonstration. Prior to certification, the Administrator may require the manufacturer to provide data showing that the distribution of catalyst temperatures of the selected durability configuration is effectively equivalent or lower than the distribution of catalyst temperatures of the vehicle configuration which is the source of the previously generated data.

(2) In the case of emission data, the manufacturer must determine that the previously generated emissions data represent a worst case or equivalent level of emissions for all applicable emission constituents compared to the configuration selected for emission compliance demonstration.

* * * * *

(c) In lieu of testing electric vehicles or plug-in hybrid electric vehicles for monitor accuracy under § 86.1822–01(a) and submitting the test data, a manufacturer may rely on previously conducted testing on a similar vehicle for which such test data have previously been submitted to demonstrate compliance with monitor accuracy requirements. For vehicles to be eligible for this provision, they must have designs for battery monitoring that are identical in all material respects to the vehicles tested under § 86.1845–04(g). If a monitor family fails to meet accuracy requirements, repeat the testing under § 86.1845–04(g) as soon as practicable.

■ 61. Revise § 86.1840–01 to read as follows:

### § 86.1840–01 Special test procedures.

Provisions for special test procedures apply as described in 40 CFR 1065.10 and 1066.10. For example, manufacturers must propose a procedure for EPA's review and advance approval for testing and certifying vehicles equipped with periodically regenerating aftertreatment devices, including sufficient documentation and data for EPA to fully evaluate the request.

■ 62. Amend § 86.1841–01 by revising paragraphs (a)(1)(iii), (a)(3), and (e) to read as follows:

### § 86.1841–01 Compliance with emission standards for the purpose of certification.

(a) * * *

(1) * * *

(iii) For a composite standard of NMHC + $NO_X$, the measured results of NMHC and $NO_X$ must each be adjusted by their corresponding deterioration factors before the composite NMHC + $NO_X$ certification level is calculated. Where the applicable FTP exhaust hydrocarbon emission standard is an NMOG standard, the applicable NMOG deterioration factor must be used in place of the NMHC deterioration factor, unless otherwise approved by the Administrator.

* * * * *

(3) Compliance with full useful life $CO_2$ exhaust emission standards shall be demonstrated at certification by the certification levels on the duty cycles specified for carbon-related exhaust emissions according to § 600.113 of this chapter.

* * * * *

(e) Unless otherwise approved by the Administrator, manufacturers must not use Reactivity Adjustment Factors (RAFs) in their calculation of the certification level of any pollutant for any vehicle.

■ 63. Amend § 86.1844–01 by:

■ a. Revising paragraphs (d)(7)(i) and (ii), (d)(11)(iv), and (d)(15).

■ b. Adding paragraphs (d)(18) through (20).

■ c. Revising paragraphs (e)(1), (3), and (5), (g)(11), and (h).

■ d. Removing paragraph (i).

The revisions and additions read as follows:

### § 86.1844–01 Information requirements: Application for certification and submittal of information upon request.

* * * * *

(d) * * *

(7) * * *

(i) For vehicles certified to any Tier 3 or Tier 4 emission standards, include a comparison of drive-cycle metrics as specified in 40 CFR 1066.425(j) for each drive cycle or test phase, as appropriate.

(ii) For gasoline-fueled vehicles subject to Tier 3 evaporative emission standards, identify the method of accounting for ethanol in determining evaporative emissions, as described in § 86.1813.

* * * * *

(11) * * *

(iv) For Tier 4 vehicles with spark-ignition engines, describe how AECDs comply with the requirements of §§ 86.1809–12(d)(2) and 86.1811–27(d).

* * * * *

(15) For vehicles with fuel-fired heaters, describe the control system logic of the fuel-fired heater, including an evaluation of the conditions under which it can be operated and an evaluation of the possible operational modes and conditions under which evaporative emissions can exist. Use good engineering judgment to establish an estimated exhaust emission rate from the fuel-fired heater in grams per mile for each pollutant subject to a fleet-average standard. Adjust fleet-average compliance calculations in §§ 86.1861, 86.1864, and 86.1865 as appropriate to account for emissions from fuel-fired heaters. Describe the testing used to establish the exhaust emission rate.

* * * * *

(18) For vehicles equipped with RESS, the recharging procedures and methods for determining battery performance, such as state of charge and charging capacity.

(19) The following information for each monitor family for electric vehicles and plug-in hybrid electric vehicles, as applicable:

(1) The monitor, battery, and other specifications that are relevant to establishing monitor families and battery durability families to comply with the requirements of this section.

(2) The certified usable battery energy for each battery durability family.

(3) A statement attesting that the SOCE monitor meets the 5 percent accuracy requirement.

(4) For light-duty program vehicles, a statement that each battery durability family meets the Minimum Performance Requirement.

(20) Acknowledgement, if applicable, that you are including vehicles with engines certified under 40 CFR part 1036 in your calculation to demonstrate compliance with the fleet average $CO_2$ standard in this subpart as described in § 86.1819–14(j).

(e) * * *

(1) Identify all emission-related components, including those that can affect GHG emissions. Also identify software, AECDs, and other elements of design that are used to control criteria, GHG, or evaporative/refueling emissions. Identify the emission-related components by part number. Identify software by part number or other convention, as appropriate. Organize part numbers by engine code or other similar classification scheme.

* * * * *

(3) Identification and description of all vehicles covered by each certificate of conformity to be produced and sold within the U.S. The description must be sufficient to identify whether any given in-use vehicle is, or is not, covered by a given certificate of conformity, the test group and the evaporative/refueling family to which it belongs and the standards that are applicable to it, by matching readily observable vehicle characteristics and information given in the emission control information label (and other permanently attached labels) to indicators in the Part 1 Application. For example, the description must include any components or features that contribute to measured or demonstrated control of emissions for meeting criteria, GHG, or evaporative/refueling standards under this subpart. In addition, the description must be sufficient to determine for each vehicle covered by the certificate, all appropriate test parameters and any special test procedures necessary to conduct an official certification exhaust or evaporative emission test as was required by this subpart to demonstrate compliance with applicable emission standards. The description shall include, but is not limited to, information such as model name, vehicle classification (light-duty vehicle, light-duty truck, or complete heavy-duty vehicle), sales area, engine displacement, engine code, transmission type, tire size and parameters necessary to conduct exhaust emission tests such as equivalent test weight, curb and gross vehicle weight, test horsepower (with and without air conditioning adjustment), coast down time, shift schedules, cooling fan configuration, etc. and evaporative tests such as canister working capacity, canister bed volume, and fuel temperature profile. Actual values must be provided for all parameters.

* * * * *

(5) Copies of all service manuals, service bulletins and instructions regarding the use, repair, adjustment, maintenance, or testing of such vehicles relevant to the control of crankcase, exhaust or evaporative emissions, as applicable, issued by the manufacturer for use by other manufacturers, assembly plants, distributors, dealers, and ultimate purchasers. These shall be

submitted in electronic form to the Agency when they are made available to the public and must be updated as appropriate throughout the useful life of the corresponding vehicles.

* * * * *

(g) * * *

(11) A description of all procedures, including any special procedures, used to comply with applicable test requirements of this subpart. Any special procedures used to establish durability data or emission deterioration factors required to be determined under §§ 86.1823, 86.1824 and 86.1825 and to conduct emission tests required to be performed on applicable emission data vehicles under § 86.1829 according to test procedures contained within this Title must also be included.

* * * * *

(h) Manufacturers must submit the in-use testing information required in § 86.1847.

■ 64. Amend § 86.1845–04 by:

■ a. Revising paragraph (a)(3)(i).

■ b. Adding paragraph (a)(4).

■ c. Revising paragraphs (b)(5) through (7), (c)(5), (d), and (e)(2).

■ d. Adding paragraph (f) introductory text.

■ e. Revising paragraph (f)(1).

■ f. Adding paragraph (g).

The revisions and additions read as follows:

**§ 86.1845–04 Manufacturer in-use verification testing requirements.**

(a) * * *

(3) * * *

(i) Vehicles certified under § 86.1811 must always measure emissions over the FTP, then over the HFET (if applicable), then over the US06. If a vehicle meets all the applicable emission standards except the FTP or HFET emission standard for NMOG + $NO_X$, and a fuel sample from the tested vehicle (representing the as-received condition) has a measured fuel sulfur level exceeding 15 ppm when measured as described in 40 CFR 1065.710, the manufacturer may repeat the FTP and HFET measurements and use the new emission values as the official results for that vehicle. For all other cases, measured emission levels from the first test will be considered the official results for the test vehicle, regardless of any test results from additional test runs. Where repeat testing is allowed, the vehicle may operate for up to two US06 cycles (with or without measurement) before repeating the FTP and HFET measurements. The repeat measurements must include both FTP and HFET, even if the vehicle failed only one of those tests, unless the HFET is not required for a particular vehicle. Vehicles may not undergo any other vehicle preconditioning to eliminate fuel sulfur effects on the emission control system, unless we approve it in advance. This paragraph (a)(3)(i) does not apply for Tier 2 vehicles.

* * * * *

(4) Battery-related in-use testing requirements apply for electric vehicles and plug-in hybrid electric vehicles as described in paragraph (g) of this section.

(b) * * *

(5) *Testing.* (i) Each test vehicle of a test group shall be tested in accordance with the FTP and the US06 as described in subpart B of this part, when such test vehicle is tested for compliance with applicable exhaust emission standards under this subpart. Test vehicles subject to applicable exhaust $CO_2$ emission standards under this subpart shall also be tested in accordance with the HFET as described in 40 CFR 1066.840.

(ii) For vehicles subject to Tier 3 p.m. standards, manufacturers must measure PM emissions over the FTP and US06 driving schedules for at least 50 percent of the vehicles tested under paragraph (b)(5)(i) of this section. For vehicles subject to Tier 4 p.m. standards, this test rate increases to 100 percent.

(iii) Starting with model year 2018 vehicles, manufacturers must demonstrate compliance with the Tier 3 leak standard specified in § 86.1813, if applicable, as described in this paragraph (b)(5)(iii). Manufacturers must evaluate each vehicle tested under paragraph (b)(5)(i) of this section, except that leak testing is not required for vehicles tested under paragraph (b)(5)(iv) of this section for diurnal emissions. In addition, manufacturers must evaluate at least one vehicle from each leak family for a given model year. Manufacturers may rely on OBD monitoring instead of testing as follows:

(A) A vehicle is considered to pass the leak test if the OBD system completed a leak check within the previous 750 miles of driving without showing a leak fault code.

(B) Whether or not a vehicle's OBD system has completed a leak check within the previous 750 miles of driving, the manufacturer may operate the vehicle as needed to force the OBD system to perform a leak check. If the OBD leak check does not show a leak fault, the vehicle is considered to pass the leak test.

(C) If the most recent OBD leak check from paragraph (b)(5)(iii)(A) or (B) of this section shows a leak-related fault code, the vehicle is presumed to have failed the leak test. Manufacturers may perform the leak measurement procedure described in 40 CFR 1066.985 for an official result to replace the finding from the OBD leak check.

(D) Manufacturers may not perform repeat OBD checks or leak measurements to over-ride a failure under paragraph (b)(5)(iii)(C) of this section.

(iv) For vehicles other than gaseous-fueled vehicles and electric vehicles, one test vehicle of each evaporative/refueling family shall be tested in accordance with the supplemental 2-diurnal-plus-hot-soak evaporative emission and refueling emission procedures described in subpart B of this part, when such test vehicle is tested for compliance with applicable evaporative emission and refueling standards under this subpart. For gaseous-fueled vehicles, one test vehicle of each evaporative/refueling family shall be tested in accordance with the 3-diurnal-plus-hot-soak evaporative emission and refueling emission procedures described in subpart B of this part, when such test vehicle is tested for compliance with applicable evaporative emission and refueling standards under this subpart. The test vehicles tested to fulfill the evaporative/refueling testing requirement of this paragraph (b)(5)(iv) will be counted when determining compliance with the minimum number of vehicles as specified in Table S04–06 and Table S04–07 in paragraph (b)(3) of this section for testing under paragraph (b)(5)(i) of this section only if the vehicle is also tested for exhaust emissions under the requirements of paragraph (b)(5)(i) of this section.

(6) *Test condition.* Each test vehicle not rejected based on the criteria specified in appendix II to this subpart shall be tested in as-received condition.

(7) *Diagnostic maintenance.* A manufacturer may conduct subsequent diagnostic maintenance and/or testing of any vehicle. Any such maintenance and/or testing shall be reported to the Agency as specified in § 86.1847.

(c) * * *

(5) *Testing.* (i) Each test vehicle shall be tested in accordance with the FTP and the US06 as described in subpart B of this part when such test vehicle is tested for compliance with applicable exhaust emission standards under this subpart. Test vehicles subject to applicable exhaust $CO_2$ emission standards under this subpart shall also be tested in accordance with the HFET as described in 40 CFR 1066.840. One test vehicle from each test group shall be tested over the FTP at high altitude. The test vehicle tested at high altitude is not required to be one of the same test vehicles tested at low altitude. The test

vehicle tested at high altitude is counted when determining the compliance with the requirements shown in Table S04–06 and Table S04–07 in paragraph (b)(3) of this section or the expanded sample size as provided for in this paragraph (c).

(ii) For vehicles subject to Tier 3 p.m. standards, manufacturers must measure PM emissions over the FTP and US06 driving schedules for at least 50 percent of the vehicles tested under paragraph (c)(5)(i) of this section. For vehicles subject to Tier 4 p.m. standards, this test rate increases to 100 percent.

(iii) Starting with model year 2018 vehicles, manufacturers must evaluate each vehicle tested under paragraph (c)(5)(i) of this section to demonstrate compliance with the Tier 3 leak standard specified in § 86.1813, except that leak testing is not required for vehicles tested under paragraph (c)(5)(iv) of this section for diurnal emissions. In addition, manufacturers must evaluate at least one vehicle from each leak family for a given model year. Manufacturers may rely on OBD monitoring instead of testing as described in paragraph (b)(5)(iii) of this section.

(iv) For vehicles other than gaseous-fueled vehicles and electric vehicles, one test vehicle of each evaporative/refueling family shall be tested in accordance with the supplemental 2-diurnal-plus-hot-soak evaporative emission procedures described in subpart B of this part, when such test vehicle is tested for compliance with applicable evaporative emission and refueling standards under this subpart. For gaseous-fueled vehicles, one test vehicle of each evaporative/refueling family shall be tested in accordance with the 3-diurnal-plus-hot-soak evaporative emission procedures described in subpart B of this part, when such test vehicle is tested for compliance with applicable evaporative emission and refueling standards under this subpart. The vehicles tested to fulfill the evaporative/refueling testing requirement of this paragraph (c)(5)(iv) will be counted when determining compliance with the minimum number of vehicles as specified in Table S04–06 and table S04–07 in paragraph (b)(3) of this section for testing under paragraph (c)(5)(i) of this section only if the vehicle is also tested for exhaust emissions under the requirements of paragraph (c)(5)(i) of this section.

* * * * *

(d) *Test vehicle procurement.* Vehicles tested under this section shall be procured as follows:

(1) *Vehicle ownership.* Vehicles shall be procured from the group of persons who own or lease vehicles registered in the procurement area. Vehicles shall be procured from persons which own or lease the vehicle, excluding commercial owners/lessees owned or controlled by the vehicle manufacturer, using the procedures described in appendix I to this subpart. See § 86.1838–01(c)(2)(i) for small volume manufacturer requirements.

(2) *Geographical limitations.* (i) Test groups certified to 50-state standards: For low altitude testing no more than fifty percent of the test vehicles may be procured from California. The test vehicles procured from the 49-state area must be procured from a location with a heating degree day 30-year annual average equal to or greater than 4,000.

(ii) Test groups certified to 49-state standards: The test vehicles procured from the 49-state area must be procured from a location with a heating degree day 30-year annual average equal to or greater than 4,000.

(iii) Vehicles procured for high altitude testing may be procured from any area located above 4,000 feet.

(3) *Rejecting candidate vehicles.* Vehicles may be rejected for procurement or testing under this section if they meet one or more of the rejection criteria in appendix II to this subpart. Vehicles may also be rejected after testing under this section if they meet one or more of the rejection criteria in appendix II to this subpart. Any vehicle rejected after testing must be replaced in order that the number of test vehicles in the sample comply with the sample size requirements of this section. Any post-test vehicle rejection and replacement procurement and testing must take place within the testing completion requirements of this section.

(e) * * *

(2) *Notification of test facility.* The manufacturer shall notify the Agency of the name and location of the testing laboratory(s) to be used to conduct testing of vehicles of each model year conducted pursuant to this section. Such notification shall occur at least thirty working days prior to the initiation of testing of the vehicles of that model year.

* * * * *

(f) *NMOG and formaldehyde.* The following provisions apply for measuring NMOG and formaldehyde:

(1) A manufacturer must conduct in-use testing on a test group by determining NMOG exhaust emissions using the same methodology used for certification, as described in 40 CFR 1066.635.

* * * * *

(g) *Battery testing.* Manufacturers of electric vehicles and plug-in hybrid electric vehicles must perform in-use testing related to battery monitor accuracy and battery durability for those vehicles as described in § 86.1815. Perform Part A testing for each monitor family as follows to verify that SOCE monitors meet accuracy requirements:

(1) Determine accuracy by measuring SOCE from in-use vehicles using the procedures specified in § 86.1815(c) and comparing the measured values to the SOCE value displayed on the monitor at the start of testing.

(2) Perform low-mileage testing of the vehicles in a monitor family within 12 months of the end of production of that monitor family for that model year. All test vehicles must have a minimum odometer mileage of 10,000 miles.

(3) Perform intermediate-mileage testing of the vehicles in a monitor family within 3 years of the end of production of that monitor family for that model year. All test vehicles must have a minimum odometer mileage of 30,000 miles.

(4) Perform high-mileage testing of the vehicles in a monitor family by starting the test program within 4 years of the end of production of the monitor family and completing the test program within 5 years of the end of production of the monitor family. All test vehicles must have a minimum odometer mileage of 50,000 miles.

(5) Select test vehicles from the United States as described in paragraphs (b)(6), (c)(6), and (d)(1) and (3) of this section. Send notification regarding test location as described in paragraph (e)(2) of this section.

(6) You may perform diagnostic maintenance as specified in paragraph (b)(7) and (c)(7) of this section.

(7) See § 86.1838–01(b)(2) for a testing exemption that applies for small-volume monitor families.

■ 65. Amend § 86.1846–01 by revising paragraphs (a)(1), (b), (e), and (j) to read as follows:

### § 86.1846–01 Manufacturer in-use confirmatory testing requirements.

(a) * * *

(1) Manufacturers must test, or cause testing to be conducted, under this section when the emission levels shown by a test group sample from testing under § 86.1845 exceeds the criteria specified in paragraph (b) of this section. The testing required under this section applies separately to each test group and at each test point (low and high mileage) that meets the specified criteria. The testing requirements apply separately for each model year. These

provisions do not apply to emissions of $CH_4$ or $N_2O$.

* * * * *

(b) *Criteria for additional testing.* (1) A manufacturer shall test a test group, or a subset of a test group, as described in paragraph (j) of this section when the results from testing conducted under § 86.1845 show mean exhaust emissions of any criteria pollutant for that test group to be at or above 1.30 times the applicable in-use standard for at least 50 percent of vehicles tested from the test group.

(2) A manufacturer shall test a test group, or a subset of a test group, as described in paragraph (j) of this section when the results from testing conducted under § 86.1845 show mean exhaust emissions of $CO_2$ (City-highway combined CREE) for that test group to be at or above the applicable in-use standard for at least 50 percent of vehicles tested from the test group.

(3) Additional testing is not required under this paragraph (b) based on evaporative/refueling testing or based on low-mileage US06 testing conducted under § 86.1845–04(b)(5)(i). Testing conducted at high altitude under the requirements of § 86.1845–04(c) will be included in determining if a test group meets the criteria triggering the testing required under this section.

(4) The vehicle designated for testing under the requirements of § 86.1845–04(c)(2) with a minimum odometer reading of 105,000 miles or 75% of useful life, whichever is less, will not be included in determining if a test group meets the triggering criteria.

(5) The SFTP composite emission levels for Tier 3 vehicles shall include the IUVP FTP emissions, the IUVP US06 emissions, and the values from the SC03 Air Conditioning EDV certification test (without DFs applied). The calculations shall be made using the equations prescribed in § 86.164. If more than one set of certification SC03 data exists (due to running change testing or other reasons), the manufacturer shall choose the SC03 result to use in the calculation from among those data sets using good engineering judgment.

(6) If fewer than 50 percent of the vehicles from a leak family pass either the leak test or the diurnal test under § 86.1845, EPA may require further leak testing under this paragraph (b)(6). Testing under this section must include five vehicles from the family. If all five of these vehicles fail the test, the manufacturer must test five additional vehicles.

EPA will determine whether to require further leak testing under this section after providing the manufacturer an opportunity to discuss the results, including consideration of any of the following information, or other items that may be relevant:

(i) Detailed system design, calibration, and operating information, technical explanations as to why the individual vehicles tested failed the leak standard.

(ii) Comparison of the subject vehicles to other similar models from the same manufacturer.

(iii) Data or other information on owner complaints, technical service bulletins, service campaigns, special policy warranty programs, warranty repair data, state I/M data, and data available from other manufacturer-specific programs or initiatives.

(iv) Evaporative emission test data on any individual vehicles that did not pass leak testing during IUVP.

* * * * *

(e) *Emission testing.* Each test vehicle of a test group or Agency-designated subset shall be tested in accordance with the driving cycles performed under § 86.1845 corresponding to emission levels requiring testing under this section) as described in subpart B of this part, when such test vehicle is tested for compliance with applicable exhaust emission standards under this subpart.

* * * * *

(j) *Testing a subset.* EPA may designate a subset of the test group for testing under this section in lieu of testing the entire test group when the results for the entire test group from testing conducted under § 86.1845 show mean emissions and a failure rate which meet these criteria for additional testing.

■ 66. Amend § 86.1847–01 by adding paragraph (g) to read as follows:

### § 86.1847–01 Manufacturer in-use verification and in-use confirmatory testing; submittal of information and maintenance of records.

* * * * *

(g) Manufacturers of electric vehicles and plug-in hybrid electric vehicles certified under this subpart must meet the following reporting and recordkeeping requirements related to testing under § 86.1815:

(1) Submit the following records organized by battery durability family and monitor family related to Part A testing to verify accuracy of SOCE monitors within 30 days after completing low-mileage, intermediate-mileage, or high-mileage testing:

(i) A complete record of all tests performed, the dates and location of testing, measured SOCE values for each vehicle, along with the corresponding displayed SOCE values at the start of testing.

(ii) Test vehicle information, including model year, make, model, and odometer reading.

(iii) A summary of statistical information showing whether the testing shows a pass or fail result.

(2) Keep the following records related to testing under paragraph (g)(1) of this section:

(i) Test reports submitted under paragraph (g)(1) of this section.

(ii) Test facility information.

(iii) Routine testing records, such as dynamometer trace, and temperature and humidity during testing.

(3) Submit an annual report related to Part B testing to verify compliance with the Minimum Performance Requirement for SOCE. Submit the report by October 1 for testing you perform over the preceding year or ask us to approve a different annual reporting period based on your practice for starting a new model year. Include the following information in your annual reports, organized by battery durability family and monitor family:

(i) Displayed values of SOCE for each sampled vehicle, along with a description of each vehicle to identify its model year, make, model, odometer reading, and state of registration. Also include the date for assessing each selected vehicle.

(ii) A summary of results to show whether 90 percent of sampled vehicles from each battery durability family meet the Minimum Performance Requirement.

(iii) A description of any selected vehicles excluded from the test results and the justification for excluding them.

(iv) Information regarding warranty claims and statistics on repairs for batteries and for other components or systems for each battery durability family that might influence a vehicle's electric energy consumption.

(4) Keep the following records related to testing under paragraph (g)(3) of this section:

(i) Test reports submitted under paragraph (g)(3) of this section.

(ii) Documentation related to the method of selecting vehicles.

(5) Keep records required under this paragraph (g) for eight years after submitting reports to EPA.

### § 86.1848–01 [Removed]

■ 67. Remove § 86.1848–01.

■ 68. Revise § 86.1848–10 to read as follows:

### § 86.1848–10 Compliance with emission standards for the purpose of certification.

(a)(1) If, after a review of the manufacturer's submitted Part I application, information obtained from any inspection, such other information as the Administrator may require, and any other pertinent data or information, the Administrator determines that the application is complete and that all vehicles within a test group or monitor family as described in the application meet the requirements of this part and the Clean Air Act, the Administrator shall issue a certificate of conformity.

(2) If, after review of the manufacturer's application, request for certification, information obtained from any inspection, such other information as the Administrator may require, and any other pertinent data or information, the Administrator determines that the application is not complete or the vehicles within a test group or monitor family as described in the application, do not meet applicable requirements or standards of the Act or of this part, the Administrator may deny the issuance of, suspend, or revoke a previously issued certificate of conformity. The Administrator will notify the manufacturer in writing, setting forth the basis for the determination. The manufacturer may request a hearing on the Administrator's determination.

(b) A certificate of conformity will be issued by the Administrator for a period not to exceed one model year and upon such terms as deemed necessary or appropriate to assure that any new motor vehicle covered by the certificate will meet the requirements of the Act and of this part.

(c) Failure to meet any of the following conditions will be considered a failure to satisfy a condition upon which a certificate was issued, and any affected vehicles are not covered by the certificate:

(1) The manufacturer must supply all required information according to the provisions of §§ 86.1843 and 86.1844.

(2) The manufacturer must comply with all certification and in-use emission standards contained in subpart S of this part both during and after model year production. This includes the monitor accuracy and battery durability requirements for electric vehicles and plug-in hybrid electric vehicles as described in § 86.1815.

(3) The manufacturer must comply with all implementation schedules sales percentages as required in this subpart.

(4) New incomplete vehicles must, when completed by having the primary load-carrying device or container attached, conform to the maximum curb weight and frontal area limitations described in the application for certification as required in § 86.1844.

(5) The manufacturer must meet the in-use testing and reporting requirements contained in §§ 86.1815, 86.1845, 86.1846, and 86.1847, as applicable.

(6) Vehicles must in all material respects be as described in the manufacturer's application for certification (Part I and Part II).

(7) Manufacturers must meet all the provisions of §§ 86.1811, 86.1813, 86.1816, and 86.1860 through 86.1862 both during and after model year production, including compliance with the applicable fleet average standard and phase-in requirements. The manufacturer bears the burden of establishing to the satisfaction of the Administrator that the terms and conditions upon which each certificate was issued were satisfied. For recall and warranty purposes, vehicles not covered by a certificate of conformity will continue to be held to the standards stated or referenced in the certificate that otherwise would have applied to the vehicles. A manufacturer may not sell credits it has not generated.

(8) Manufacturers must meet all provisions related to cold temperature standards in §§ 86.1811 and 86.1864 both during and after model year production, including compliance with the applicable fleet average standard and phase-in requirements. The manufacturer bears the burden of establishing to the satisfaction of the Administrator that the terms and conditions upon which each certificate was issued were satisfied. For recall and warranty purposes, vehicles not covered by a certificate of conformity will continue to be held to the standards stated or referenced in the certificate that otherwise would have applied to the vehicles. A manufacturer may not sell credits it has not generated.

(9) Manufacturers must meet all the provisions of §§ 86.1818, 86.1819, and 86.1865 both during and after model year production, including compliance with the applicable fleet average standard. The manufacturer bears the burden of establishing to the satisfaction of the Administrator that the terms and conditions upon which the certificate(s) was (were) issued were satisfied. For recall and warranty purposes, vehicles not covered by a certificate of conformity will continue to be held to the standards stated or referenced in the certificate that otherwise would have applied to the vehicles. A manufacturer may not sell credits it has not generated.

(i) Manufacturers that are determined to be operationally independent under § 86.1838–01(d) must report a material change in their status within 60 days as required by § 86.1838–01(d)(2).

(ii) Manufacturers subject to an alternative fleet average greenhouse gas emission standard approved under § 86.1818–12(g) must comply with the annual sales thresholds that are required to maintain use of those standards, including the thresholds required for new entrants into the U.S. market.

(10) Manufacturers must meet all the provisions of § 86.1815 both during and after model year production. The manufacturer bears the burden of establishing to the satisfaction of the Administrator that the terms and conditions related to issued certificates were satisfied.

(d) One certificate will be issued for each test group and evaporative/refueling family combination. For plug-in hybrid electric vehicles, one certificate will be issued for each test group, evaporative/refueling family, and monitor family combination. For electric vehicles, one certificate will be issued for each monitor family. For diesel fueled vehicles, one certificate will be issued for each test group. A certificate of conformity is deemed to cover the vehicles named in such certificate and produced during the model year.

(e) A manufacturer of new light-duty vehicles, light-duty trucks, and complete heavy-duty vehicles must obtain a certificate of conformity covering such vehicles from the Administrator prior to selling, offering for sale, introducing into commerce, delivering for introduction into commerce, or importing into the United States the new vehicle. Vehicles produced prior to the effective date of a certificate of conformity may also be covered by the certificate, once it is effective, if the following conditions are met:

(1) The vehicles conform in all respects to the vehicles described in the application for the certificate of conformity.

(2) The vehicles are not sold, offered for sale, introduced into commerce, or delivered for introduction into commerce prior to the effective date of the certificate of conformity.

(3) EPA is notified prior to the beginning of production when such production will start, and EPA is provided a full opportunity to inspect and/or test the vehicles during and after their production. EPA must have the opportunity to conduct SEA production line testing as if the vehicles had been produced after the effective date of the certificate.

(f) Vehicles imported by an original equipment manufacturer after December 31 of the calendar year for which the model year is named are still covered by the certificate of conformity as long as the production of the vehicle was completed before December 31 of that year.

(g) For test groups required to have an emission control diagnostic system, certification will not be granted if, for any emission data vehicle or other test vehicle approved by the Administrator in consultation with the manufacturer, the malfunction indicator light does not illuminate as required under § 86.1806.

(h) Vehicles equipped with aftertreatment technologies such as catalysts, otherwise covered by a certificate, which are driven outside the United States, Canada, and Mexico will be presumed to have been operated on leaded gasoline resulting in deactivation of such components as catalysts and oxygen sensors. If these vehicles are imported or offered for importation without retrofit of the catalyst or other aftertreatment technology, they will be considered not to be within the coverage of the certificate unless included in a catalyst or other aftertreatment technology control program operated by a manufacturer or a United States Government agency and approved by the Administrator.

■ 69. Amend § 86.1850–01 by revising the section heading and paragraphs (b) introductory text and (d) and removing paragraph (f).

The revisions read as follows:

### § 86.1850–01 EPA decisions regarding a certificate of conformity.

* * * * *

(b) Notwithstanding the fact that the vehicles described in the application may comply with all other requirements of this subpart, the Administrator may deny issuance of, suspend, revoke, or void a previously issued certificate of conformity if the Administrator finds any one of the following infractions:

* * * * *

(d) If a manufacturer commits any fraudulent act that results in the issuance of a certificate of conformity, or fails to comply with the conditions specified in § 86.1843, the Administrator may deem such certificate void ab initio.

* * * * *

### § 86.1860–04 [Removed]

■ 70. Remove § 86.1860–04.

■ 71. Amend § 86.1860–17 by revising the section heading and paragraphs (a) and (b) and removing paragraph (c)(4).

The revisions read as follows:

### § 86.1860–17 How to comply with the Tier 3 and Tier 4 fleet-average standards.

(a) You must show that you meet the applicable Tier 3 fleet-average NMOG + $NO_X$ standards from §§ 86.1811–17 and 86.1816–18, the Tier 3 fleet-average evaporative emission standards from § 86.1813–17, and the Tier 4 fleet-average NMOG + $NO_X$ standards from § 86.1811–27 as described in this section. Note that separate fleet-average calculations are required for Tier 3 FTP and SFTP exhaust emission standards under § 86.1811–17.

(b) Calculate your fleet-average value for each model year for all vehicle models subject to a separate fleet-average standard using the following equation, rounded to the nearest 0.001 g/mile for NMOG + $NO_X$ emissions and the nearest 0.001 g/test for evaporative emissions:

$$\textit{Fleet average value} = \frac{\sum_{i=1}^{b}(N_i \cdot FEL_i)}{N_{total}}$$

Where:

$I$ = A counter associated with each separate test group or evaporative family.

$B$ = The number of separate test groups or evaporative families from a given averaging set to which you certify your vehicles.

$N_i$ = The actual nationwide sales for the model year for test group or evaporative family *i*. Include allowances for evaporative emissions as described in § 86.1813.

$FEL_i$ = The FEL selected for test group or evaporative family *i*. Disregard any separate standards that apply for in-use testing or for testing under high-altitude conditions.

$N_{total}$ = The actual nationwide sales for the model year for all vehicles from the averaging set, except as described in paragraph (c) of this section. The pool of vehicle models included in $N_{total}$ may vary by model year, and it may be different for evaporative standards, FTP exhaust standards, and SFTP exhaust standards in a given model year.

* * * * *

### § 86.1861–04 [Removed]

■ 72. Remove § 86.1861–04.

■ 73. Amend § 86.1861–17 by revising paragraphs (b) and (c) to read as follows:

### § 86.1861–17 How do the NMOG + $NO_X$ and evaporative emission credit programs work?

* * * * *

(b) The following restrictions apply instead of those specified in 40 CFR 1037.740:

(1) Except as specified in paragraph (b)(2) of this section, emission credits may be exchanged only within an averaging set, as follows:

(i) HDV represent a separate averaging set with respect to all emission standards.

(ii) Except as specified in paragraph (b)(1)(iii) of this section, LDV and LDT represent a single averaging set with respect to all emission standards. Note that FTP and SFTP credits for Tier 3 vehicles are not interchangeable.

(iii) LDV and LDT1 certified to standards based on a useful life of 120,000 miles and 10 years together represent a single averaging set with respect to NMOG + $NO_X$ emission standards. Note that FTP and SFTP credits for Tier 3 vehicles are not interchangeable.

(iv) The following separate averaging sets apply for evaporative emission standards:

(A) LDV and LDT1 together represent a single averaging set.

(B) LDT2 represents a single averaging set.

(C) HLDT represents a single averaging set.

(D) HDV represents a single averaging set.

(2) You may exchange evaporative emission credits across averaging sets as follows if you need additional credits to offset a deficit after the final year of maintaining deficit credits as allowed under paragraph (c) of this section:

(i) You may exchange LDV/LDT1 and LDT2 emission credits.

(ii) You may exchange HLDT and HDV emission credits.

(3) Except as specified in paragraph (b)(4) of this section, credits expire after five years.

For example, credits you generate in model year 2018 may be used only through model year 2023.

(4) For the Tier 3 declining fleet-average FTP and SFTP emission standards for NMOG + $NO_X$ described in § 86.1811–17(b)(8), credits generated in model years 2017 through 2024 expire after eight years, or after model year 2030, whichever comes first; however, these credits may not be

traded after five years. This extended credit life also applies for small-volume manufacturers generating credits under § 86.1811–17(h)(1) in model years 2022 through 2024. Note that the longer credit life does not apply for heavy-duty vehicles, for vehicles certified under the alternate phase-in described in § 86.1811–17(b)(9), or for vehicles generating early Tier 3 credits under § 86.1811–17(b)(11) in model year 2017.

(5) Tier 3 credits for NMOG+$NO_X$ may be used to demonstrate compliance with Tier 4 standards without adjustment, except as specified in § 86.1811–27.

(c) The credit-deficit provisions 40 CFR 1037.745 apply to the NMOG + $NO_X$ and evaporative emission standards for Tier 3 and Tier 4 vehicles.

* * * * *

■ 74. Amend § 86.1862–04 by revising paragraphs (a), (c)(2), and (d) to read as follows:

### § 86.1862–04 Maintenance of records and submittal of information relevant to compliance with fleet-average standards.

(a) *Overview.* This section describes reporting and recordkeeping requirements for vehicles subject to the following standards:

(1) Tier 4 criteria exhaust emission standards, including cold temperature NMOG+$NO_X$ standards, in § 86.1811–27.

(2) Tier 3 evaporative emission standards in § 86.1813–17.

(3) Tier 3 FTP emission standard for NMOG + $NO_X$ for LDV and LDT in § 86.1811–17.

(4) Tier 3 SFTP emission standard for NMOG + $NO_X$ for LDV and LDT (including MDPV) in § 86.1811–17.

(5) Tier 3 FTP emission standard for NMOG + $NO_X$ for HDV (other than MDPV) in § 86.1816–18.

(6) Cold temperature NMHC standards in § 86.1811–17 for vehicles subject to Tier 3 NMOG+$NO_X$ standards.

* * * * *

(c) * * *

(2) When a manufacturer calculates compliance with the fleet-average standard using the provisions in § 86.1860–17(f), the annual report must state that the manufacturer has elected to use such provision and must contain the fleet-average standard as the fleet-average value for that model year.

* * * * *

(d) *Notice of opportunity for hearing.* Any voiding of the certificate under this section will be made only after EPA has offered the manufacturer concerned an opportunity for a hearing conducted in accordance with 40 CFR part 1068, subpart G, and, if a manufacturer requests such a hearing, will be made only after an initial decision by the Presiding Officer.

### § 86.1863–07 [Removed]

■ 75. Remove § 86.1863–07.

■ 76. Revise § 86.1864–10 to read as follows:

### § 86.1864–10 How to comply with cold temperature fleet-average standards.

(a) *Applicability.* Cold temperature fleet-average standards apply for NMHC or NMOG+$NO_X$ emissions as described in § 86.1811. Certification testing provisions described in this subpart apply equally for meeting cold temperature exhaust emission standards except as specified.

(b) *Calculating the cold temperature fleet-average standard.* Manufacturers must compute separate sales-weighted cold temperature fleet-average emissions at the end of the model year using actual sales and certifying test groups to FELs, as defined in § 86.1803–01. The FEL becomes the standard for each test group, and every test group can have a different FEL. The certification resolution for the FEL is 0.1 grams/mile. Determine fleet-average emissions separately for each set of vehicles subject to different fleet-average emission standards. Do not include electric vehicles or fuel cell vehicles when calculating fleet-average emissions. Starting with Tier 4 vehicles, determine fleet-average emissions based on separate averaging sets for light-duty program vehicles and medium-duty vehicles. Calculate the sales-weighted cold temperature fleet averages using the following equation, rounded to the nearest 0.1 grams/mile:

$$\text{Cold temperature fleet-average exhaust emissions (grams/mile)} = \Sigma(N \times FEL) \div \text{Total number of vehicles sold from the applicable cold temperature averaging set}$$

Where:

N = The number of vehicles subject to a given fleet-average emission standard based on vehicles counted at the point of first sale.

FEL = Family Emission Limit (grams/mile).

(c) *Certification compliance and enforcement requirements for cold temperature fleet-average standards.* Each manufacturer must comply on an annual basis with fleet-average standards as follows:

(1) Manufacturers must report in their annual reports to the Agency that they met the relevant fleet-average standard by showing that their sales-weighted cold temperature fleet-average emissions are at or below the applicable fleet-average standard for each averaging set.

(2) If the sales-weighted average is above the applicable fleet-average standard, manufacturers must obtain and apply sufficient credits as permitted under paragraph (d)(8) of this section. A manufacturer must show via the use of credits that they have offset any exceedance of the cold temperature fleet-average standard. Manufacturers must also include their credit balances or deficits.

(3) If a manufacturer fails to meet the cold temperature fleet-average standard for two consecutive years, the vehicles causing the exceedance will be considered not covered by the certificate of conformity (see paragraph (d)(8) of this section). A manufacturer will be subject to penalties on an individual-vehicle basis for sale of vehicles not covered by a certificate.

(4) EPA will review each manufacturer's sales to designate the vehicles that caused the exceedance of the fleet-average standard. EPA will designate as nonconforming those vehicles in test groups with the highest certification emission values first, continuing until reaching a number of vehicles equal to the calculated number of noncomplying vehicles as determined above. In a group where only a portion of vehicles would be deemed nonconforming, EPA will determine the actual nonconforming vehicles by counting backwards from the last vehicle produced in that test group. Manufacturers will be liable for penalties for each vehicle sold that is not covered by a certificate.

(d) *Requirements for the cold temperature averaging, banking, and trading (ABT) program.* (1) Manufacturers must average the cold temperature fleet average emissions of their vehicles and comply with the cold temperature fleet average standard. A manufacturer whose cold temperature fleet average emissions exceed the applicable standard must complete the calculation in paragraph (d)(4) of this section to determine the size of its credit deficit. A manufacturer whose cold temperature fleet average emissions are less than the applicable standard must complete the calculation in paragraph (d)(4) of this section to generate credits.

(2) There are no property rights associated with cold temperature credits generated under this subpart. Credits are a limited authorization to emit the designated amount of emissions. Nothing in this part or any other provision of law should be construed to limit EPA's authority to terminate or limit this authorization through rulemaking.

(3) Cold temperature NMHC credits may be used to demonstrate compliance with the cold temperature NMOG+$NO_X$ emission standards for Tier 4 vehicles.

The value of a cold temperature NMHC credit is deemed to be equal to the value of a cold temperature NMOG+$NO_X$ credit.

(4) Credits are earned on the last day of the model year. Manufacturers must calculate, for a given model year, the number of credits or debits it has generated according to the following equation, rounded to the nearest 0.1 grams/mile:

Fleet average Credits or Debits = (Cold Temperature NMHC or NMOG+$NO_X$ Standard—Manufacturer's Sales-Weighted Cold Temperature Fleet Average Emissions) × (Total Number of Vehicles Sold)

Where:

Manufacturer's Sales-Weighted Cold Temperature Fleet Average Emissions = average calculated according to paragraph (b) of this section.

Total Number of Vehicles Sold = Total 50-State sales based on the point of first sale.

(5) [Reserved]

(6) NMHC credits are not subject to any discount or expiration date except as required under the deficit carryforward provisions of paragraph (d)(8) of this section. There is no discounting of unused credits. NMHC credits have unlimited lives, subject to the limitations of paragraph (d)(2) of this section. Tier 3 to Tier 4.

(7) Credits may be used as follows:

(i) Credits generated and calculated according to the method in paragraph (d)(4) of this section may be used only to offset deficits accrued with respect to the standard in § 86.1811–10(g)(2). Credits may be banked and used in a future model year in which a manufacturer's average cold temperature fleet-average level exceeds the applicable standard. Credits may be exchanged only within averaging sets. Credits may also be traded to another manufacturer according to the provisions in paragraph (d)(9) of this section. Before trading or carrying over credits to the next model year, a manufacturer must apply available credits to offset any credit deficit, where the deadline to offset that credit deficit has not yet passed.

(ii) The use of credits shall not be permitted to address Selective Enforcement Auditing or in-use testing failures. The enforcement of the averaging standard occurs through the vehicle's certificate of conformity. A manufacturer's certificate of conformity is conditioned upon compliance with the averaging provisions. The certificate will be void ab initio if a manufacturer fails to meet the corporate average standard and does not obtain appropriate credits to cover its shortfalls in that model year or in the subsequent model year (see deficit carryforward provision in paragraph (d)(8) of this section). Manufacturers must track their certification levels and sales unless they produce only vehicles certified with FELs at or below the applicable to cold temperature fleet-average levels below the standard and have chosen to forgo credit banking.

(8) The following provisions apply if debits are accrued:

(i) If a manufacturer calculates that it has negative credits (also called ''debits'' or a ''credit deficit'') for a given model year, it may carry that deficit forward into the next model year. Such a carry-forward may only occur after the manufacturer exhausts any supply of banked credits. At the end of that next model year, the deficit must be covered with an appropriate number of credits that the manufacturer generates or purchases. Any remaining deficit is subject to an enforcement action, as described in this paragraph (d)(8). Manufacturers are not permitted to have a credit deficit for two consecutive years.

(ii) If debits are not offset within the specified time period, the number of vehicles not meeting the cold temperature fleet average standards (and therefore not covered by the certificate) must be calculated by dividing the total amount of debits for the model year by the cold temperature fleet average standard applicable for the model year in which the debits were first incurred.

(iii) EPA will determine the number of vehicles for which the condition on the certificate was not satisfied by designating vehicles in those test groups with the highest certification cold temperature NMHC or NMOG+$NO_X$ emission values first and continuing until reaching a number of vehicles equal to the calculated number of noncomplying vehicles as determined above. If this calculation determines that only a portion of vehicles in a test group contribute to the debit, EPA will designate actual vehicles in that test group as not covered by the certificate, starting with the last vehicle produced and counting backwards.

(iv)(A) If a manufacturer ceases production of vehicles affected by a debit balance, the manufacturer continues to be responsible for offsetting any debits outstanding within the required time period. Any failure to offset the debits will be considered a violation of paragraph (d)(8)(i) of this section and may subject the manufacturer to an enforcement action for sale of vehicles not covered by a certificate, pursuant to paragraphs (d)(8)(ii) and (iii) of this section.

(B) If a manufacturer is purchased by, merges with, or otherwise combines with another manufacturer, the controlling entity is responsible for offsetting any debits outstanding within the required time period. Any failure to offset the debits will be considered a violation of paragraph (d)(8)(i) of this section and may subject the manufacturer to an enforcement action for sale of vehicles not covered by a certificate, pursuant to paragraphs (d)(8)(ii) and (iii) of this section.

(v) For purposes of calculating the statute of limitations, a violation of the requirements of paragraph (d)(8)(i) of this section, a failure to satisfy the conditions upon which a certificate(s) was issued and hence a sale of vehicles not covered by the certificate, all occur upon the expiration of the deadline for offsetting debits specified in paragraph (d)(8)(i) of this section.

(9) The following provisions apply for trading cold temperature credits:

(i) EPA may reject credit trades if the involved manufacturers fail to submit the credit trade notification in the annual report. A manufacturer may not sell credits that are not available for sale pursuant to the provisions in paragraphs (d)(7)(i) of this section.

(ii) In the event of a negative credit balance resulting from a transaction that a manufacturer could not cover by the reporting deadline for the model year in which the trade occurred, both the buyer and seller are liable, except in cases involving fraud by either the buyer or seller. EPA may void ab initio the certificates of conformity of all engine families participating in such a trade.

(iii) A manufacturer may only trade credits that it has generated pursuant to paragraph (d)(4) of this section or acquired from another party.

■ 77. Amend § 86.1865–12 by revising paragraphs (i)(1), (i)(2) introductory text, and (j) and removing paragraph (k)(7)(iii).

The revisions read as follows:

### § 86.1865–12 How to comply with the fleet average $CO_2$ standards.

* * * * *

(i) * * *

(1) Through model year 2026, manufacturers must compute separate production-weighted fleet average carbon-related exhaust emissions at the end of the model year for passenger automobiles and light trucks, using actual production, where production means vehicles produced and delivered for sale, and certifying model types to standards as defined in § 86.1818–12.

The model type carbon-related exhaust emission results determined according to 40 CFR part 600, subpart F (in units of grams per mile rounded to the nearest whole number) become the certification standard for each model type.

(2) Through model year 2026, manufacturers must separately calculate production-weighted fleet average carbon-related exhaust emissions levels for the following averaging sets according to the provisions of 40 CFR part 600, subpart F:

* * * * *

(j) *Certification compliance and enforcement requirements for $CO_2$ exhaust emission standards.* (1) Compliance and enforcement requirements are provided in this section and § 86.1848–10(c)(9).

(2) The certificate issued for each test group requires all model types within that test group to meet the in-use emission standards to which each model type is certified. The in-use standards for passenger automobiles and light duty trucks (including MDPV) are described in § 86.1818–12(d). The in-use standards for non-MDPV heavy-duty vehicles are described in § 86.1819–14(b).

(3) EPA will issue a recall order as described in 40 CFR part 85, subpart S, if EPA or the manufacturer determines that a substantial number of a class or category of vehicles produced by that manufacturer, although properly maintained and used, do not conform to in-use $CO_2$ emission standards, or do not conform to the monitor accuracy requirements in § 86.1815. The recall would be intended to remedy repairable problems to bring the vehicle into compliance; however, if there is no demonstrable, repairable problem that could be remedied to bring the vehicles into compliance, the manufacturer must submit an alternative plan for to address the noncompliance. For example, manufacturers may need to calculate a correction to its emission credit balance based on the GHG emissions of the actual number of vehicles produced. EPA may void credits originally calculated from noncompliant vehicles, unless traded, and will adjust debits. In the case of traded credits, EPA will adjust the selling manufacturer's credit balance to reflect the sale of such credits and any resulting credit deficit. Manufacturers may voluntarily recall vehicles to remedy such a noncompliance and submit a voluntary recall report as described in 40 CFR part 85, subpart T.

(4) The manufacturer may request a hearing under 40 CFR part 1068, subpart G, regarding any voiding of credits or adjustment of debits under paragraph (j)(3) of this section. Manufacturers must submit such a request in writing describing the objection and any supporting data within 30 days after we make a decision.

(5) Each manufacturer must comply with the applicable $CO_2$ fleet average standard on a production-weighted average basis, at the end of each model year. Use the procedure described in paragraph (i) of this section for passenger automobiles and light trucks (including MDPV). Use the procedure described in § 86.1819–14(d)(9)(iv) for non-MDPV heavy-duty vehicles.

(6) Each manufacturer must comply on an annual basis with the fleet average standards as follows:

(i) Manufacturers must report in their annual reports to the Agency that they met the relevant corporate average standard by showing that the applicable production-weighted average $CO_2$ emission levels are at or below the applicable fleet average standards; or

(ii) If the production-weighted average is above the applicable fleet average standard, manufacturers must obtain and apply sufficient $CO_2$ credits as authorized under paragraph (k)(8) of this section. A manufacturer must show that they have offset any exceedance of the corporate average standard via the use of credits. Manufacturers must also include their credit balances or deficits in their annual report to the Agency.

(iii) If a manufacturer fails to meet the corporate average $CO_2$ standard for four consecutive years, the vehicles causing the corporate average exceedance will be considered not covered by the certificate of conformity (see paragraph (k)(8) of this section). A manufacturer will be subject to penalties on an individual-vehicle basis for sale of vehicles not covered by a certificate.

(iv) EPA will review each manufacturer's production to designate the vehicles that caused the exceedance of the corporate average standard. EPA will designate as nonconforming those vehicles in test groups with the highest certification emission values first, continuing until reaching a number of vehicles equal to the calculated number of noncomplying vehicles as determined in paragraph (k)(8) of this section. In a group where only a portion of vehicles would be deemed nonconforming, EPA will determine the actual nonconforming vehicles by counting backwards from the last vehicle produced in that test group. Manufacturers will be liable for penalties for each vehicle sold that is not covered by a certificate.

* * * * *

■ 78. Amend § 86.1866–12 by revising paragraphs (a) and (c)(3) to read as follows:

### § 86.1866–12 $CO_2$ credits for advanced technology vehicles.

* * * * *

(a) Electric vehicles, plug-in hybrid electric vehicles, and fuel cell vehicles that are certified and produced for sale in the states and territories of the United States may use a value of zero grams $CO_2$ per mile to represent the proportion of electric operation of a vehicle that is derived from electricity generated from sources that are not onboard the vehicle.

* * * * *

(c) * * *

(3) Multiplier-based credits for model years 2022 through 2024 may not exceed credit caps, as follows:

(i) Calculate a nominal annual credit cap in Mg using the following equation, rounded to the nearest whole number:

$$CAP_{annual} = 5.0\,\frac{\text{g}}{\text{mile}} \cdot \left[195{,}264\text{ miles} \cdot P_{auto} + 225{,}865 \cdot P_{truck}\right] \cdot 10^{-6}\,\frac{\text{tonne}}{\text{g}}$$

Where:

$P_{auto}$ = total number of certified passenger automobiles the manufacturer produced in a given model year for sale in any state or territory of the United States.

$P_{truck}$ = total number of certified light trucks (including MDPV) the manufacturer produced in a given model year for sale in any state or territory of the United States.

(ii) Calculate an annual g/mile equivalent value for the multiplier-based credits using the following equation, rounded to the nearest 0.1 g/mile:

$$annual\ g\ per\ mile\ equivalent\ value = 5.0 \cdot \frac{annual\ credits}{CAP_{annual}}$$

Where:

*annual credits* = a manufacturer's total multiplier-based credits in a given model year from all passenger automobiles and light trucks as calculated under this paragraph (c).

(iii) Calculate a cumulative g/mile equivalent value for the multiplier-based credits in each year by adding the annual g/mile equivalent values calculated under paragraph (c)(3)(ii) of this section.

(iv) The cumulative g/mile equivalent value may not exceed 10.0 in any year.

(v) For every year of certifying with multiplier-based credits, the annual credit report must include the calculated values for the nominal annual credit cap in Mg and the cumulative g/mile equivalent value.

■ 79. Amend § 86.1867–12 by revising the introductory text to read as follows:

### § 86.1867–12 $CO_2$ credits for reducing leakage of air conditioning refrigerant.

Through model year 2026, manufacturers may generate credits applicable to the $CO_2$ fleet average program described in § 86.1865–12 by implementing specific air conditioning system technologies designed to reduce air conditioning refrigerant leakage over the useful life of their passenger automobiles and/or light trucks (including MDPV); only the provisions of paragraph (a) of this section apply for non-MDPV heavy-duty vehicles. Credits shall be calculated according to this section for each air conditioning system that the manufacturer is using to generate $CO_2$ credits. Manufacturers may no longer generate credits under this section starting in model year 2027.

* * * * *

■ 80. Amend § 86.1868–12 by:

■ a. Revising the introductory text.

■ b. Removing paragraph (a)(1).

■ c. Redesignating paragraph (a)(2) as paragraph (a).

■ d. Revising the redesignated paragraph (a).

■ e. Adding a heading to the table in newly redesignated paragraph (a).

■ f. Revising paragraph (b).

■ g. Removing and reserving paragraphs (e) and (f).

■ h. Revising paragraph (g) introductory text.

The revisions and addition read as follows:

### § 86.1868–12 $CO_2$ credits for improving the efficiency of air conditioning systems.

Manufacturers may generate credits applicable to the $CO_2$ fleet average program described in § 86.1865–12 by implementing specific air conditioning system technologies designed to reduce air conditioning-related $CO_2$ emissions over the useful life of their passenger automobiles and light trucks (including MDPV). The provisions of this section do not apply for non-MDPV heavy-duty vehicles. Credits shall be calculated according to this section for each air conditioning system that the manufacturer is using to generate $CO_2$ credits. Manufacturers must validate credits under this section based on testing as described in paragraph (g) of this section. Starting in model year 2027, manufacturers may generate credits under this section only for vehicles propelled by internal combustion engines.

(a) Air conditioning efficiency credits are available for the following technologies in the gram per mile amounts indicated for each vehicle category in the following table:

**Table 1 to Paragraph (a)**

* * * * *

(b) Air conditioning efficiency credits are determined on an air conditioning system basis. For each air conditioning system that is eligible for a credit based on the use of one or more of the items listed in paragraph (a) of this section, the total credit value is the sum of the gram per mile values for the appropriate model year listed in paragraph (a) for each item that applies to the air conditioning system. The total credit value for an air conditioning system may not be greater than 5.0 grams per mile for any passenger automobile or 7.2 grams per mile for any light truck.

* * * * *

(g) *AC17 validation testing and reporting requirements.* Manufacturers must validate air conditioning credits by using the AC17 Test Procedure in 40 CFR 1066.845 as follows:

* * * * *

■ 81. Amend § 86.1869–12 by revising the introductory text and paragraph (b)(2) to read as follows:

### § 86.1869–12 $CO_2$ credits for off-cycle $CO_2$ reducing technologies.

This section describes how manufacturers may generate credits for off-cycle $CO_2$-reducing technologies through model year 2030. The provisions of this section do not apply for non-MDPV heavy-duty vehicles, except that § 86.1819–14(d)(13) describes how to apply paragraphs (c) and (d) of this section for those vehicles. Manufacturers may no longer generate credits under this section starting in model year 2027 for vehicles deemed to have zero tailpipe emissions and in model year 2031 for all other vehicles. Manufacturers may no longer generate credits under paragraphs (c) and (d) of this section for any type of vehicle starting in model year 2027.

* * * * *

(b) * * *

(2) The maximum allowable decrease in the manufacturer's combined passenger automobile and light truck fleet average $CO_2$ emissions attributable to use of the default credit values in paragraph (b)(1) of this section is specified in paragraph (b)(2)(v) of this section. If the total of the $CO_2$ g/mi credit values from paragraph (b)(1) of this section does not exceed the specified off-cycle credit cap for any passenger automobile or light truck in a manufacturer's fleet, then the total off-cycle credits may be calculated according to paragraph (f) of this section. If the total of the $CO_2$ g/mi credit values from paragraph (b)(1) of this section exceeds the specified off-cycle credit cap for any passenger automobile or light truck in a manufacturer's fleet, then the gram per mile decrease for the combined passenger automobile and light truck fleet must be determined according to paragraph (b)(2)(ii) of this section to determine whether the applicable limitation has been exceeded.

(i) Determine the gram per mile decrease for the combined passenger automobile and light truck fleet using the following formula:

$$\text{Decrease} = \frac{Credits \times 1{,}000{,}000}{[(\text{Prod}_\text{C} \times 195{,}264) + (\text{Prod}_\text{T} \times 225{,}865)]}$$

Where:

Credits = The total of passenger automobile and light truck credits, in Megagrams, determined according to paragraph (f) of this section and limited to those credits accrued by using the default gram per mile values in paragraph (b)(1) of this section.

$Prod_C$ = The number of passenger automobiles produced by the manufacturer and delivered for sale in the U.S.

$Prod_T$ = The number of light trucks produced by the manufacturer and delivered for sale in the U.S.

(ii) If the value determined in paragraph (b)(2)(i) of this section is greater than the off-cycle credit cap specified in paragraph (b)(2)(v) of this section, the total credits, in Megagrams, that may be accrued by a manufacturer using the default gram per mile values in paragraph (b)(1) of this section shall be determined using the following formula:

$$\text{Credit (Megagrams)} = \frac{\left[\text{cap} \times \left((\text{Prod}_C \times 195{,}264) + (\text{Prod}_T \times 225{,}865)\right)\right]}{1{,}000{,}000}$$

Where:

cap = the off-cycle credit cap specified in paragraph (b)(2)(v) of this section.

$Prod_C$ = The number of passenger automobiles produced by the manufacturer and delivered for sale in the U.S.

$Prod_T$ = The number of light trucks produced by the manufacturer and delivered for sale in the U.S.

(iii) If the value determined in paragraph (b)(2)(i) of this section is not greater than the off-cycle credit cap specified in paragraph (b)(2)(v) of this section, then the credits that may be accrued by a manufacturer using the default gram per mile values in paragraph (b)(1) of this section do not exceed the allowable limit, and total credits may be determined for each category of vehicles according to paragraph (f) of this section.

(iv) If the value determined in paragraph (b)(2)(i) of this section is greater than the off-cycle credit cap specified in paragraph (b)(2)(v) of this section, then the combined passenger automobile and light truck credits, in Megagrams, that may be accrued using the calculations in paragraph (f) of this section must not exceed the value determined in paragraph (b)(2)(ii) of this section. This limitation should generally be done by reducing the amount of credits attributable to the vehicle category that caused the limit to be exceeded such that the total value does not exceed the value determined in paragraph (b)(2)(ii) of this section.

(v) The manufacturer's combined passenger automobile and light truck fleet average $CO_2$ emissions attributable to use of the default credit values in paragraph (b)(1) of this section may not exceed the specific values as described in this paragraph (b)(2)(v). Starting in model year 2027, adjust the credit contribution from PHEVs in the fleet-average calculation by dividing the PHEV off-cycle credit value by the utility factor established under 40 CFR 600.116–12(c)(1) or (c)(10)(iii) (weighted 55 percent city, 45 percent highway). For example, if a PHEV has utility factor of 0.3 and an off-cycle credit of 3.0, count it as having a credit value of 10 (3/0.3) for calculating the fleet average value. The following maximum values apply for off-cycle credits:

| Model year | Off-cycle credit cap (g/mile) |
|---|---|
| (A) 2023–2026 | 15 |
| (B) 2027 | 10 |
| (C) 2028 | 8.0 |
| (D) 2029 | 6.0 |
| (E) 2030 | 3.0 |

* * * * *

**§ 86.1871–12 [Removed]**

■ 82. Remove § 86.1871–12.

## PART 600—FUEL ECONOMY AND GREENHOUSE GAS EXHAUST EMISSIONS OF MOTOR VEHICLES

■ 83. The authority citation for part 1036 continues to read as follows:

**Authority:** 49 U.S.C. 32901—23919q, Pub. L. 109–58.

■ 84. Amend § 600.007 by revising paragraph (b)(4) introductory text to read as follows:

**§ 600.007 Vehicle acceptability.**

* * * * *

(b) * * *

(4) Each fuel economy data vehicle must meet the same exhaust emission standards as certification vehicles of the respective engine-system combination during the test in which the fuel economy test results are generated. This may be demonstrated using one of the following methods:

* * * * *

■ 85. Amend § 600.113–12 by revising the introductory text and paragraph (n) to read as follows:

**§ 600.113–12 Fuel economy, $CO_2$ emissions, and carbon-related exhaust emission calculations for FTP, HFET, US06, SC03 and cold temperature FTP tests.**

The Administrator will use the calculation procedure set forth in this section for all official EPA testing of vehicles fueled with gasoline, diesel, alcohol-based or natural gas fuel. The calculations of the weighted fuel economy and carbon-related exhaust emission values require input of the weighted grams/mile values for total hydrocarbons (HC), carbon monoxide (CO), and carbon dioxide ($CO_2$); and, additionally for methanol-fueled automobiles, methanol ($CH_3OH$) and formaldehyde (HCHO); and, additionally for ethanol-fueled automobiles, methanol ($CH_3OH$), ethanol ($C_2H_5OH$), acetaldehyde ($C_2H_4O$), and formaldehyde (HCHO); and additionally for natural gas-fueled vehicles, non-methane hydrocarbons (NMHC) and methane ($CH_4$). For manufacturers selecting the fleet averaging option for $N_2O$ and $CH_4$ as allowed under § 86.1818 of this chapter the calculations of the carbon-related exhaust emissions require the input of grams/mile values for nitrous oxide ($N_2O$) and methane ($CH_4$). Emissions shall be determined for the FTP, HFET, US06, SC03, and cold temperature FTP tests. Additionally, the specific gravity, carbon weight fraction and net heating value of the test fuel must be determined. The FTP, HFET, US06, SC03, and cold temperature FTP fuel economy and carbon-related exhaust emission values shall be calculated as specified in this section. An example fuel economy calculation appears in Appendix II of this part.

* * * * *

(n) Manufacturers may use a value of 0 grams $CO_2$ and CREE per mile to represent the emissions of fuel cell vehicles and the proportion of electric operation of a electric vehicles and plug-in hybrid electric vehicles that is derived from electricity that is generated from sources that are not onboard the vehicle.

* * * * *

■ 86. Amend § 600.116–12 by revising paragraphs (c)(1), (c)(2)(i) and (iii), and (c)(5) and (10) and adding paragraph (c)(11) to read as follows:

**§ 600.116–12 Special procedures related to electric vehicles and hybrid electric vehicles.**

* * * * *

(c) * * *

(1) To determine CREE values to demonstrate compliance with GHG standards, calculate composite values representing combined operation during charge-depleting and charge-sustaining operation using the following utility factors, except as otherwise specified in this paragraph (c):

TABLE 1 TO PARAGRAPH (c)(1)—FLEET UTILITY FACTORS FOR URBAN "CITY" DRIVING

| Schedule range for UDDS phases, miles | Model year 2026 and earlier | | Model year 2027 and later | |
|---|---|---|---|---|
| | Cumulative UF | Sequential UF | Cumulative UF | Sequential UF |
| 3.59 | 0.125 | 0.125 | 0.062 | 0.062 |
| 7.45 | 0.243 | 0.117 | 0.125 | 0.062 |
| 11.04 | 0.338 | 0.095 | 0.178 | 0.054 |
| 14.90 | 0.426 | 0.088 | 0.232 | 0.053 |
| 18.49 | 0.497 | 0.071 | 0.278 | 0.046 |
| 22.35 | 0.563 | 0.066 | 0.324 | 0.046 |
| 25.94 | 0.616 | 0.053 | 0.363 | 0.040 |
| 29.80 | 0.666 | 0.049 | 0.403 | 0.040 |
| 33.39 | 0.705 | 0.040 | 0.437 | 0.034 |
| 37.25 | 0.742 | 0.037 | 0.471 | 0.034 |
| 40.84 | 0.772 | 0.030 | 0.500 | 0.029 |
| 44.70 | 0.800 | 0.028 | 0.530 | 0.029 |
| 48.29 | 0.822 | 0.022 | 0.555 | 0.025 |
| 52.15 | 0.843 | 0.021 | 0.580 | 0.025 |
| 55.74 | 0.859 | 0.017 | 0.602 | 0.022 |
| 59.60 | 0.875 | 0.016 | 0.624 | 0.022 |
| 63.19 | 0.888 | 0.013 | 0.643 | 0.019 |
| 67.05 | 0.900 | 0.012 | 0.662 | 0.019 |
| 70.64 | 0.909 | 0.010 | 0.679 | 0.017 |

TABLE 2 TO PARAGRAPH (c)(1)—FLEET UTILITY FACTORS FOR HIGHWAY DRIVING

| Schedule range for HFET, miles | Model year 2026 and earlier | | Model year 2027 and later | |
|---|---|---|---|---|
| | Cumulative UF | Sequential UF | Cumulative UF | Sequential UF |
| 10.3 | 0.123 | 0.123 | 0.168 | 0.168 |
| 20.6 | 0.240 | 0.117 | 0.303 | 0.136 |
| 30.9 | 0.345 | 0.105 | 0.414 | 0.110 |
| 41.2 | 0.437 | 0.092 | 0.503 | 0.090 |
| 51.5 | 0.516 | 0.079 | 0.576 | 0.073 |
| 61.8 | 0.583 | 0.067 | 0.636 | 0.060 |
| 72.1 | 0.639 | 0.056 | 0.685 | 0.049 |

(2) * * *

(i) For vehicles that are not dual fueled automobiles, determine fuel economy using the utility factors specified in paragraph (c)(1) of this section for model year 2026 and earlier vehicles. Do not use the petroleum-equivalence factors described in 10 CFR 474.3.

* * * * *

(iii) For 2016 and later model year dual fueled automobiles, you may determine fuel economy based on the following equation, separately for city and highway driving:

$$MPGe_{\mathrm{CAFE}} = \frac{1}{\left(\frac{UF}{MPG_{\mathrm{elec}}} + \frac{(1-UF)}{MPGe_{\mathrm{gas}}}\right)}$$

Where:

UF = The appropriate utility factor for city or highway driving specified in paragraph (c)(1) of this section for model year 2026 and earlier vehicles.

* * * * *

(5) Instead of the utility factors specified in paragraphs (c)(1) through (3) of this section, calculate utility factors using the following equation for vehicles whose maximum speed is less than the maximum speed specified in the driving schedule, where the vehicle's maximum speed is determined, to the nearest 0.1 mph, from observing the highest speed over the first duty cycle (FTP, HFET, etc.):

$$UF_i = 1 - \left[\exp\left(-\sum_{j=1}^{k}\left(\left(\frac{d_i}{ND}\right)^j \times C_j\right)\right)\right] - \sum_{i=1}^{n} UF_{i-1}$$

Where:

$UF_i$ = the utility factor for phase $i$. Let $UF_0 = 0$.

$J$ = a counter to identify the appropriate term in the summation (with terms numbered consecutively).

$K$ = the number of terms in the equation (see Table 5 of this section).

$d_i$ = the distance driven in phase $i$.

$ND$ = the normalized distance. Use 399 for both FTP and HFET operation for fleet values CAFE, and for GHG through model year 2026. Use 583 for both FTP and HFET operation for GHG fleet values starting in model year 2027. Use 399 for both FTP and HFET operation for multi-day individual value for labeling.

$C_j$ = the coefficient for term $j$ from the following table:

TABLE 5 TO PARAGRAPH (c)(5)—CITY/HIGHWAY SPECIFIC UTILITY FACTOR COEFFICIENTS

| Coefficient | Fleet values for I, and for GHG through MY 2026 | | Fleet values for GHG starting in MY 2027 | Multi-day individual value for labeling |
|---|---|---|---|---|
| | City | Highway | City or highway | City or highway |
| 1 | 14.86 | 4.8 | 10.52 | 13.1 |
| 2 | 2.965 | 13 | −7.282 | −18.7 |
| 3 | −84.05 | −65 | −26.37 | 5.22 |
| 4 | 153.7 | 120 | 79.08 | 8.15 |
| 5 | −43.59 | −100.00 | −77.36 | 3.53 |
| 6 | −96.94 | 31.00 | 26.07 | −1.34 |
| 7 | 14.47 | | | −4.01 |
| 8 | 91.70 | | | −3.90 |
| 9 | −46.36 | | | −1.15 |
| 10 | | | | 3.88 |

$n$ = the number of test phases (or bag measurements) before the vehicle reaches the end-of-test criterion.

* * * * *

(10) The utility factors described in this paragraph (c) and in § 600.510 are derived from equations in SAE J2841. You may alternatively calculate utility factors from the corresponding equations in SAE J2841 as follows:

(i) Calculate utility factors for labeling directly from the equation in SAE J2841 Section 6.2 using the Table 2 MDIUF Fit Coefficients (C1 through C10) and a normalized distance (norm_dist) of 399 miles.

(ii) Calculate utility factors for fuel economy standards from the equation in SAE J2841 Section 6.2 using the Table 5 Fit Coefficients for city/Hwy Specific FUF curves weighted 55 percent city, 45 percent highway and a normalized distance (norm_dist) of 399 miles.

(iii) Starting in model year 2027, calculate utility factors for GHG compliance with emission standards from the equation in SAE J2841 Section 6.2 using the Table 2 FUF Fit Coefficients (C1 through C6) and a normalized distance (norm_dist) of 583 miles. For model year 2026 and earlier, calculate utility factors for compliance with GHG emission standards as described in paragraph (c)(10)(ii) of this section.

(11) The following methodology is used to determine the useable battery energy (UBE) for a PHEV using data obtained during either the UDDS Full Charge Test (FCT) or the HFET Full Charge Test as described in SAE J1711:

(i) Perform the measurements described in SAE J1711 Section 4.3.2.3.d. Record initial and final SOC of the RESS for each cycle in the FCT.

(ii) Calculate utility factors for fuel economy standards from the equation in SAE J2841 Section 6.2 using the Table 5 Fit Coefficients for city/Hwy Specific FUF curves (weighted 55 percent city, 45 percent highway) and a normalized distance (norm_dist) of 399 miles.

(iii) Determine average RESS voltage during each cycle of the FCT by averaging the results of either the continuous voltage measurement or by averaging the initial and final voltage measurement.

(iv) Determine the DC discharge energy for each cycle of the FCT by multiplying the change in SOC of each cycle by the average voltage for the cycle. You may instead use a DC wideband power analyzer meeting the requirements of SAE J1711 Section 4.2.a. to directly measure the DC discharge energy of the RESS during each cycle of the FCT.

(v) After completing the FCT, determine the cycles comprising the Charge-Depleting Cycle Range (Rcdc) as described in SAE J1711 Section 3.1.13. Rcdc includes the transitional cycle or cycles where the vehicle may have operated in both charge-depleting and charge-sustaining modes. Do not include charge-sustaining cycles in Rcdc.

(vi) Determine the UBE of the PHEV by summing the measured DC discharge energy for each cycle comprising Rcdc. Following the charge-depleting cycles and during the transition to charge-sustaining operation, one or more of the transition cycles may involve vehicle charging without discharging the RESS. Include these negative discharge results in the summation.

* * * * *

■ 87. Revise § 600.117 to read as follows:

### § 600.117 Interim provisions.

(a) The following provisions apply instead of other provisions specified in this part through model year 2026:

(1) Except as specified in paragraphs (a)(5) and (6) of this section, manufacturers must demonstrate compliance with greenhouse gas emission standards and determine fuel economy values using E0 gasoline test fuel as specified in 40 CFR 86.113–04(a)(1), regardless of any testing with E10 test fuel specified in 40 CFR 1065.710(b) under paragraph (a)(2) of this section.

(2) Manufacturers may demonstrate that vehicles comply with emission standards for criteria pollutants as specified in 40 CFR part 86, subpart S, during fuel economy measurements using the E0 gasoline test fuel specified in 40 CFR 86.113–04(a)(1), as long as this test fuel is used in fuel economy testing for all applicable duty cycles specified in 40 CFR part 86, subpart S. If a vehicle fails to meet an emission standard for a criteria pollutant using the E0 gasoline test fuel specified in 40 CFR 86.113–04(a)(1), the manufacturer must retest the vehicle using the E10 test fuel specified in 40 CFR 1065.710(b) (or the equivalent LEV III test fuel for California) to demonstrate compliance with all applicable emission standards over that test cycle.

(3) If a manufacturer demonstrates compliance with emission standards for criteria pollutants over all five test cycles using the E10 test fuel specified in 40 CFR 1065.710(b) (or the equivalent LEV III test fuel for California), the manufacturer may use test data with the same test fuel to determine whether a test group meets the criteria described in § 600.115 for derived 5-cycle testing for fuel economy labeling. Such vehicles may be tested over the FTP and HFET cycles with the E0 gasoline test fuel specified in 40 CFR 86.113–04(a)(1) under this paragraph (a)(3); the vehicles must meet the emission standards for criteria pollutants over those test cycles as described in paragraph (a)(2) of this section.

(4) Manufacturers may perform testing with the appropriate gasoline test fuels specified in 40 CFR 86.113–04(a)(1), 86.213(a)(2), and 1065.710(b) to evaluate whether their vehicles meet the criteria for derived 5-cycle testing under § 600.115. All five tests must use test fuel with the same nominal ethanol concentration.

(5) For IUVP testing under 40 CFR 86.1845, manufacturers may demonstrate compliance with greenhouse gas emission standards using a test fuel meeting specifications for demonstrating compliance with emission standards for criteria pollutants.

(6) Manufacturers may alternatively demonstrate compliance with greenhouse gas emission standards and determine fuel economy values using E10 gasoline test fuel as specified in 40 CFR 1065.710(b). However, manufacturers must then multiply measured $CO_2$ results by 1.0166 and round to the nearest 0.01 g/mile and calculate fuel economy using the equations appropriate equation for testing with E10 test fuel.

(7) If a vehicle uses an E10 test fuel for evaporative emission testing and E0 is the applicable test fuel for exhaust emission testing, exhaust measurement and reporting requirements apply over the course of the evaporative emission test, but the vehicle need not meet the exhaust emission standards during the evaporative emission test run.

(b) Manufacturers may certify model year 2027 through 2029 vehicles to greenhouse gas emission standards using data with E0 test fuel from testing for earlier model years, subject to the carryover provisions of 40 CFR 86.1839. In the case of the fleet average $CO_2$ standard, manufacturers must divide the measured $CO_2$ results by 1.0166 and round to the nearest 0.01 g/mile.

## PART 1036—CONTROL OF EMISSIONS FROM NEW AND IN-USE HEAVY-DUTY HIGHWAY ENGINES

■ 88. The authority citation for part 1036 continues to read as follows:

**Authority:** 42 U.S.C. 7401–7671q.

■ 89. Add § 1036.635 to read as follows:

### § 1036.635 Certification requirements for high-GCWR medium-duty vehicles.

This section describes provisions that apply for engines certified under this part for installation in vehicles at or below 14,000 pounds GVWR that have GCWR above 22,000 pounds.

(a) Engines that will be installed in complete vehicles must meet the criteria pollutant emission standards specified in § 1036.104. Those engines are exempt from the greenhouse gas emission standards in § 1036.108, but engine certification under this part 1036 depends on the following conditions:

(1) The vehicles in which the engines are installed must meet the following vehicle-based standards under 40 CFR part 86, subpart S:

(i) Evaporative and refueling emission standards as specified in 40 CFR 86.1813–17.

(ii) Greenhouse gas emission standards as specified in 40 CFR 86.1819–14.

(iii) For electric vehicles, battery durability standards in 40 CFR 86.1815.

(2) Additional provisions related to greenhouse gas emission standards from 40 CFR part 86, subpart S, apply for certifying engines under this part, as illustrated in the following examples:

(i) The engine's emission control information label must state that the vehicle meets evaporative and refueling emission standards under 40 CFR 86.1813–17 and greenhouse gas emission standards under 40 CFR 86.1819–14.

(ii) The application for certification must include the information related to complying with evaporative, refueling, and greenhouse gas emission standards.

(iii) We may require you to perform testing on in-use vehicles as specified in 40 CFR 86.1845–04 and 86.1846–01.

(iv) Demonstrate compliance with the fleet average $CO_2$ standard as described in 40 CFR 86.1865–12 by including vehicles certified under this section in the compliance calculations as part of the averaging set for medium-duty vehicles certified under 40 CFR part 86, subpart S.

(3) State in the application for certification that you are using the provisions of this section to meet the fleet average $CO_2$ standard in 40 CFR 86.1819–14 instead of meeting the standards of § 1036.108 and instead of certifying the vehicle to standards under 40 CFR part 1037.

(b) The provisions of this section are optional for engines installed in incomplete vehicles at or below 14,000 pounds GVWR that have GCWR above 22,000 pounds.

## PART 1037—CONTROL OF EMISSIONS FROM NEW HEAVY-DUTY MOTOR VEHICLES

■ 90. The authority citation for part 1037 continues to read as follows:

**Authority:** 42 U.S.C. 7401–7671q.

■ 91. Amend § 1037.150 by revising paragraph (l) to read as follows:

### § 1037.150 Interim provisions.

* * * * *

(l) *Optional certification to GHG standards under 40 CFR part 86.* The greenhouse gas standards in 40 CFR part 86, subpart S, may apply instead of the standards of § 1037.105 as follows:

(1) Complete or cab-complete vehicles may optionally meet alternative standards as described in 40 CFR 86.1819–14(j).

(2) Complete high-GCWR vehicles must meet the greenhouse gas standards of 40 CFR part 86, subpart S, as described in 40 CFR 1036.635.

(3) Incomplete high-GCWR vehicles may meet the greenhouse gas standards of 40 CFR part 86, subpart S, as described in 40 CFR 1036.635.

* * * * *

## PART 1066—VEHICLE-TESTING PROCEDURES

■ 92. The authority citation for part 1066 continues to read as follows:

**Authority:** 42 U.S.C. 7401–7671q.

■ 93. Amend § 1066.801 by revising the introductory text and paragraphs (c) and (e) to read as follows:

### § 1066.801 Applicability and general provisions.

This subpart I specifies how to apply the test procedures of this part for light-duty vehicles, light-duty trucks, and heavy-duty vehicles at or below 14,000 pounds GVWR that are subject to chassis testing for exhaust emissions under 40 CFR part 86, subpart S. For these vehicles, references in this part 1066 to the standard-setting part include this subpart I.

* * * * *

(c) This subpart covers the following test procedures:

(1) The Federal Test Procedure (FTP), which includes the general driving cycle. This procedure is also used for measuring evaporative emissions. This may be called the conventional test since it was adopted with the earliest emission standards.

(i) The FTP consists of one Urban Dynamometer Driving Schedule (UDDS) as specified in paragraph (a) of appendix I of 40 CFR part 86, followed by a 10-minute soak with the engine off and repeat driving through the first 505 seconds of the UDDS. Note that the UDDS represents about 7.5 miles of driving in an urban area. Engine startup (with all accessories turned off), operation over the initial UDDS, and engine shutdown make a complete cold-start test. The hot-start test consists of the first 505 seconds of the UDDS following the 10-minute soak and a hot-running portion of the UDDS after the first 505 seconds. The first 505 seconds of the UDDS is considered the transient portion; the remainder of the UDDS is considered the stabilized (or hot-stabilized) portion. The hot-stabilized portion for the hot-start test is generally measured during the cold-start test; however, in certain cases, the hot-start test may involve a second full UDDS following the 10-minute soak, rather than repeating only the first 505 seconds. See §§ 1066.815 and 1066.820.

(ii) Evaporative emission testing includes a preconditioning drive with the UDDS and a full FTP cycle, including exhaust measurement, followed by evaporative emission measurements. In the three-day diurnal test sequence, the exhaust test is followed by a running loss test consisting of a UDDS, then two New York City Cycles as specified in paragraph (e) of appendix I of 40 CFR part 86, followed by another UDDS; see 40 CFR 86.134. Note that the New York City Cycle represents about 1.18 miles of driving in a city center. The running loss test is followed by a high-temperature hot soak test as described in 40 CFR 86.138 and a three-day diurnal emission test as described in 40 CFR 86.133. In the two-day diurnal test sequence, the exhaust test is followed by a low-temperature hot soak test as described in 40 CFR 86.138–96(k) and a two-day diurnal emission test as described in 40 CFR 86.133–96(p).

(iii) Refueling emission tests for vehicles that rely on integrated control of diurnal and refueling emissions includes vehicle operation over the full FTP test cycle corresponding to the three-day diurnal test sequence to precondition and purge the evaporative canister. For non-integrated systems, there is a preconditioning drive over the UDDS and a refueling event, followed by repeated UDDS driving to purge the evaporative canister. The refueling emission test procedures are described in 40 CFR 86.150 through 86.157.

(2) The US06 driving cycle is specified in paragraph (g) of appendix I of 40 CFR part 86. Note that the US06 driving cycle represents about 8.0 miles of relatively aggressive driving.

(3) The SC03 driving cycle is specified in paragraph (h) of appendix I of 40 CFR part 86. Note that the SC03 driving schedule represents about 3.6 miles of urban driving with the air conditioner operating.

(4) The hot portion of the LA–92 driving cycle is specified in paragraph (c) of appendix I of 40 CFR part 86. Note that the hot portion of the LA–92 driving cycle represents about 9.8 miles of relatively aggressive driving for commercial trucks. This driving cycle applies for heavy-duty vehicles above 10,000 pounds GVWR and at or below 14,000 pounds GVWR only for vehicles subject to Tier 3 standards.

(5) The Highway Fuel Economy Test (HFET) is specified in appendix I of 40 CFR part 600. Note that the HFET represents about 10.2 miles of rural and freeway driving with an average speed of 48.6 mi/hr and a maximum speed of 60.0 mi/hr. See § 1066.840.

(6) Cold temperature standards apply for CO and NMHC emissions when vehicles operate over the FTP at a nominal temperature of −7 °C. See 40 CFR part 86, subpart C, and subpart H of this part.

(7) Emission measurement to determine air conditioning credits for greenhouse gas standards. In this optional procedure, manufacturers operate vehicles over repeat runs of the AC17 test sequence to allow for calculating credits as part of demonstrating compliance with $CO_2$ emission standards. The AC17 test sequence consists of a UDDS preconditioning drive, followed by emission measurements over the SC03 and HFET driving cycles. See § 1066.845.

(8) The mid-temperature intermediate soak FTP is specified as the procedure for Partial Soak Emission Testing in Section E4.4 of CARB's PHEV Test Procedures for plug-in hybrid electric vehicles, in Part II Section I.7 of CARB's LMDV Test Procedures for other hybrid electric vehicles, and in Part II, Section B.9.1 and B.9.3 of CARB's LMDV Test Procedures for other vehicles (both incorporated by reference, see § 1066.1010).

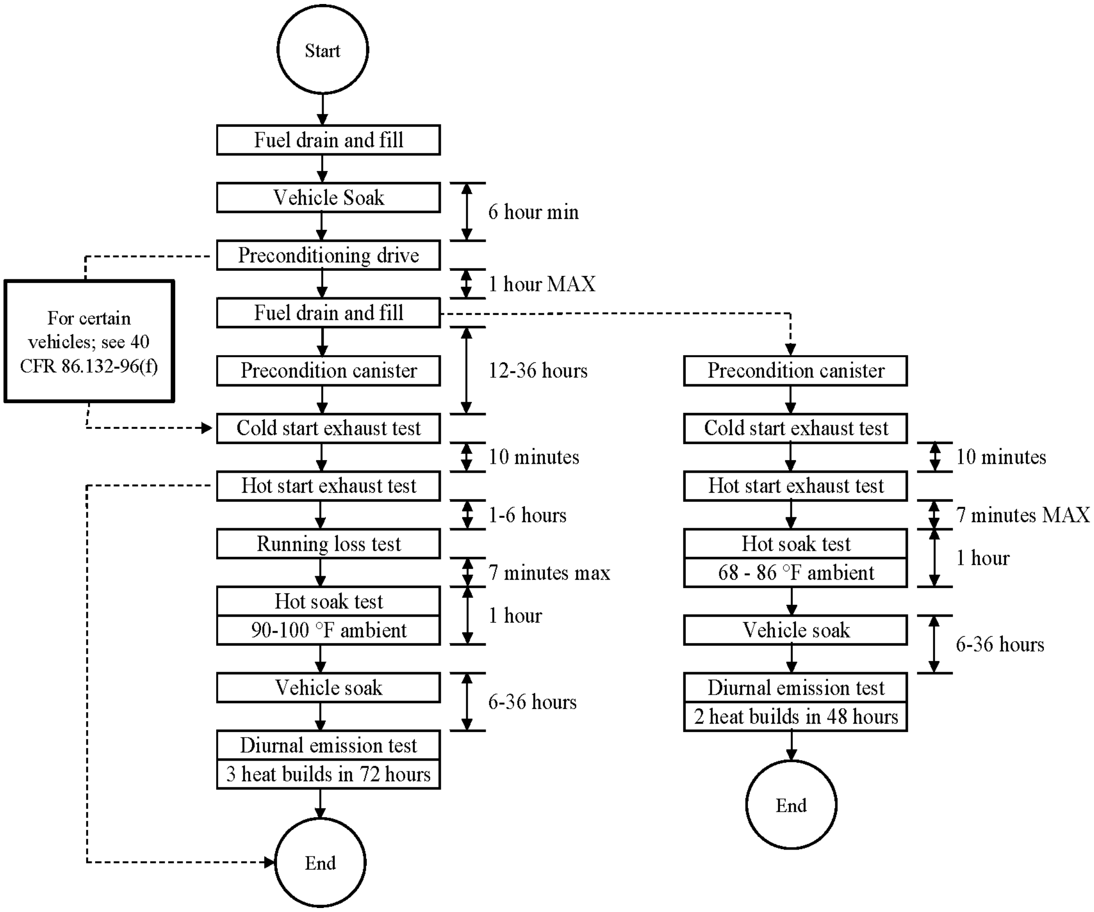
(9) The early driveaway FTP is specified as the procedure for Quick Drive-Away Emission Testing in Section E4.5 of CARB's PHEV Test Procedures for plug-in hybrid electric vehicles, in Part II Section I.8 of CARB's LMDV Test Procedures for other hybrid electric vehicles, and in Part II, Section B.9.2 and B.9.4 of CARB's LMDV Test Procedures for other vehicles (both incorporated by reference, see § 1066.1010).

(10) The high-load PHEV engine starts US06 is specified in Section E7.2 of CARB's PHEV Test Procedures using the cold-start US06 Charge-Depleting Emission Test (incorporated by reference, see § 1066.1010).

* * * * *

(e) The following figure illustrates the FTP test sequence for measuring exhaust and evaporative emissions:

**Figure 1 to Paragraph (e)**



■ 94. Amend § 1066.805 by revising paragraph (c) to read as follows:

### § 1066.805 Road-load power, test weight, and inertia weight class determination.

* * * * *

(c) For FTP, US06, SC03, New York City Cycle, HFET, and LA–92 testing, determine road-load forces for each test vehicle at speeds between 9.3 and 71.5 miles per hour. The road-load force must represent vehicle operation on a smooth, level road with no wind or calm winds, no precipitation, an ambient temperature of approximately 20 °C, and atmospheric pressure of 98.21 kPa. You may extrapolate road-load force for speeds below 9.3 mi/hr.

■ 95. Revise § 1066.830 to read as follows:

### § 1066.830 Supplemental Federal Test Procedures; overview.

Sections 1066.831 and 1066.835 describe the detailed procedures for the Supplemental Federal Test Procedure (SFTP). This testing applies for Tier 3 vehicles subject to the SFTP standards in 40 CFR 86.1811–17 or 86.1816–18. The SFTP test procedure consists of FTP testing and two additional test elements—a sequence of vehicle operation with more aggressive driving and a sequence of vehicle operation that accounts for the impact of the vehicle's air conditioner. Tier 4 vehicles subject to 40 CFR 86.1811–27 must meet standards for each individual driving cycle.

(a) The SFTP standard applies as a composite representing the three test elements. The emission results from the aggressive driving test element (§ 1066.831), the air conditioning test element (§ 1066.835), and the FTP test element (§ 1066.820) are analyzed according to the calculation methodology and compared to the applicable SFTP emission standards as described in 40 CFR part 86, subpart S.

(b) The test elements of the SFTP may be run in any sequence that includes the specified preconditioning steps.

■ 96. Amend § 1066.831 by revising paragraph (e)(2) to read as follows:

### § 1066.831 Exhaust emission test procedures for aggressive driving.

* * * * *

(e) * * *

(2) Operate the vehicle over the full US06 driving schedule, with the following exceptions that apply only for Tier 3 vehicles:

(i) For heavy-duty vehicles above 10,000 pounds GVWR, operate the vehicle over the Hot LA–92 driving schedule.

(ii) Heavy-duty vehicles at or below 10,000 pounds GVWR with a power-to-weight ratio at or below 0.024 hp/pound may be certified using only the highway portion of the US06 driving schedule as described in 40 CFR 86.1816.

* * * * *

■ 97. Amend § 1066.1001 by removing the definition of ‘‘SFTP’’ and adding a definition of ‘‘Supplemental FTP (SFTP)’’ in alphabetical order.

The addition reads as follows:

### § 1066.1001 Definitions.

* * * * *

*Supplemental FTP (SFTP)* means the collection of test cycles as given in 1066.830.

* * * * *

■ 98. Amend § 1066.1010 by adding paragraph (c) to read as follows:

### § 1066.1010 Incorporation by reference.

* * * * *

(c) *California Air Resources Board.* The following documents are available from the California Air Resources Board, 1001 I Street, Sacramento, CA 95812, (916) 322–2884, or *http://www.arb.ca.gov:*

(1) California 2026 and Subsequent Model Year Criteria Pollutant Exhaust Emission Standards and Test Procedures for Passenger Cars, Light-Duty Trucks, And Medium-Duty Vehicles (''CARB's LMDV Test Procedures''); adopted August 25, 2022; IBR approved for § 1066.801(c).

(2) California Test Procedures for 2026 and Subsequent Model Year Zero-Emission Vehicles and Plug-In Hybrid Electric Vehicles, in the Passenger Car, Light-Duty Truck and Medium-Duty Vehicle Classes (''CARB's PHEV Test Procedures''); adopted August 25, 2022; IBR approved for § 1066.801(c).

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