



June 16, 2023

Submitted online at: [www.regulations.gov](http://www.regulations.gov)

*Attention: Docket ID No. EPA-HQ-OAR-2022-0985*

**Re.: Greenhouse Gas Emissions Standards for Heavy-Duty Vehicles, Notice of Proposed Rulemaking, 88 Fed. Reg. 25926 (April 27, 2023)**

Environmental Defense Fund (EDF) respectfully submits the following comments in support of Environmental Protection Agency's (EPA) Proposed Rule, Greenhouse Gas Emissions Standards for Heavy-Duty Vehicles, 88 Fed. Reg. 25926 (April 27, 2023) ("Proposal" or "Proposed Standards"). These comments highlight the importance and urgency of finalizing health protective standards by the end of the year that ensure deep reductions in pollution by leveraging rapid deployment of zero-emission technologies. Near-term emissions reductions are vital to mitigating the effects of climate change and to protecting public health, especially the health of low-income communities and communities of color, which are disproportionately impacted by transportation air pollution.

EPA's proposal is a vital step forward toward addressing the largest source of greenhouse gas emissions in the United States. EDF urges EPA to finalize protective heavy-duty standards, consistent with and building from the proposals the agency has put forward, that account for the progress already underway thanks to manufacturer and fleet investments and commitments, federal spending, and state policies like the Advanced Clean Trucks (ACT) rule. These standards must help to ensure we are on a path to zero tailpipe emissions from new vehicles by 2035.

## Executive Summary

EPA's primary proposal is eminently feasible, and in fact, reflects a conservative assessment of zero-emitting vehicle (ZEV) deployment in the coming years. The historic investments in the Inflation Reduction Act (IRA) and Bipartisan Infrastructure Law (BIL) have rapidly accelerated an American electric vehicle manufacturing renaissance, dramatically advanced purchase price parity for heavy-duty ZEVs, and accelerated already declining costs for vehicles at the same time. Leveraging these trends, some manufacturers and fleets have already made commitments exceeding the levels of ZEV deployment EPA projects in this rule and leading states have continued to adopt California's ACT rule. We believe all of these factors support even stronger standards that help deliver nationwide levels of ZEVs consistent with the ACT.<sup>1</sup>

- **Section I** presents information and analyses related to the urgent need to reduce climate and health harming pollution from heavy duty vehicles. This includes new analytical case studies EDF has undertaken in partnership with researchers at UNC, Columbia and Boston University to examine granular air pollution impacts and benefits of heavy-duty ZEVs in New York and Atlanta.
- **Section II** describes EPA's manifest legal authority to adopt standards to reduce harmful greenhouse gas pollution from heavy-duty vehicles and assesses how EPA's proposed standards are consistent with section 202 of the Clean Air Act and the Agency's longstanding approach to setting vehicle emissions standards.
- **Section III** includes EDF's recommendations for strengthening EPA's standards. In particular, we encourage EPA to:
  - 1) Adopt final standards that help to ensure nationwide ZEV levels consistent with California's Advanced Clean Trucks Rule. In support of this recommendation, we provide extensive and detailed technical analyses (including several reports EDF undertook with Roush and ERM) to assess the rapid cost

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<sup>1</sup> See, e.g., 88 Fed. Reg. 26,007 (seeking comment on standards that help ensure ZEV levels consistent with the ACT).

declines of heavy-duty ZEVs, catalyzed by the IRA. We also provide information from ERM, WSP, and other sources demonstrating rapidly accelerating ZEV sales, other market trends, manufacturer commitments, and leading state policies that all reinforce the feasibility of more protective standards.

- 2) Adopt more protective standards for tractors and school buses. We urge EPA to strengthen tractor standards to be consistent with at least 50% of all new tractor sales being zero-emission vehicles by 2032 and provide new, detailed analysis from Roush submitted along with our comments supporting the feasibility and cost-effectiveness of BEV tractors. We likewise recommend EPA strengthen the vocation vehicle standards consistent with a projection that 80% of new school and transit buses will be ZEV by 2029 and 90% by 2032.
- 3) Update conservative assumptions. Finally, we identify overly conservative assumptions in EPA's own modeling, that when adjusted to better reflect reality, likewise support more protective standards. Among other analyses, we provide a new heavy-duty ZEV adoption curve built from data secured from NREL that supports more accelerated ZEV adoption than is reflected in EPA's primary proposal.
- **Section IV** provides information and analysis related to heavy-duty ZEV infrastructure. We submit a new analysis from the Analysis Group that examines infrastructure needed to support heavy-duty ZEV deployment at levels more protective than EPA's proposal. The analysis demonstrates that generation and transmission infrastructure pose no barriers to heavy-duty electrification and likewise examines both longstanding and emerging practices that have successfully supported additional distribution system enhancements. Based on this analysis and the additional solutions states and companies are pioneering to ensure infrastructure will be in place to support protective levels of ZEV deployment, we urge EPA not to finalize any infrastructure-related offramps in its standards.
- **Section V** examines supply chain issues and the availability of the critical minerals needed to support protective standards. We include a summary table of manufacturer and

other company announcements and investments in securing domestic supply of minerals sufficient to support rapid electrification.

- **Section VI** recommends EPA ensure that its final standards take a protective approach related to potential deployment of hydrogen vehicles. We urge EPA to do a more comprehensive analysis of the impacts of additional hydrogen use and include new analysis demonstrating that hydrogen fuel cell and ICE vehicles powered using current sources of hydrogen will have climate disbenefits when compared to diesel vehicles. We likewise urge EPA to adopt guardrails, including removing credit multipliers for fuel cell electric vehicles and applying a utility factor to FCEVs and H2 ICEVs that better reflect their current, substantial climate impacts. We also encourage EPA to allow manufacturers capable of submitting actual data demonstrating vehicles are being powered by green hydrogen to adjust these values to reflect their greater climate benefits.
- **Section VII** includes a critique of EPA's cost benefit analysis and identifies several areas where adjusting EPA's conservative assumptions would result in the program delivering even greater net benefits, including reductions in climate and air pollution.
- **Section VIII** provides strong support for EPA's proposal to revise its regulations related to preemption of state locomotive standards.

The above analyses and others are included as attachments to these comments and summarized more fully in Appendix A. We appreciate EPA's consideration of our comments and respectfully urge the agency to swiftly finalize standards in order to fully realize the health, environmental, and economic benefits of this rule, and to provide a stable investment signal and regulatory certainty for manufacturers.

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## **I. Strong Standards Are Urgently Needed to Improve Public Health and Help Address the Climate Crisis**

Despite making up less than 10 percent of vehicles on the road, the buses, trucks, and tractor trailers that distribute our goods are the largest contributor to ozone-forming oxides of nitrogen (NO<sub>x</sub>) emissions from all highway vehicles.<sup>2</sup> They are also responsible for a significant amount of health-harming fine particulate matter (PM<sub>2.5</sub>) and more than 430 million tons of climate pollution<sup>3</sup> – nearly a quarter of all transportation sector emissions and more than the entire country of Australia.<sup>4</sup>

The health burden from truck and bus pollution is substantial, causing adverse health impacts in utero, in infants and children, and in adults and the elderly – with those who live closest to our nation’s roads and highways, ports, distribution centers, freight depots, and other well-known sources of truck pollution facing the greatest harms. EPA has estimated that 72 million people live within 200 meters of a truck freight route, and relative to the rest of the population, people of color and those with lower incomes are more likely to live near truck routes.<sup>5</sup> Please see EDF’s comments on the Proposed Rule, *Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards*, 87 Fed. Reg. 17414 (Mar. 28, 2022) dated May 16, 2022 and resubmitted to this docket for a more thorough discussion of the substantial health and environmental harms associated with the diesel and GHG emissions from medium- and heavy-duty vehicles.<sup>6</sup>

In addition to the research presented in our previous comments, EDF has since conducted additional analyses that further demonstrate the impact of diesel emissions on vulnerable

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<sup>2</sup> EPA Fact Sheet: Heavy-Duty 2027 and Beyond: Clean Trucks Final Rulemaking (December 2022), <https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P101695R.pdf>.

<sup>3</sup> EPA, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2021, <https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2021>.

<sup>4</sup> International Energy Agency, Atlas of Energy (2020), <http://energyatlas.iea.org/#!/tellmap/1378539487>.

<sup>5</sup> 87 Fed. Reg. 17451 (Mar. 28, 2022).

<sup>6</sup> EDF’s comments on the Proposed Rule, *Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards*, 87 Fed. Reg. 17414 (Mar. 28, 2022) dated May 16, 2022 (Attachment A).

populations and the need for and benefits of zero-emitting solutions, especially in pollution hot spots. In particular, we highlight two recent analyses that we submit along with these comments.

**Warehouse Pollution and Proximity Mapping.** New research from EDF looks at U.S. warehouse proliferation and the exposure to air pollution from warehouse trucks. EDF researchers analyzed 10 states and combined warehouse industry data with a Geospatial Information System (GIS) application known as Proximity Mapping, which applies areal apportionment to estimate the characteristics of populations living near specific facilities and pollution sources, using the U.S. Census Bureau's American Community Survey 5-Year estimates.<sup>7</sup> The analysis found an estimated 15 million people live within a half-mile of a warehouse in 10 states across the country and more than 1 million children under the age of 5 live within a half-mile of a warehouse. Exposure to air pollution from the trucks that frequent warehouses is linked to a range of health issues, including the risk of developing childhood asthma, heart disease, adverse birth outcomes like premature birth and low birth weight, cognitive decline, and stroke. Each warehouse generates hundreds, if not thousands, of truck trips every day, and trucks can emit more pollution while idling or traveling at slow speeds than while driving at faster speeds.

The results also show that warehouse proliferation does not distribute the pollution risk evenly. In some states like Illinois, Massachusetts and Colorado, the concentration of Black and Latino residents around warehouses is nearly double the state average. The study notes that zero-emission options already exist for delivery vans, yard trucks and regional haul trucks and manufacturers are investing billions to expand zero-emission technology for long-haul trucking. Increasing deployment of ZEVs would significantly reduce the harmful diesel pollution around warehouses and help protect nearby communities.

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<sup>7</sup> Aileen Nowlan. 2023. Making the Invisible Visible, EDF. <https://globalcleanair.org/files/2023/04/EDF-Proximity-Mapping-2023.pdf> (Attachment B)



**NYC and Atlanta ZEV Case Studies.**<sup>8</sup> In comments on EPA’s March 28, 2022 proposed rule, *Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards*,<sup>9</sup> EDF submitted preliminary results of a case study on the health and air quality benefits of deploying heavy-duty ZEVs in New York City; for which we now have finalized results. Compared to traditional transportation air quality health benefit tools, our data and methods represent a significant improvement in the ability to ascertain disparities. Conducted by researchers at EDF, Boston University, and the University of North Carolina, we conducted a full chain air pollution health impact assessment to model two electrification scenarios for New York City and Atlanta.

Our two medium- and heavy-duty electrification policy scenarios differ in how rapidly on-road electrification occurs, and consequently, how quickly the current medium- and heavy-duty fleet turns over. Scenario 1 assumes 100% sales for zero emission transit and school buses by 2030, with a phased-in approach for other medium- and heavy-duty sales (30% by 2030 and 100% by 2040). Scenario 2 does not phase in ZEV sales, but simply requires 100% on-road zero emission medium- and heavy-duty ZEVs by 2040. We find that full electrification (Scenario 2) would prevent \$2.4 billion in health damages every year by 2040 (248 deaths, 173 childhood asthma emergency department (ED) visits) in the New York area. In Atlanta, full electrification (Scenario 2) in 2040 would prevent \$4.14 billion in health damages (428 deaths and 88 childhood asthma ED visits).

Our research in Atlanta and New York also demonstrates that many communities of color and low-income communities with high baseline asthma ED visits also have elevated diesel truck and bus traffic and pollution and therefore face disproportionate impacts. In New York City, census

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<sup>8</sup> Presentation by Jonathan Buonocore, Chet France, Rick Rykowski, Brian Naess, Komal Shukla, Catherine Seppanen, Dylan Morgan, Frederica Perera, Katie Coomes, Ananya Roy, Sarav Arunachalam. 2022. “Distribution of Air Quality Health Benefits of MHEV policies: New York and Atlanta,” University of North Carolina, Boston University, Columbia University Mailman School of Public Health and Environmental Defense Fund. (Attachment C)

<sup>9</sup> EDF’s comments on the Proposed Rule, *Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards*, 87 Fed. Reg. 17414 (Mar. 28, 2022) dated May 16, 2022.

tracts with 97 percent persons of color bear greater than 35 percent of total childhood asthma ED visits attributable to medium- and heavy-duty vehicles, despite being only 19 percent of the population. Similarly in Atlanta, persons of color make up 36 percent of the population, but account for 46 percent of NO<sub>2</sub>-attributable deaths, and 40 percent of NO<sub>2</sub>-attributable asthma ED visits.

These recent studies align with and reinforce EPA's conclusions in the proposal regarding the disparate impacts of truck pollution<sup>10</sup> and highlight the urgent need for EPA to rigorously consider the health and equity benefits of more protective standards.

## **II. EPA has Authority to Set Standards Under the Clean Air Act That Ensure Deep Reductions in Harmful Pollution Based on the Availability of ZEV and Other Technologies.**

EPA has clear authority to establish performance-based emission standards under Section 202(a)(1). EPA's approach, including setting performance-based standards, considering ZEVs, and continuing the longstanding use of averaging, banking, and trading (ABT), is consistent with the text and structure of the Clean Air Act (CAA) and the history of EPA regulation. Moreover, the recent enactment of the IRA strongly reaffirms EPA's authority under the CAA and removes any doubt that EPA's actions here are fully consistent with Congress's will.

### **a) EPA Has Authority to Consider ZEV Technology in Setting Emission Standards**

The language and structure of the CAA clearly show that Congress granted EPA authority to consider all available technologies, including ZEV technologies in setting emission standards under Section 202(a). Relying on this authority, EPA has factored such technologies into its

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<sup>10</sup> 88 Fed. Reg. 26064 (“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<sub>x</sub>, SO<sub>2</sub>, VOC, CO, and mobile source air toxics from heavy-duty vehicles in this proposal.”).

standards for over two decades,<sup>11</sup> including in each of its six past GHG rules.<sup>12</sup> Accordingly, its decision to do so again in this rule now that ZEV technologies are more widely available is eminently reasonable.

Section 202(a)(1) directs EPA to set emissions standards applicable regardless of “whether such vehicles and engines are designed as complete systems or incorporate devices to prevent or control such pollution.”<sup>13</sup> This language explicitly rejects limitations to internal-combustion engines or to particular kinds of technologies. It just as clearly includes technology beyond internal combustion engine vehicles (ICEVs), including zero-emission vehicles (ZEVs), which are plainly a “complete system[]” that can “prevent” pollution.

This reading of Section 202 is well supported by its core function and the long history of its interpretation by EPA and the courts. In Section 202, Congress authorized EPA to “project future advances” in technology, and not be confined to pollution-control methods that were currently available.<sup>14</sup> Indeed, Congress expected EPA to “adjust to changing technology.”<sup>15</sup>

Based on its clear CAA authority, EPA has factored ZEV technologies (ranging from mild hybrid technologies to fully electric battery-powered vehicles) into its rules for more than two decades.<sup>16</sup> EPA first included ZEVs in its fleetwide averages in its 2000 “Tier 2” criteria

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<sup>11</sup> 65 Fed. Reg. 6698 (Feb. 10, 2000) (“Tier 2” criteria pollutant standards).

<sup>12</sup> 75 Fed. Reg. 25324 (May 7, 2010) (Light-duty model year 2011 and later); 76 Fed. Reg. 57106 (Sept. 15, 2011) (Heavy-duty model year 2014 and later); 77 Fed. Reg. 62624 (Oct. 15, 2012) (Light-duty model year 2017 and later); 81 Fed. Reg. 73478 (Oct. 25, 2016) (Heavy-duty model year 2021 and later); 85 Fed. Reg. 24174 (Apr. 30, 2020) (Light-duty model year 2021 and later); 86 Fed. Reg. 74434 (Dec. 30, 2021) (Light-duty model year 2023 and later).

<sup>13</sup> 42 U.S.C. § 7521(a)(1).

<sup>14</sup> *NRDC v. EPA*, 655 F.2d 318, 329 (1981) (quoting Senate report from 1970 amendments stating EPA was “expected to press for the development and application of improved technology rather than be limited by that which exists today.” S. Rep. No. 1196, 91<sup>st</sup> Cong., 2d Sess. 24 (1970)).

<sup>15</sup> S. Rep. No. 89-192, at 4 (1965).

<sup>16</sup> For a detailed review of this history, *see* Brief of Amici Curiae Margo Oge and John Hannon in Support of Respondents, *Texas v. EPA*, No. 22-1031, 24-31 (D.C. Cir., Mar. 2, 2023), *Texas v. EPA*, No. 22-1031, 33 (D.C. Cir., Mar. 2, 2023). (Attachment D)

pollutant standards.<sup>17</sup> The agency has continued to consider and incentivize these technologies in every one of its six greenhouse gas (GHG) rules for both light- and heavy-duty vehicles.<sup>18</sup> More recent acts of Congress have reaffirmed Congress’ intention that EPA consider the emissions-reducing potential of ZEVs in its rules. The IRA and BIL both include myriad provisions that seek to support a transition to ZEV technology through funding of credits for vehicles, components, and critical infrastructure. These laws were passed with the knowledge that EPA was already setting standards under Section 202(a) that would increase ZEV proliferation and an intent to support those regulations.<sup>19</sup> Congress’ aim with the funding was to “combine[] new economic incentives to reduce climate pollution with bolstered regulatory drivers that will allow EPA to drive further reduction under its CAA authorities,”<sup>20</sup> with the expectation that “future EPA regulations will increasingly rely on and incentivize zero-emission vehicles as appropriate.”<sup>21</sup> Moreover, given that, in setting standards under Section 202(a), EPA must consider the present or probable future availability of effective technologies, as well as the cost of such technologies and the time necessary to apply them, the significant changes of the IRA and BIL will result in accelerating broader availability of ZEV technologies, and reducing their cost, which will necessarily affect EPA’s analysis of what emissions standards are appropriate.

Additionally, several provisions in the IRA directly affirm EPA’s authority to consider ZEVs under Section 202(a). Section 60106 of the law provides \$5 million for EPA “to provide grants to States to adopt and implement greenhouse gas and zero-emission standards for mobile sources

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<sup>17</sup> 65 Fed. Reg. 6698 (Feb. 10, 2000).

<sup>18</sup> Supra note 1212; See also EPA’s Answering Brief, *Texas v. EPA*, No. 22-1031, 15-16 (D.C. Cir, Apr. 27, 2023), <https://www.edf.org/sites/default/files/2023-05/Texas%20-%20EPA%20Final%20Brief.pdf>. (Attachment E)

<sup>19</sup> The BIL was passed after EPA’s 2023-2026 light-duty GHG standards, which rely on ZEV technology, had been proposed and the IRA was passed 9 months after they were finalized. Brief of Senator Thomas R. Carper and Representative Frank Pallone, Jr. as Amici Curiae in Support of Respondents, *Texas v. EPA*, No. 22-1031, 29 (D.C. Cir, Mar. 2, 2023).(Attachment F).

<sup>20</sup> 168 Cong. Rec. E868-02 (daily ed. Aug. 12, 2022) (statement of Rep. Pallone discussing the IRA).

<sup>21</sup> 168 Cong. Rec. at 880-02 (daily ed. Aug. 12, 2022) (statement of Rep. Pallone); see also Greg Dotson and Dustin J. Maghamfar, *The Clean Air Act Amendments of 2022: Clean Air, Climate Change, and the Inflation Reduction Act*, 53 ENV’T L. REP. 10017, 10030 (2023) (“The IRA directs EPA to support zero emission technologies for heavy-duty vehicles and port equipment, to reduce emissions in low-income and disadvantaged communities, as well as to support state ZEV requirements. This is a recognition of the evolving importance and availability of zero emission technologies.”), <https://www.eli.org/sites/default/files/files-pdf/53.10017.pdf>. (Attachment G)

pursuant to section 177 of the [CAA].”<sup>22</sup> Section 177 allows other states to adopt California’s vehicle emission standards, which must be at least as protective as the federal standards and meet certain other statutory requirements.<sup>23</sup> Thus, as members of Congress stated in an amicus brief supporting EPA’s MY 2023-2026 light-duty GHG standards, “Congress’s explicit endorsement of states’ use of Section 177 to enact ‘greenhouse gas and zero-emission standards’ clearly demonstrates its comfort with and support for state and federal standards that contemplate compliance through zero-emission vehicle manufacturing.”<sup>24</sup>

The IRA also made amendments to the CAA affirming that Congress regards programs incorporating ZEV technology as an important aspect of EPA’s mission to reduce air pollution under the law.<sup>25</sup> Those amendments include adding a definition of “zero-emission vehicle” into the newly added CAA Section 132, which consists of a program of EPA grants and rebates towards the purchase of zero-emission heavy duty vehicles.<sup>26</sup> In passing the IRA, Congress made clear that it “recognizes EPA’s longstanding authority under CAA Section 202 to adopt standards that rely on zero emission technologies.”<sup>27</sup>

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<sup>22</sup> Inflation Reduction Act of 2022, P.L. 117-1698, 136 Stat. 2068-69 (2022).

<sup>23</sup> 42 U.S.C. § 7507, 7543(b).

<sup>24</sup> Brief of Senator Thomas R. Carper and Representative Frank Pallone, Jr. as Amici Curiae in Support of Respondents, *Texas v. EPA*, No. 22-1031, 33 (D.C. Cir, Mar. 2, 2023), <https://www.edf.org/sites/default/files/2023-03/Texas%20-%20Members%20of%20Congress%20%28Sen.%20Carper%20and%20Rep.%20Pallone%29.pdf>; see also Greg Dotson and Dustin J. Maghamfar, *The Clean Air Act Amendments of 2022: Clean Air, Climate Change, and the Inflation Reduction Act*, 53 ENV’T L. REP. 10017, 10030 (2023) (“[I]t is a necessary precondition [of the IRA’s funding for zero-emission standards under section 177] that . . . EPA can establish zero emission standards pursuant to the CAA.”), <https://www.eli.org/sites/default/files/files-pdf/53.10017.pdf>.

<sup>25</sup> Brief of Senator Thomas R. Carper and Representative Frank Pallone, Jr. as Amici Curiae in Support of Respondents, *Texas v. EPA*, No. 22-1031, 32 (D.C. Cir, Mar. 2, 2023) (“By incorporating these new programs into the Act’s existing air pollution control framework, Congress clearly demonstrated that clean energy and zero-emission vehicle programs are central to the Act’s implementation going forward.”), <https://www.edf.org/sites/default/files/2023-03/Texas%20-%20Members%20of%20Congress%20%28Sen.%20Carper%20and%20Rep.%20Pallone%29.pdf>.

<sup>26</sup> 42 U.S.C. § 7432(d)(5); see also Inflation Reduction Act of 2022, P.L. 117-1698, 136 Stat. 2064-65 (2022) (creating new CAA section 133 to provide grants for “zero-emission port equipment or technology.”).

<sup>27</sup> 168 Cong. Rec. E879–02, at 880 (daily ed. Aug. 26, 2022) (statement of Rep. Pallone).

b) EPA Properly Decided Not to Reopen its Longstanding Use of Averaging, Banking, and Trading in its Rules

EPA has used an ABT approach in standards for light- and heavy-duty vehicles since the 1980s, including the Phase 1 and Phase 2 medium- and heavy-duty GHG rules that this proposal builds upon.<sup>28</sup> Within this decades-long history, EPA has repeatedly explained why such an approach is reasonable and consistent with the text of Section 202.<sup>29</sup> Based on EPA's settled and longstanding use of ABT in its Section 202 rules and ABT's well-established basis in the statute, the agency's decision not to reopen "the general availability of ABT" is reasonable.<sup>30</sup>

**III. EPA Should Adopt Stronger Final Standards that help ensure nationwide ZEV levels consistent with ACT and more protective levels of ZEV tractors and buses.**

In this section, we provide support for our recommendations that EPA should adopt more protective final standards. In particular, Part a evaluates information that EDF and others have developed on feasibility, cost, and lead time supporting standards that help to ensure ZEV levels consistent with California's Advanced Clean Trucks (ACT) program that has been adopted by eight states. Part B presents information specific to two areas where EPA's standards should be even more protective: tractor trailers and school buses. Part C surveys and critiques key (and conservative) EPA assumptions related to ZEV costs and deployment, which, when adjusted to be more reasonable, further strengthen the feasibility of ZEV deployment levels consistent with our recommendations.

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<sup>28</sup> 76 Fed. Reg. 57106, 57127-28 (Sept. 15, 2011) (HD Phase 1 GHG standards); 81 Fed. Reg. 73428, 73495 (Oct. 25, 2016) (HD Phase 2 GHG standards).

<sup>29</sup> *See, e.g.*, 55 Fed. Reg. 30584, 30593-94 (1990) (EPA explaining in the context of its 1990 programs for HD banking and trading of NOx and particulate matter why it "continues to believe . . . that trading and banking are consistent with the statutory aims").

<sup>30</sup> 88 Fed. Reg. 25952 n. 211.

a) Feasibility, Cost, and Lead Time Support Final Standards Consistent with ACT Levels of ZEV Deployment Nationwide

Emission standards at a level that will deliver ZEVs nationwide comparable to the ACT standards are consistent with EPA’s obligations under Section 202 of the Clean Air Act to consider the cost of compliance and to provide adequate lead time to permit the development of requisite technology. In this section, we examine a series of interlocking analyses and factors that support this conclusion, including 1) extensive, independent analysis related to rapidly-declining ZEV costs; 2) the impacts of the IRA in further advancing ZEV cost declines and accelerating ZEV deployment; 3) an assessment of market indicators, including manufacturer and fleet commitments, which are broadly consistent with and reinforce these study findings; and 4) a discussion of leading state actions, including the ACT and Advanced Clean Fleets rule. Each of these factors, both individually and when taken together, demonstrate that EPA’s standards consistent with the ACT are feasible and cost-effective and the agency has provided adequate lead time to achieve them.

i. Independent Analyses support the feasibility and declining costs of ZEVs

The feasibility and cost-effectiveness of final standards consistent with the ACT rule is clearly evidenced by a large and growing body of analyses that show the declining upfront costs of electrification and the significant cost savings over time. A February 2022 study conducted by Roush Industries for EDF evaluated both the upfront and ongoing costs of electrifying several types of medium and heavy-duty vehicles that are commonly used in urban areas (including Class 8 transit buses, Class 7 school buses, Class 3–7 shuttles and delivery vehicles, and Class 8 refuse haulers).<sup>31</sup> These vehicles tend to be concentrated in urban areas where average trip distances are shorter and health and pollution impacts are of most concern, making them particularly important opportunities for deeper electrification. This rigorous, ground-up study

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<sup>31</sup> Vishnu Nair, Sawyer Stone, Gary Rogers, Sajit Pillai. 2022. *Medium and Heavy-Duty Electrification Costs for MY 2027- 2030*, Roush Industries for Environmental Defense Fund. See [http://blogs.edf.org/climate411/files/2022/02/EDF-MDHD-Electrification-v1.6\\_20220209.pdf](http://blogs.edf.org/climate411/files/2022/02/EDF-MDHD-Electrification-v1.6_20220209.pdf). (Attachment H).

found that, when considering up front purchase price alone, by 2027 electric freight trucks and buses will be less expensive than their combustion engine counterparts in nearly all categories. All of these electric vehicle categories will also be less expensive on a total cost of ownership basis producing substantial savings in the same timeframe.

Importantly, the study was conducted prior to the passage of the IRA and so does not consider the important impacts those investments will have in further lowering costs (described in the next section).

The 2022 Roush study developed projections for upfront costs and total cost of ownership for electric vehicles in the 2027 to 2030 timeframe and compared the costs of equivalent internal combustion vehicles that meet EPA Greenhouse Gas Phase 1 and 2 rules, as well as California Low NOx regulations.<sup>32</sup> The study determined the total cost of ownership for all financial aspects of ownership, including vehicle purchase cost of either an internal combustion engine or electric freight truck or bus, fuel or energy costs, charging or fueling infrastructure costs, maintenance costs, and vehicle mid-life refresh if applicable. It focused exclusively on the direct financial costs and savings related to vehicle ownership and did not include the substantial health and welfare benefits associated with switching to electric trucks.

The study found decreasing upfront costs for electric freight trucks and buses, driven largely by steeply decreasing battery costs. As shown in Table 1, the analysis also concluded that for vehicles purchased in 2027, electric vehicle costs will be less than internal combustion vehicle costs over the life of the vehicle, largely because maintenance and energy costs will be lower. Total cost of ownership parity will occur immediately for some segments evaluated and very quickly for the rest.

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<sup>32</sup> 76 Fed. Reg. 57106 (Sept. 15, 2011); 81 Fed. Reg. 73478 (Oct. 25, 2016); California's Heavy-Duty Engine and Vehicle Omnibus Regulation (Dec. 22, 2021).



Table 1: Roush Assessment of BEV Costs and TCO (not considering IRA investments)

Class	Segment	Batt. Size	Purchase	Operating	Total Cost	TCO Parity
		kWh	% Cost Reduction of EV vs ICE			Year
<b>Class 8</b>	Transit Bus	400	0.8	49.5	31.6	2
<b>Class 7</b>	School Bus	60	12.4	26.5	23.7	1
<b>Class 5</b>	Shuttle Bus	200	0.2	15.9	13.7	3
<b>Class 3</b>	Delivery Van	100	0.7	31.2	16.9	3
<b>Class 5</b>	Delivery Truck	150	12.4	52.0	34.0	1
<b>Class 7</b>	Delivery Truck	100	9.4	14.3	12.7	4
<b>Class 8</b>	Refuse Hauler	200	7.3	35.6	23.9	1

Source: Roush, Medium and Heavy-Duty Electrification Costs for MY 2027- 2030  
 Roush’s findings were confirmed in other reports released around the same time. The National

Renewable Energy Lab (NREL) looked at all classes and segments of medium- and heavy-duty vehicles and concluded that with continued improvements in vehicle and fuel technologies, ZEVs can reach TCO parity with diesel vehicles as early as 2026 for some applications and no later than 2035 for all segments, including long-haul trucks.<sup>33</sup> NREL also concluded that if economics drive adoption, 42 percent of all medium- and heavy-duty truck sales will be ZEVs by 2030. NREL also concluded that if economics drive adoption, 42 percent of all medium- and heavy-duty truck sales will be ZEVs by 2030. These findings also occurred prior to the passage of the IRA. Without economic incentives, their modeling projects all heavy-duty vehicle segments can reach total cost of driving parity with diesel vehicles by 2035.

A study published by Argonne National Laboratory’s Energy System Division in April 2021 estimated that electric Class 4 delivery trucks will reach life-cycle cost parity with diesel trucks in model year 2025, while day-cab tractors will reach cost parity in model year 2027, and sleeper-cab tractors will reach cost parity in model year 2032.<sup>34</sup> The analysis included all costs of vehicle ownership including vehicle purchase, fuel, and maintenance costs as well as insurance, financing costs, and depreciation. It did not account for the impacts of the IRA or the BIL.

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<sup>33</sup> Muratori, Matteo et al. 2022. Decarbonizing Medium- and Heavy-Duty On-Road Vehicles: Zero-Emission Vehicles Cost Analysis. NREL Transforming Energy. <https://www.nrel.gov/docs/fy22osti/82081.pdf>. (Attachment I)  
<sup>34</sup> A. Burnham et al. 2021. Comprehensive Total Cost of Ownership Quantification for Vehicles with Different Size Classes and Powertrains, Argonne National Laboratory, Energy Systems Division, ANL/ESD-21/4. (Attachment J)

A study published by Argonne National Laboratory's Energy System Division in April 2021 estimated that electric Class 4 delivery trucks will reach life-cycle cost parity with diesel trucks in model year 2025, while day-cab tractors will reach cost parity in model year 2027, and sleeper-cab tractors will reach cost parity in model year 2032.<sup>35</sup> The analysis included all costs of vehicle ownership including vehicle purchase, fuel, and maintenance costs as well as insurance, financing costs, and depreciation. It did not account for the Impacts of the IRA or the BIL.

Another report developed by M.J. Bradley & Associates for EDF in 2021 showed a large and growing opportunity to expand America's zero-emission freight trucks and buses.<sup>36</sup> The report evaluated four factors in assessing the readiness of zero-emitting medium and heavy-duty vehicles in different applications – the availability of electric models from manufacturers, the requirements for charging, the ability of electric models to meet operating requirements, and the business case for zero-emitting vehicles. It found that a large number of market segments have favorable ratings across at least three of the categories, which indicates strong potential for near-term zero-emitting vehicle deployment. These market segments, which represent about 66% of the current in-use fleet, include heavy-duty pickups and vans, local delivery and service trucks and vans, transit and school buses, class 3 to 5 box trucks, class 3 to 7 stake trucks, dump trucks and garbage trucks.

These analyses demonstrate in a compelling way the feasibility of EPA's proposed standards even before the introduction of recent federal and state incentives, discussed below.

- ii. Impacts of Historic IRA Investment Further Support Feasibility and Accelerating Cost Declines.

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<sup>35</sup> A. Burnham et al. 2021. Comprehensive Total Cost of Ownership Quantification for Vehicles with Different Size Classes and Powertrains, Argonne National Laboratory, Energy Systems Division, ANL/ESD-21/4.

<sup>36</sup> Dana Lowell and Jane Culklin. 2021. Medium- and Heavy-duty Vehicles: Market Structure, Environmental Impact, and EV Readiness, MJ Bradley & Assoc. for EDF.  
<http://blogs.edf.org/climate411/files/2021/08/EDFMHDDVEVFeasibilityReport22jul21.pdf> (Attachment K).

Substantial investments in the IRA only further confirm the feasibility and cost-effectiveness of EPA standards that help ensure nationwide ZEV levels consistent with the ACT rule. In particular, the IRA included “Credit for Qualified Commercial Clean Vehicles” which provides a tax credit for those who purchase qualified M/HDVs between 2023 and 2032 of up to \$40,000.<sup>37</sup> In particular, the IRA included “Credit for Qualified Commercial Clean Vehicles” which provides a tax credit for those who purchase qualified M/HDVs between 2023 and 2032 of up to \$40,000.<sup>38</sup> ERM estimates that these and other IRA provisions will provide almost \$3 billion in incentives for MHD ZEV purchases.<sup>39</sup> This funding has already catalyzed significant investments in EV manufacturing and associated jobs. For example, EDF and WSP found that over \$120 billion in private EV supply ecosystem investments and 143,000 new jobs have been announced in the last eight years.<sup>40</sup> Nearly \$90 billion in EV manufacturing announcements has occurred since the IRA and BIL laws passed and almost \$50 billion of that, representing 42 percent of all announced EV investments, has occurred in just the last 6 months since the passage of the IRA.

Table 2: ERM List of IRA Funding Programs for MHD Purchases

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<sup>37</sup> Inflation Reduction Act of 2022, P.L. 117-169, § 13404.

<sup>38</sup> Inflation Reduction Act of 2022, P.L. 117-169, § 13404.

<sup>39</sup> Ellen Robo and Dave Seamonds. 2022. Inflation Reduction Act Supplemental Assessment: Analysis of Alternative Medium- and Heavy-duty Zero-Emission Vehicle Business-as-Usual Scenarios, ERM for EDF, Table 2. (Attachment L).

<sup>40</sup> See *infra* n 195. (Attachment AA)

Program	Total Apportioned Funding	Eligible Vehicle Type	Assumed Percent of Total Funding for M/HD ZEV Purchases
Clean Heavy-Duty Vehicles	\$1,000,000,000	Class 6 and 7 Vehicles	85%
Greenhouse Gas Reduction Fund	\$27,970,000,000	All M/HD	5%
Diesel Emissions Reductions	\$60,000,000	Single-Unit and Combination Trucks	75%
Funding to Reduce Air Pollution at Schools	\$50,000,000	School Buses	50%
Funding to Reduce Air Pollution at Ports	\$3,000,000,000	Combination Trucks	20%
<b>Total IRA Funding Assumed for M/HD ZEV Purchases</b>		<b>\$2,830,100,000</b>	

Source: ERM, *Investment Reduction Act Supplemental Assessment: Analysis of Alternative Medium- and Heavy-Duty Zero-Emission Vehicles Business-As-Usual-Scenarios*

These laws have also led to a significant decrease in upfront and lifetime ownership costs of EVs for consumers and fleets. An updated study by Roush Industries for EDF in May 2023 assessed and quantified, where possible, the key impacts of the IRA on the cost of electrifying medium- and heavy-duty vehicles that have access to overnight recharging at a central location (assessing the same vehicle classes from the earlier 2022 report, including Class 8 transit buses, Class 7 school buses, Class 3–7 shuttles and delivery vehicles, and Class 8 refuse haulers), using the previous study costs as a baseline.<sup>41</sup> The analysis found that IRA credits help absorb the near-term higher upfront cost of battery electric vehicles (BEVs) and will accelerate the purchase parity with the segments analyzed. According to the research, all segments analyzed will now

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<sup>41</sup> H. Saxena, S. Pillai. 2023. Impact of the Inflation Reduction Act of 2022 on Medium- and Heavy- Duty Electrification on MYs 2024 and 2027, Roush for EDF (Attachment M).

meet purchase price parity with their diesel counterparts if purchased as early as MY 2024, assuming reasonable economies of scale for BEV production.

The earlier cost projections by Roush in 2022 also showed that BEV operating costs are always lower than internal combustion engine vehicle (ICEV) operating costs.<sup>42</sup> Because of this, the original analysis found that the time needed for a BEV to achieve total cost of ownership (TCO) parity with an ICEV could occur at the time of purchase in 2027 for a few of the segments analyzed and 1-4 years later for other segments. As shown in Table 3, the new IRA credits for BEVs and chargers will reduce the amount of time needed for BEVs to achieve TCO parity with ICEVs by an additional 1-2 years so that many segments analyzed will see TCO parity at the time of purchase as early as 2024.

Table 3: Year TCO parity is reached from 2024 and 2027 without and with IRA credits

Vehicle Type	2024 Purchase Timeframe		2027 Purchase Timeframe	
	Without IRA	With IRA	Without IRA	With IRA
C8 Transit	2026	2025	2028	2028
C7 School	2024	2024	2027	2027
C5 Shuttle	2027	2025	2029	2028
C3 Delivery	2027	2026	2029	2028
C5 Delivery	2024	2024	2027	2027
C7 Delivery	2028	2027	2030	2029
C8 Refuse	2025	2024	2027	2027

Source: Roush, *Impact of the Inflation Reduction Act of 2022 on Medium- and Heavy- Duty Electrification on Mys 2024 and 2027* (2023)

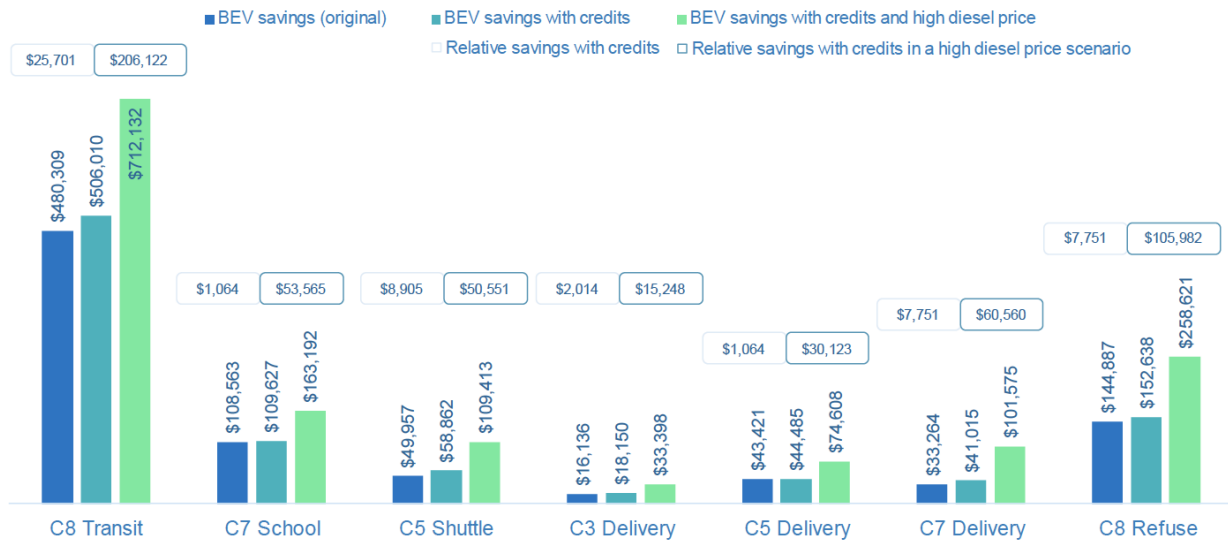
As a result of the IRA, the purchaser of a BEV in MY 2024 could save an estimated \$18,000 on a Class 3 delivery van and \$500,000 on an urban transit bus over the life of the BEV compared to a comparable diesel vehicle (Figure 1). If we assume that diesel fuel prices return to the prices

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<sup>42</sup> Nair, V., Stone, S., Rogers, G., Pillai, S. 2022. Medium- and Heavy-duty Electrification Costs for MY 2027-2030, Roush for EDF.

occurring during the summer of 2022 (\$5.18/gallon versus \$3.25/gallon the lifetime savings due to switching to a BEV would increase to \$33,000 for a Class 3 delivery van and \$700,000 for an urban transit bus.<sup>43</sup>

Figure 1: Lifetime savings for BEVs purchased in 2027 for original case, IRA credit case and high diesel fuel price case



Source: Roush, *Impact of the Inflation Reduction Act of 2022 on Medium- and Heavy- Duty Electrification on MYs 2024 and 2027* (2023)

The IRA also includes tax credits and other incentives for several aspects of battery production. These IRA provisions could lead to lower-priced batteries and batteries with competitive prices where much of the manufacturing occurred in the U.S. and North America.

iii. Manufacturers and fleets have committed to electrification

Market developments, including manufacturer investments and commitments are consistent with and reinforce the conclusions of the above-described analyses and likewise support the feasibility of protective EPA standards. For instance, Daimler Trucks, the market leader in the U.S. for Class 7 and 8 truck sales, has a goal of selling only CO2-neutral vehicles in Europe, Japan, and

<sup>43</sup> H. Saxena, S. Pillai. 2023. *Impact of the Inflation Reduction Act of 2022 on Medium- and Heavy- Duty Electrification on MYs 2024 and 2027*, Roush for EDF.

North America by 2039.<sup>44</sup> Daimler Trucks' North America Freightliner division has developed electric versions of its Cascadia Class 8 tractor, M2 Class 6 medium-duty chassis, and MT50 medium-duty step van<sup>45</sup> and has the capacity to produce around 2,000 eCascadia trucks annually.<sup>46</sup> Both Traton SE, the parent company of Navistar, and Volvo Trucks set a global target that 50 percent of all truck sales will be electric by 2030.<sup>47</sup> Volvo set a higher target in North America and Europe to reach 70 percent electric trucks sales by 2030. Volvo and Navistar are also market leaders in sales of Class 7 and 8 trucks, school buses, transit buses and coach buses in the U.S.<sup>48</sup> In 2021 Volvo Trucks took orders, including letters of intent to buy, for more than 1,100 electric trucks in over 20 countries and in September 2022 started producing electric version of its heavy-duty Volvo FH, FM, and FMX trucks.<sup>49</sup> Volvo Trucks also plans to start production in 2023 for electric versions of the Volvo FH, FM, and FMX trucks.<sup>50</sup> General Motors launched BrightDrop in 2021, a new business unit that focuses on electric first-to-last-mile products, software and services. It has secured more than 30 commercial customers across industries like retail, rental, parcel delivery and service-based utilities, including FedEx,

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<sup>44</sup> David Cullen, *Daimler to Offer Carbon Neutral Trucks by 2039*, Truckinginfo (Oct. 25, 2019), <https://www.truckinginfo.com/343243/daimler-aims-to-offer-only-co2-neutral-trucks-by-2039-in-key-markets>.

<sup>45</sup> Daimler North America, *Daimler Truck Electric Commercial Vehicles*, <https://northamerica.daimlertruck.com/emobility>.

<sup>46</sup> Alan Adler, *Daimler built excess electric truck capacity in '22*, Freight Waves (Jan. 31, 2023). <https://www.freightwaves.com/news/daimler-built-more-electric-truck-capacity-in-22-than-chargers-could-support>.

<sup>47</sup> De Lombaerde, Geert, *Traton boosting its trucking electrification investments*, Fleet Owner (16 Mar 2022). <https://www.fleetowner.com/emissions-efficiency/article/21236316/traton-adding-to-electrification-investments>.

Volvo Trucks, *Record order from Maersk for Volvo electric trucks*, Volvo Trucks. 29 March 2022. <https://www.volvotrucks.com/en-en/news-stories/press-releases/2022/mar/volvo-trucks-receives-record-order-for-electric-trucks-from-maersk.html>.

<sup>48</sup> Ben Sharpe et. al. 2020. Race to Zero: How manufacturers are positioned for zero emission commercial trucks and buses in North America, ICCT, EDF and Propulsion Quebec.

<sup>49</sup> Volvo Trucks, *Sales start for Volvo's heavy-duty electric trucks*, Volvo Trucks, (2 May 2022). <https://www.volvotrucks.com/en-en/news-stories/press-releases/2022/may/sales-start-for-volvos-heavy-duty-electric-trucks.html>. Volvo Trucks, *Break-through: Volvo Trucks starts series production of heavy electric trucks*, Volvo Trucks (14 Sep 2022). <https://www.volvotrucks.com/en-en/news-stories/press-releases/2022/sep/volvo-trucks-starts-series-production-of-heavy-electric-trucks.html>.

<sup>50</sup> "Volvo launches more electric trucks. Volvo Trucks. 12 Dec 2022. <https://www.volvotrucks.com/en-en/news-stories/press-releases/2022/dec/volvo-launches-more-electric-trucks.html>.

Walmart, Hertz, DHL Express and Purolator.<sup>51</sup> Demand for BrightDrop commercial EVs continues to grow, resulting in its 2023 Zevo 600 already sold out. With all its momentum, the company anticipates accelerating production of its electric delivery vans to reach a 50,000 unit annual volume capacity by 2025.<sup>52</sup> Tesla Semi Class 8 electric trucks annually starting 2024, after a year of production ramp-up, with the first units (36 electric trucks) delivered to Pepsi in December 2022. to Pepsi in December 2022 and has plans for greater production. These and many other commitments are summarized in ERM's April 2023 EV Market Update.<sup>53</sup>

Manufacturer and company commitments to electrification have accelerated the number of medium- and heavy-duty ZEV models available for purchase. ERM's EV Market Update lists all current medium- and heavy-duty model announcements and availability. The report shows that there are currently 17 Class 2b and 3 ZEV models, more than 40 Class 4-6 ZEV models, nearly 35 Class 7-8 ZEV models and more than 45 ZEV buses available by the end of 2024, with many already available for purchase today (Figure 2).<sup>54</sup>

Figure 2: Medium- and Heavy-duty EV Models Available in the U.S. and Canada

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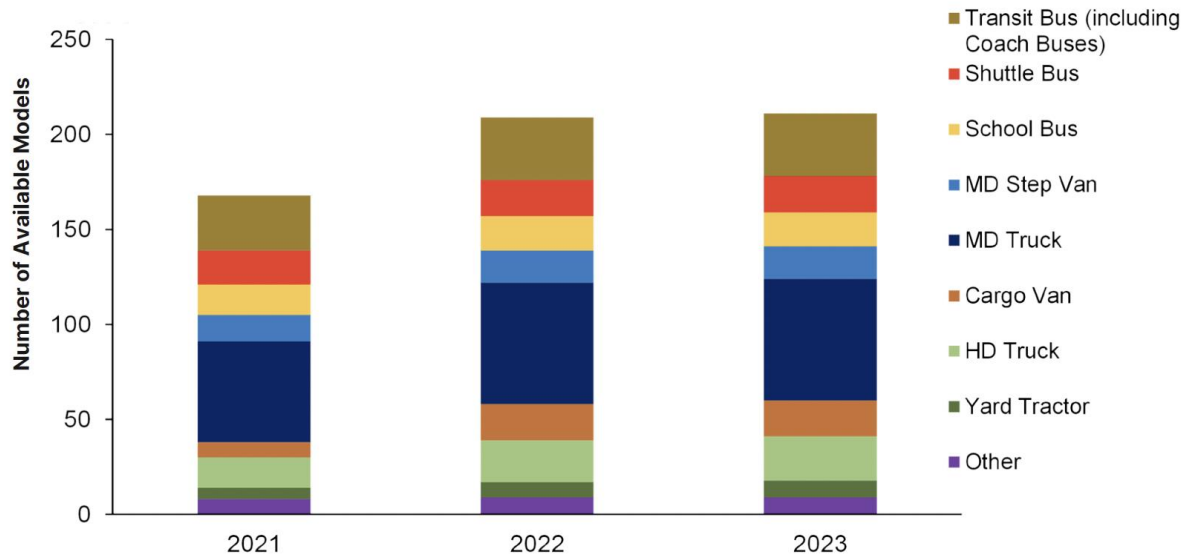
<sup>51</sup> Roberts, Daniel and Maria Violette, *Order Update: Your BrightDrop EV is on the Way.*” Brightdrop. (3 April 2023.) <https://www.gobrightdrop.com/newsroom/first-canadian-built-zevos-shipped>  
<https://www.gobrightdrop.com/newsroom/first-canadian-built-zevos-shipped>  
<https://www.gobrightdrop.com/newsroom/first-canadian-built-zevos-shipped>

<sup>52</sup> *Id.*

<sup>53</sup> Electric Vehicle Market Update: Manufacturing and Commercial Fleet Electrification Commitments Supporting Electric Mobility in the United States. April 2023. ERM for EDF. (Attachment N)

<sup>54</sup> *Id.*, Appendix C.





Source: ERM EV Market Update (April 2023)

Manufacturer commitments have translated into a growing number of ZEV sales and deployments. According to a May 2023 market update from CALSTART, since January 2017, annual zero-emission truck (ZET) deployments increased year-over-year by 104% in 2018, 23% in 2019, 60% in 2020, 397% in 2021, and 163% in 2022.<sup>55</sup> Cumulative U.S. medium- and heavy-duty ZET deployments from January 2017 to December 2022 totaled 5,483 vehicles. In 2022 alone, 3,510 MHD ZETs were deployed across the country, surpassing deployments of the previous five years (2017–2021) combined. Of the ZETs with known locations, 59 percent were deployed in states that have adopted the Advanced Clean Trucks (ACT) rule as of December 2022.

iv. Fleet deployment of ZEVs is on the rise

As manufacturers continue to expand model availability, fleets have made public commitments to electrification and deployments are growing every year. The April 2023 EV Market Update report published by ERM for EDF summarizes the status of the commercial fleet EV market

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<sup>55</sup> Calstart. 2023. Zeroing In On ZETs, May 2023 Market Update. <https://calstart.org/zio-zets-may-2023-market-update/> (Attachment O).

showing fleet commitments to electrification as well as purchase commitments.<sup>56</sup> It finds that the demand from commercial fleet operators for EV options has grown dramatically in the last few years. The report highlights some of the most recent commitments including Zeeba, a California-based fleet leasing and management provider, which signed an agreement to purchase 5,450 EVs from Canoo, with an initial binding commitment of 3,000 units through 2024.<sup>57</sup> And Kingbee, a Utah-based work-ready van rental provider, which placed a binding order for 9,300 all-electric last-mile delivery vehicles from Canoo, with an option to increase to 18,600 vehicles.<sup>58</sup> EDF maintains an electric fleet tracker that reflects publicly available information about zero-emission truck deployments and commitments.<sup>59</sup> As of May 2023, the tracker identified nearly 270 fleets that are deploying or have placed orders for an estimated 244,000 zero-emission medium- and heavy-duty vehicles. The tracker shows widespread and growing interest in electric trucks across nearly every application, including tractors, yard trucks, dump trucks, emergency vehicles, utility trucks, and refuse trucks.

CALSTART tracks the availability and deployment of zero-emission buses (ZEBs). They find that transit ZEBs have grown nationally to 5,480 on the road, awarded or on order in the beginning of 2023, an increase of 66 percent since the beginning of 2021.<sup>60</sup> As of December 2022, CALSTART estimates there were 3,043 electric school buses (ESBs) funded, ordered, delivered and deployed across the U.S.<sup>61</sup>

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<sup>56</sup> Electric Vehicle Market Update: Manufacturing and Commercial Fleet Electrification Commitments Supporting Electric Mobility in the United States, ERM for EDF, (April 2023).

<sup>57</sup> Canoo. “Zeeba Signs Binding Agreement to Purchase 3,000 Canoo Electric Vehicles.” Canoo. 11 Oct 2022. <https://www.press.canoo.com/press-release/zeeba>.

<sup>58</sup> Canoo. “Kingbee Places Binding Order for 9,300 Canoo Electric Vehicles.” Canoo. 17 Oct 2022. <https://www.press.canoo.com/press-release/kingbee>.

<sup>59</sup> See EDF Tracker at: [https://docs.google.com/spreadsheets/d/110m2Do1mjSemrb\\_DT40YNGou4o2m2Ee-KLSvHC-5vAc/edit#gid=680680398](https://docs.google.com/spreadsheets/d/110m2Do1mjSemrb_DT40YNGou4o2m2Ee-KLSvHC-5vAc/edit#gid=680680398)

<sup>60</sup> Rachel Chard, Mike Hynes, Bryan Lee and Jared Schnader, Zeroing in on ZEBs, The Advanced Technology Transit Bus Index: A ZEB Inventory Report for the United States and Canada, CALSTART (February 2023). [https://calstart.org/wp-content/uploads/2023/02/Zeroing-in-on-ZEBs-February-2023\\_Final.pdf](https://calstart.org/wp-content/uploads/2023/02/Zeroing-in-on-ZEBs-February-2023_Final.pdf).

<sup>61</sup> Rachel Chard, Juan Espinoza, Ian Fried, Liza Walsh, Zeroing in on Electric School Buses, The Advanced Technology School Bus Index: A U.S. Electric School Bus Inventory Report, CALSTART (May 2023). <https://calstart.org/wp-content/uploads/2023/05/ZIO-ESBs-final-with-May-cover-4.28.23.pdf>. (Attachment P)

EDF’s tracker also shows fleet announcements and commitments, which indicate an even greater demand for electric trucks and buses. For example, Republic Services is the 5<sup>th</sup> largest private truck fleet in the U.S. with over 17,000 trucks. Our tracker lists the three electric vehicles it has currently announced: one acquired in 2020 and two that are to be in service this fall. However, the company has also announced that it “expects EVs to represent half of its new truck purchases in the next five years,” which would represent thousands of new EV units.<sup>62</sup>

Similarly, FedEx currently has about 2,600 EVs deployed or ordered, but announced in 2021 that it plans for its entire parcel pickup and delivery fleet to be zero-emission electric vehicles by 2040. In its phased approach to this goal, it committed to have 50% of new vehicle purchases be ZEVs by 2025 and 100% by 2030, which likely translates into many thousands of new units of demand annually by 2025.<sup>63</sup>

Other leading fleets are making clear commitments to reduce emissions and adopt zero-emission solutions. For example, each of the four largest private tractor fleets in the nation are making major investments in electric trucks. PepsiCo has a goal to “reduce absolute greenhouse gas (GHG) emissions across our value chain by more than 40% by 2030, including a 75% reduction in emissions from our direct operations. Achieve net-zero emissions by 2040.”<sup>64</sup> It has been a leader in deploying electric vehicles for years and is currently deploying 36 Tesla Semis in its operations in California.<sup>65</sup> Walmart has committed to have a zero-emission fleet by 2040 and has already acquired thousands of electric cargo vans and recently acquired its first eCascadia

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<sup>62</sup> Republic Services, *News Release: Republic Services is Rolling Out Industry’s First Fully Integrated Electric Recycling and Waste Trucks*, <https://investor.republicservices.com/news-releases/news-release-details/republic-services-rolling-out-industrys-first-fully-integrated>.

<sup>63</sup> FedEx, *Press Release: FedEx Commits to Carbon-Neutral Operations by 2040*, <https://investors.fedex.com/news-and-events/investor-news/investor-news-details/2021/FedEx-Commits-to-Carbon-Neutral-Operations-by-2040/default.aspx>.

<sup>64</sup> PepsiCo, 2021 ESG Performance Metrics, <https://www.pepsico.com/our-impact/sustainability/esg-summary/goals-progress>.

<sup>65</sup> CNBC, *PepsiCo is Using 36 Tesla Semis in its Fleet and is Upgrading Facilities for More in 2023* (Dec. 16, 2022), <https://www.cnbc.com/2022/12/16/pepsico-is-using-36-tesla-semis-in-its-fleet-and-is-upgrading-facilities-for-more-in-2023-exec-says.html>.

truck.<sup>66</sup> Sysco has a goal of electrifying 35 percent of its U.S. fleet by 2030 and received its first electric truck in November 2022.<sup>67</sup> Finally, US Foods just received its first battery-electric powered Freightliner eCascadia trucks at its La Mirada, California distribution center.<sup>68</sup> The company previously announced plans to add 30 electric trucks to its La Mirada fleet in 2023.<sup>69</sup> Collectively, these four fleets have nearly 35,000 electric trucks on the road in the U.S. Their collective demand alone will account for thousands of annual orders for zero-emission trucks. For-hire fleets are also making major investments in zero-emission trucks. UPS just received its first 10 electric tractors,<sup>70</sup> Schneider just opened a large-scale electric charging depot in California that will support up to 100 Class 8 BEV trucks at one time<sup>71</sup> and JB Hunt has set a goal to reduce its emissions by 34% within the decade and is piloting several electric trucks.<sup>72</sup> The EV tracker also shows demand for electric trucks from smaller fleets. ENAT Transportation and Logistics, a last mile delivery services company in New Jersey, has been growing its fleet of electric vans and trucks,<sup>73</sup> while Sunburst Truck Lines, a Texas-based drayage fleet, is operating

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<sup>66</sup> Jason Mathers, *Walmart Commits to 100% Zero-Emission Trucks by 2040, Signaling Electric is the Future*, EDF (Sep. 22, 2020) <https://blogs.edf.org/energyexchange/2020/09/22/walmart-commits-to-100-zero-emission-trucks-by-2040-signaling-electric-is-the-future/>.

<sup>67</sup> Daimler Truck North America, *Transforming the Future of Foodservice Delivery: Sysco Receives First Battery Electric Freightliner eCascadia* (Nov. 11, 2022), <https://www.prnewswire.com/news-releases/transforming-the-future-of-foodservice-delivery-sysco-receives-first-battery-electric-freightliner-ecascadia-301675939.html>.

<sup>68</sup> US Foods Supports Emissions Reduction Efforts with Initial Delivery of Battery-Electric Trucks (Feb. 14, 2023), <https://ir.usfoods.com/investors/stock-information-news/press-release-details/2023/US-Foods-Supports-Emissions-Reduction-Efforts-With-Initial-Delivery-of-Battery-Electric-Trucks/default.aspx>.

<sup>69</sup> US Foods Supports Emissions Reduction Efforts with Initial Delivery of Battery-Electric Trucks (Feb. 14, 2023), <https://ir.usfoods.com/investors/stock-information-news/press-release-details/2023/US-Foods-Supports-Emissions-Reduction-Efforts-With-Initial-Delivery-of-Battery-Electric-Trucks/default.aspx>.

<sup>70</sup> Rich DeMuro, *I Took a Ride in UPS's First All Electric Semi Truck*, KTLA 5 (Feb. 6, 2023), <https://ktla.com/morning-news/i-took-a-ride-in-upss-first-all-electric-semi-truck/>.

<sup>71</sup> Schneider says California site can charge 32 battery-powered trucks at once, DC Velocity (June 9, 2023), <https://www.dcvelocity.com/articles/57730-schneider-says-california-site-can-charge-32-battery-powered-trucks-at-once>.

<sup>72</sup> J.B. Hunt, J.B. Hunt Announces Ambitious Goal to Reduce Carbon Emission Intensity 32% by 2034, <https://www.jbhunt.com/our-company/newsroom/2022/11/j-b-hunt-ambitious-goal-reduce-carbon-emission-intensity>.

<sup>73</sup> ENAT Transportation & Logistics, *homepage*, <https://www.enattl.com/>.

an electric tractor in Houston<sup>74</sup> and Valley Malt, a Massachusetts-based malt house and one-vehicle fleet, has purchased a Ford E-Transit.<sup>75</sup>

For-hire fleets are also making major investments in zero-emission trucks. UPS just received its first 10 electric tractors,<sup>76</sup> Schneider just opened a large-scale electric charging depot in California that will support up to 100 Class 8 BEV trucks at one time<sup>77</sup> and JB Hunt has set a goal to reduce its emissions by 34% within the decade and is piloting several electric trucks.<sup>78</sup> The EV tracker also shows demand for electric trucks from smaller fleets. ENAT Transportation and Logistics, a last mile delivery services company in New Jersey, has been growing its fleet of electric vans and trucks,<sup>79</sup> while Sunburst Truck Lines, a Texas-based drayage fleet, is operating an electric tractor in Houston<sup>80</sup> and Valley Malt, a Massachusetts-based malt house and one-vehicle fleet, has purchased a Ford E-Transit.<sup>81</sup>

- v. State leadership further supports the feasibility of protective standards

States have also been leading the way with protective standards. California adopted the Advanced Clean Trucks (ACT) rule in 2021, which requires truck manufacturers to produce an increasing percentage of new zero-emission trucks and buses beginning with model year 2024.<sup>82</sup>

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<sup>74</sup> American Journal of Transportation, *Port Houston Welcomes First Zero-Emissions Drayage Truck* (June 9, 2022), <https://ajot.com/news/port-houston-welcomes-first-zero-emissions-drayage-truck>.

<sup>75</sup> Valley Malt, Facebook Post on Mar. 27, 2022, <https://www.facebook.com/photo/?fbid=5311291732223050&set=a.1907173599301564>.

<sup>76</sup> Rich DeMuro, *I Took a Ride in UPS's First All Electric Semi Truck*, KTLA 5 (Feb. 6, 2023), <https://ktla.com/morning-news/i-took-a-ride-in-upss-first-all-electric-semi-truck/>.

<sup>77</sup> Schneider says California site can charge 32 battery-powered trucks at once, DC Velocity (June 9, 2023), <https://www.dcvelocity.com/articles/57730-schneider-says-california-site-can-charge-32-battery-powered-trucks-at-once>.

<sup>78</sup> J.B. Hunt, J.B. Hunt Announces Ambitious Goal to Reduce Carbon Emission Intensity 32% by 2034, <https://www.jbhunt.com/our-company/newsroom/2022/11/j-b-hunt-ambitious-goal-reduce-carbon-emission-intensity>.

<sup>79</sup> ENAT Transportation & Logistics, *homepage*, <https://www.enattl.com/>.

<sup>80</sup> American Journal of Transportation, *Port Houston Welcomes First Zero-Emissions Drayage Truck* (June 9, 2022), <https://ajot.com/news/port-houston-welcomes-first-zero-emissions-drayage-truck>.

<sup>81</sup> Valley Malt, Facebook Post on Mar. 27, 2022, <https://www.facebook.com/photo/?fbid=5311291732223050&set=a.1907173599301564>.

<sup>82</sup> California Air Resources Board, *Final Regulation Order: Advanced Clean Trucks Regulation*, <https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2019/act2019/fro2.pdf>.

By 2035, zero-emission truck/chassis sales in the state will need to be 55% of Class 2b – 3 truck sales, 75% of Class 4 – 8 straight truck sales, and 40% of truck tractor sales. The ACT regulation helps ensure that manufacturers offer affordable zero emission choices to fleets, while delivering air quality benefits to communities across the state.

The ACT rule has garnered widespread support from major business interests across the nation, including more than 85 companies that signed a letter urging governors across the country to adopt the policy.<sup>83</sup> On April 21, 2023, Colorado became the eighth state to adopt the ACT regulation, joining California, Massachusetts, New Jersey, New York, Oregon, Vermont and Washington.<sup>84</sup> Maryland will soon become the ninth state, having recently passed a law requiring the Maryland Department of Environment to adopt the rule by the end of 2023.<sup>85</sup><sup>86</sup> With the recent additions of Colorado and Maryland, ACT states now account for 24% of national truck sales based on data from MOVES3. The ACT rule will help ensure sufficient supply for zero-emission trucks and vans to meet the growing demand from businesses.

As a complement to the ACT rule, California recently adopted the Advanced Clean Fleets (ACF) regulation, a requirement for medium- and heavy-duty fleets to purchase an increasing percentage of zero-emission trucks. The rule sets a 100% ZEV truck sales target for 2036, with an on ramp for fleets to meet that goal. The ACF regulation is expected to save \$26.5 billion in statewide health benefits from criteria pollutant emissions and provide fleets with net cost savings of \$48 billion.<sup>87</sup>

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<sup>83</sup> Ceres, *85 Businesses Call for the Advanced Clean Trucks Rule*, <https://www.ceres.org/policy/state/ACT>

<sup>84</sup> Environmental Defense Fund, *Colorado Adopts Proactive New Standards for Zero-Emission Trucks* (Apr. 21, 2023), <https://www.edf.org/media/colorado-adopts-protective-new-standards-zero-emission-trucks>.

<sup>85</sup> Maryland Passes Clean Trucks Act With Key Caveats, Transport Trucking (April 13, 2023). <https://www.ttnews.com/articles/md-clean-trucks-act>.

<sup>86</sup> Maryland Passes Clean Trucks Act With Key Caveats, Transport Trucking (April 13, 2023). <https://www.ttnews.com/articles/md-clean-trucks-act>.

<sup>87</sup> California Air Resources Board, *Advanced Clean Fleets Regulation Summary* (May 17, 2023), <https://ww2.arb.ca.gov/resources/fact-sheets/advanced-clean-fleets-regulation-summary>.

States are also providing billions of dollars in grants and incentives to produce and sell electric vehicles, batteries and components. According to EDF and WSP, the more than \$120 billion in private EV ecosystem investments over the last 8 years have been spurred by the nearly \$14 billion in state and local incentives.

In addition to state rulemakings, a diverse collection of seventeen states and the District of Columbia joined a multi-state initiative to advance and accelerate the market for electric medium- and heavy-duty vehicles.<sup>88</sup> Together, the signatories account for 35 percent of the medium- and heavy-duty fleet in the U.S..<sup>89</sup> The voluntary initiative set a target of 30 percent of new truck and bus sales being ZEV by 2030 and 100 percent ZEV sales by 2050 with an emphasis on the need to accelerate and prioritize deployment in disadvantaged communities.

Together, these state programs and incentives further support the feasibility of strong Phase 3 emissions standards consistent with the ACT that drive the deployment of ZEVs.

#### b) New Analyses Support More Protective Standards for Tractor Trailers and Buses

In addition to the array of studies, analyses, and market and policy developments discussed in section a) that broadly support more protective standards consistent with the ACT, EDF undertook specific additional analytical work to demonstrate the feasibility and cost-effectiveness of stronger standards for two key HD segments. In section i, below we describe analysis related to the feasibility and cost of BEV tractor trailers, section ii addresses how updating EPA's assumptions related to FCVs and depot charging supports stronger standards, and section iii evaluates buses.

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<sup>88</sup> The current signatories are California, Colorado, Connecticut, Hawaii, Maine, Maryland, Massachusetts, New Jersey, New York, Nevada, North Carolina, Oregon, Pennsylvania, Rhode Island, Vermont, Washington, the District of Columbia, and Quebec, Canada. "Multi-State Medium- and Heavy-Duty Zero Emission Vehicle Memorandum of Understanding," (July 14, 2020), <https://www.nescaum.org/documents/mhdv-zev-mou-20220329.pdf/>.

<sup>89</sup> Arijit Sen, Ray Minjares, Josh Miller, and Caleb Braun. April 2022. "Benefits of the 2020 Multi-State Medium- and Heavy-Duty Zero-Emission Vehicle Memorandum of Understanding," ICCT Briefing. <https://theicct.org/wp-content/uploads/2022/04/md-hd-mou-benefits-apr22.pdf>.

i. New Research Supports the Feasibility and Need for Protective Tractor Trailer Standards

Tractor trailers are the largest source of climate destabilizing and health harming pollution from the heavy-duty vehicle sector and so protective pollution safeguards that help to ensure ZEV deployment levels beyond EPA's proposal are vital and urgently needed. The analysis below supports our recommendation that EPA finalize standards consistent with at least 50% of all new tractor sales in the U.S. being ZEVs by 2032.

EDF undertook new work submitted as part of our comments on this rulemaking with Roush Industries to conduct a robust, bottom up evaluation of both the upfront and total costs of a range of BEV tractors including two battery ranges for each Class 7 day cab, Class 8 day cab, and Class 8 sleeper cab.<sup>90</sup> The focus of the study was to better understand the set of tractors that are best suited to be converted to BEVs in the time frame of the EPA proposed rule. Roush modeled the 6 tractor configurations for MYs 2030 and 2032 in GT-Suite, an industry-leading, physics-based simulation tool. They used the tool to calculate energy consumption, battery capacity, motor power, and inverter power. Roush used their internal battery price and physics projections to establish the cost, weight, and volume of the battery packs needed for each of the tractors. The main analysis assumed all depot charging, consistent with the assumption EPA makes in their modeling.

With the IRA credits, most BEVs' effective powertrain retail price is the same or less than diesel vehicles.

Roush based their diesel powertrain costs on EPA's modeling. BEV powertrain costs were sourced from teardown studies, the current body of literature, and their expert evaluations. When IRA tax credits including the Commercial Clean Vehicle Credit as well as the production tax credit for domestically made batteries are included, all of the BEVs considered by Roush except the long range Class 8 sleeper cab in MY 2032 were the same price or cheaper than their

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<sup>90</sup> Vishnu Nair, Himanshu Saxena, Sajit Pillai. 2023. *Class 7 and Class 8 Tractor-Trailer Electrification for MYs 2030 and 2032*, Roush Industries for Environmental Defense Fund. (Attachment Q).



counterpart ICE vehicles and BEV long rang Class 8 sleeper cab in MY 2032 is projected to be less than a \$10,000 increase in cost relative to the diesel ICE vehicle.

TCO of BEVs is significantly lower than diesel ICE across all segments in 2030-32

The TCO per mile for BEVs is between 17 and 35% lower than the corresponding ICE vehicle. Roush used the U.S. Energy Information Administration's Annual Energy Outlook 2023 reference case values for electricity and diesel prices. To be conservative they removed the fuel tax from the diesel price to better compare equal fuel costs. Roush calculated maintenance costs for BEVs as 30% lower than ICE vehicles.

Figure 3: TCO per mile and its components for Class 7 and 8 tractors from primary analysis



Source: Roush, *Class 7 and Class 8 Tractor-Trailer Electrification for MYs 2030 and 2032*

All of the BEV tractors have a payback period of less than 3 years.

Table 4: Years to reach total-cost-of-ownership parity between BEVs and ICEVs

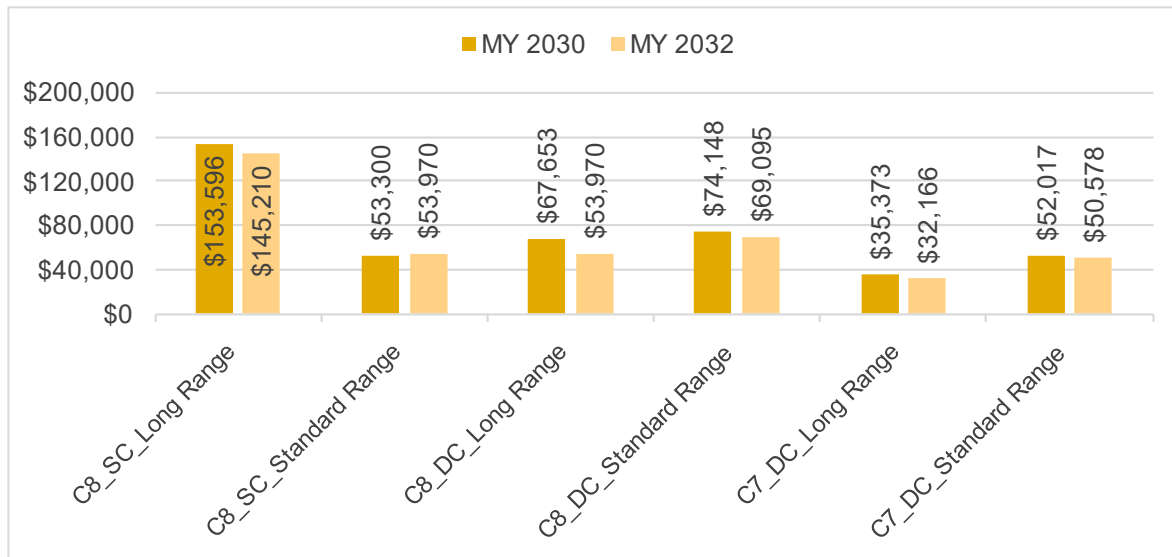
Vehicle Categories	Annual VMT (miles)	Payback Period (in years)	
		MY 2030	MY 2032
CL8 Sleeper Cab Long Range	97,935	1	2
CL8 Sleeper Cab Standard Range	46,636	3	3
CL8 Day Cab Long Range	47,634	3	3
CL8 Day Cab Standard Range	47,634	2	3
CL7 Day Cab Long Range	26,576	3	3
CL7 Day Cab Standard Range	26,576	<1	<1

Source: Roush, *Class 7 and Class 8 Tractor-Trailer Electrification for MYs 2030 and 2032*

All tractors included in this analysis have attractive payback periods of less than three years. Due to the high annual mileage and the corresponding high fuel and maintenance savings, BEV tractors quickly payback any increased upfront costs associated with their powertrains or EVSE equipment and save fleet owners money for the majority of the vehicles’ lifetimes.

Substantial lifetime net savings from BEV adoption over ICEV demonstrate the potential for sustained benefits for fleet owners

Figure 4: Cumulative Net Savings of BEVs over ICEVs in MYs 2030 and 2032



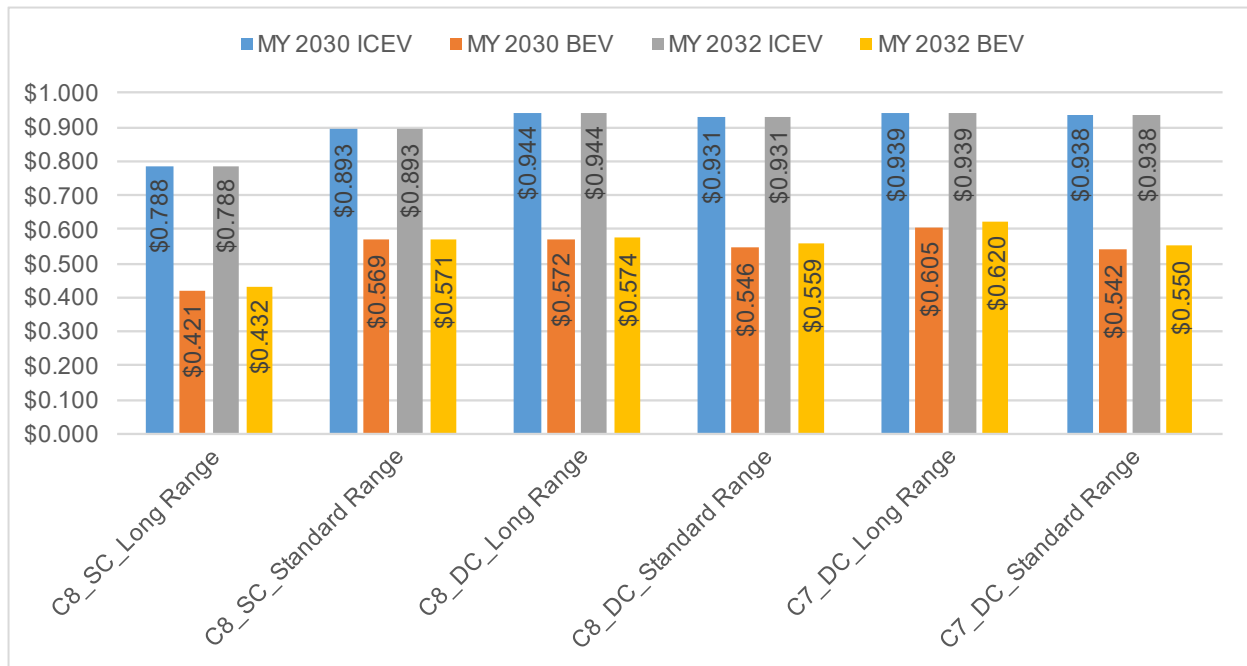
Source: Roush, *Class 7 and Class 8 Tractor–Trailer Electrification for MYs 2030 and 2032*

The vehicles considered in Roush’s study also demonstrate that BEV tractors provide impressive lifetime savings. Figure 4 shows the extent of savings possible over the life of the vehicle. A Class 8 long-range sleeper cab purchased in 2030 could see up to \$153,000 in savings over its life. The lifetime savings estimates also demonstrate the limitations in using a pure payback period metric for assessing adoption likelihood. For vehicles with high mileage over their lifetime, BEVs provide an even more significant cost savings opportunity.

Under a high diesel fuel scenario, most BEV tractors have a payback period of less than 1 year.

In this sensitivity analysis, Roush used the high oil price scenario from AEO2023. The last couple years have seen record high diesel prices. Under such a scenario, the savings from BEV adoption increase tremendously. The TCO per mile of BEVs under the high diesel cost scenario is between 36% and 47% lower than ICEV.

Figure 5: Comparison of the total cost of ownership (TCO) in \$/mile in a high diesel price scenario across MYs 2030 and 2032



Source: Roush, *Class 7 and Class 8 Tractor–Trailer Electrification for MYs 2030 and 2032*

Higher annual operational VMTs lead to an even shorter payback period for BEVs.

The annual VMT used in the Roush study matches EPA and is the 10 year average annual VMT. This represents a conservative estimate of the potential benefits BEVs can provide. For the long range Class 8 day cab, the study assumes the vehicle travels just under 48,000 miles per year which, using EPA’s 250 driving days per year, this corresponds with 190 miles per day even though the battery is sized to travel around 400 miles per day. If the vehicle drove 20% more annually, or 57,000 miles per year, it would reduce the payback period by a third - to less than 2 years. Currently, tractors drive the most miles in the first few years and then are transitioned to operations such as drayage with fewer miles.<sup>91</sup> This is partly due to the higher maintenance costs of vehicles as they age. BEVs have significantly fewer moving parts and reduced maintenance costs and as a result owners may decide to leave BEVs in higher annual mileage operations increasing their potential savings relative to ICEVs.

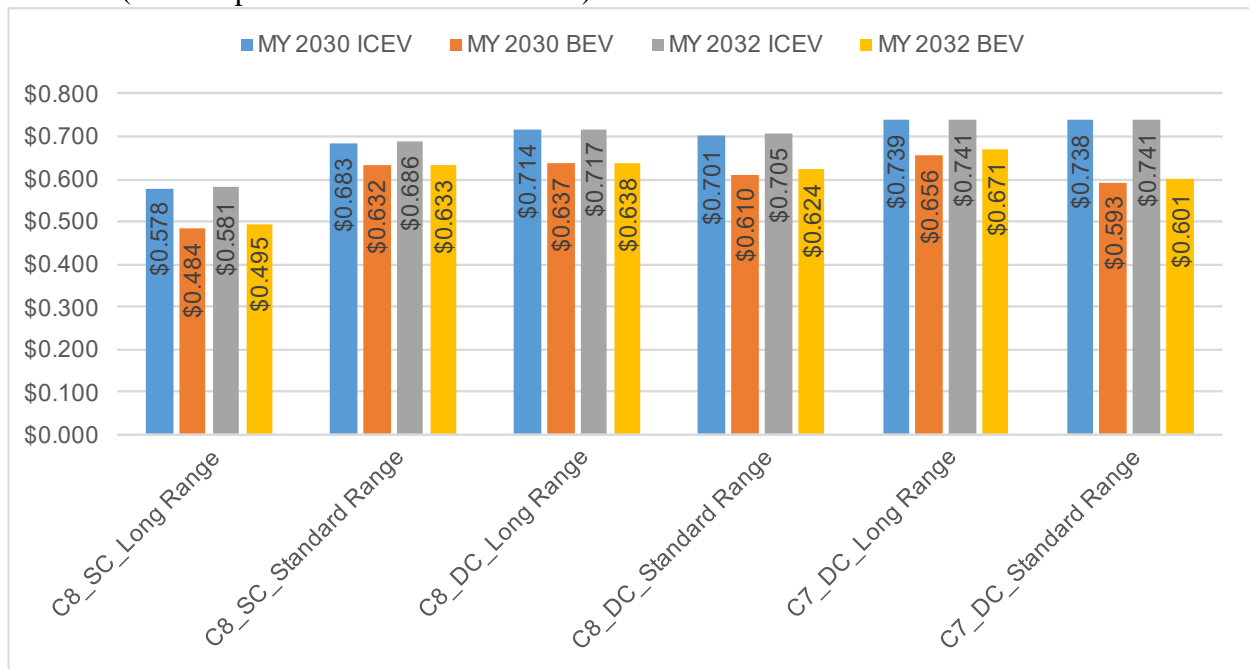
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<sup>91</sup> *Population and Activity of Onroad Vehicles in MOVES3*. 2021. U.S. Environmental Protection Agency, Office of Transportation and Air Quality, Assessments and Standards Division. <https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1011TF8.pdf>

BEVs have a lower TCO per mile even with significant enroute charging.

The report includes a scenario that investigates the impact on TCO and payback period if vehicles were assumed to use enroute charging for part of the time. The scenario assumes vehicles charge 70% at a depot and 30% enroute using a highspeed, 3 MW charger. Roush used an enroute charging electricity price of \$0.23/kWh based on a December 2022 NREL study entitled “Estimating the Breakeven Cost of Delivered Electricity to Charge Class 8 Electric Tractors.”<sup>92</sup>

Figure 6: Comparison of the total cost of ownership (TCO) in \$/mile in a mixed charging scenario (70% Depot and 30% Enroute MCS) across MYs 2030 and 2032



Source: Roush, *Class 7 and Class 8 Tractor-Trailer Electrification for MYs 2030 and 2032*

Even with higher electricity prices, BEV tractors still showed significant savings relative to ICEVs with TCOs 9% to 20% lower. The payback periods remain attractive in the mixed charging scenarios. All tractors have a payback period less than 5 years.

<sup>92</sup> Jesse Bennett et al. *Estimating the Breakeven Cost of Delivered Electricity To Charge Class 8 Electric Tractors*. 2022. National Renewable Energy Laboratory, <https://www.nrel.gov/docs/fy23osti/82092.pdf> (Attachment FF)

Table 5: Payback period of BEV compared to ICE tractors in a mixed charging scenario (70% Depot, 30% Enroute MCS)

Vehicle Categories	Payback Period (in years)	
	MY 2030	MY 2032
C8_SC_Long Range	2	3
C8_SC_Standard Range	5	5
C8_DC_Long Range	4	4
C8_DC_Standard Range	3	4
C7_DC_Long Range	4	5
C7_DC_Standard Range	1	1

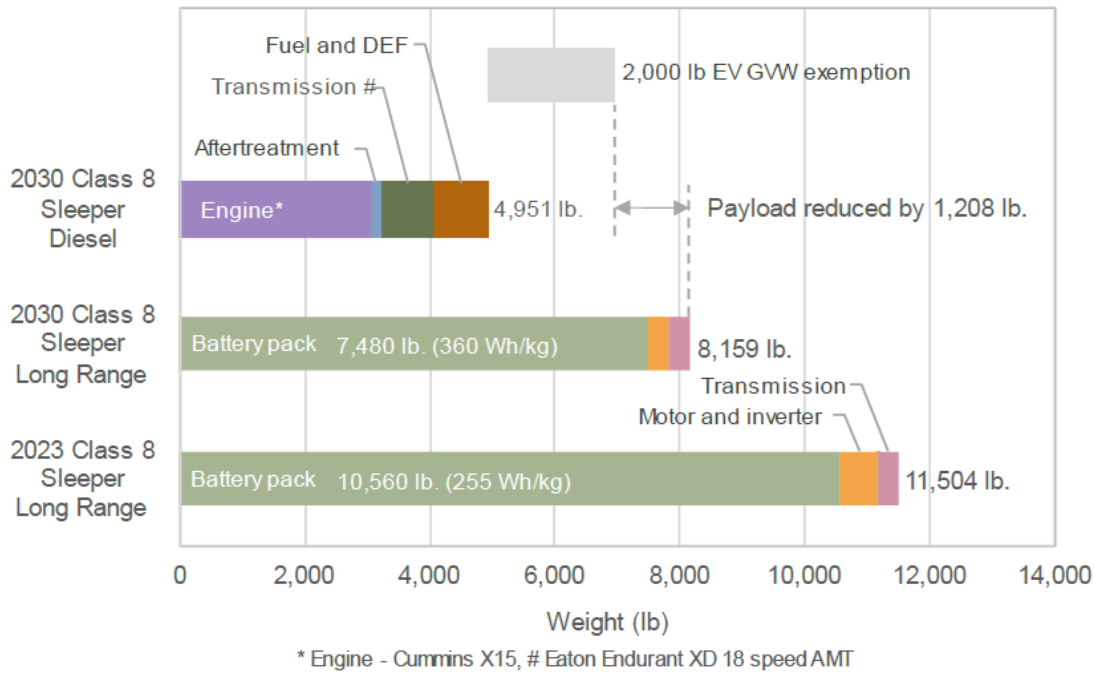
Source: Roush, *Class 7 and Class 8 Tractor–Trailer Electrification for MYs 2030 and 2032*

BEV tractors will have comparable cargo capacity to conventional vehicles.

The advancements in battery chemistry and pack construction are highly likely to significantly improve the energy density of the battery pack between 2023 and 2030. Lighter batteries combined with the 2,000 lb gross vehicle weight exemption for BEVs, will minimally affect the cargo capacity of BEVs. As is shown in Figure 7, even the vehicle with the largest battery in the study, the long-range Class 8 sleeper cab, will see a 1,200 lb reduction in payload.

Figure 7: Comparison of the powertrain weight of Class 8 Sleeper long-range diesel and electric powertrains, respectively

Class 8 Sleeper BEV and ICE Powertrain Component Weights 2023-2032



Source: Roush, *Class 7 and Class 8 Tractor-Trailer Electrification for MYs 2030 and 2032*

A number of other studies support the findings in Roush’s analysis. A 2021 study from NREL looked at all classes and segments of medium- and heavy-duty vehicles and estimated that tractors could reach TCO parity with their diesel counterparts by 2025.<sup>93</sup> Another study by the North American Council for Freight Efficiency (NACFE) concluded that a BEV short haul tractor purchased in 2022 would save more than \$9,000 annually on fuel costs compared to a diesel truck.<sup>94</sup> Both of these studies occurred before the passage of the IRA. A 2023 study by ICCT, which included the economic benefits of the IRA, found that by 2030, the TCO of BEV

<sup>93</sup> Chad Hunter, Michael Penev, Evan Reznicek, Jason Lustbader, Alicia Birky, and Chen Zhang. 2021. Spatial and Temporal Analysis of the Total Cost of Ownership for Class 8 Tractors and Class 4 Parcel Delivery Trucks, Nation Renewable Energy Lab, Technical Report. <https://www.nrel.gov/docs/fy21osti/71796.pdf> (Attachment R)

<sup>94</sup> North American Council for Freight Efficiency. 2022. Electric Trucks Have Arrived: The Use Case for Heavy-Duty Regional Haul Tractors. <https://nacfe.org/heavy-duty-regional-haul-tractors/>



long-haul trucks will likely be lower than that of their diesel counterparts in all representative states considered in the analysis.<sup>95</sup>

The majority of tractors drive daily distances that allow for their transition to BEV in the timeframe of the proposed rule

Tractor use is not homogenous; daily mileage can range from less than 50 miles a day to over 500 miles a day. Understanding this distribution is vital to setting standards given the impact battery range has on vehicle price. EDF used the U.S. Department of Transportation's 2002 Vehicle Inventory and Use Survey (VIUS) and the California Air Resources Board's Large Entity Fleet Reporting to better understand the maximum distances that vehicles travel in a day and calculate the percentage of the fleet that is electrifiable based on VMT and battery range from Roush.<sup>96 97</sup>

VIUS asked vehicle owners to assign percentage of trips that vehicle took over the year to a set of trip lengths (less than 50 miles, 51 to 100 miles, 101 to 200 miles, 201 to 500 miles, and more than 500 miles). We divided the tractors into day and sleeper cabs. To take into consideration the higher mileage vehicles drive at the beginning of their life compared to the end, we only included vehicles in the first 5 years of their use. This left the dataset with 7,840 tractors – 58% sleeper cab and 42% day cab.

We calculated the 90<sup>th</sup> percentile of daily trip distances for vehicles allowing for 10% of daily trip lengths to be in the category one above. For example, if a vehicle reported 95% of its trips were between 51 to 100 miles and 5% were 101 to 200 miles, then that vehicle's 90<sup>th</sup> percentile

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<sup>95</sup> Basma, H., Buysse, C., Zhou, Y., Rodriguez, F., Total Cost of Ownership of Alternative Powertrain Technologies for Class 8 Long-Haul Trucks in the United States, ICCT, April 2023, , <https://theicct.org/publication/tco-alt-powertrain-long-haul-trucks-us-apr23/> (Attachment S).

<sup>96</sup> Vehicle Inventory and Use Survey 2002. U.S. Department of Transportation, Bureau of Transportation Statistics, 2004, <https://rosap.nhtl.bts.gov/view/dot/42632>

<sup>97</sup> California Air Resources Board. 2022. *Large Entity Fleet Reporting: Statewide Aggregated Data*. [https://ww2.arb.ca.gov/sites/default/files/2022-02/Large\\_Entity\\_Reporting\\_Aggregated\\_Data\\_ADA.pdf](https://ww2.arb.ca.gov/sites/default/files/2022-02/Large_Entity_Reporting_Aggregated_Data_ADA.pdf)

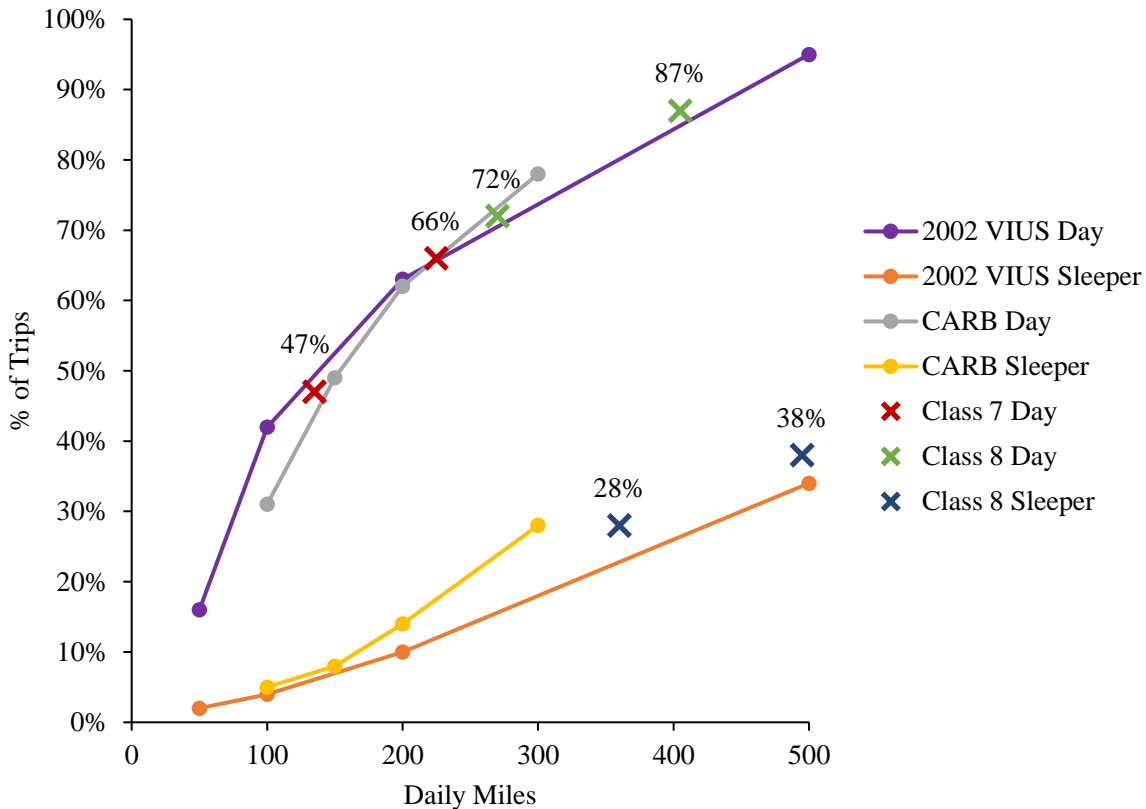
trip length was 51 to 100 miles. However, if instead the 5% was in 201 to 500 miles, the 90<sup>th</sup> percentile trip length was 101 to 200 miles.

The analysis found that a significant share of tractors, particularly day cab tractors, travel daily distances that are easily electrifiable – 42% of day cabs traveled less than 100 miles a day and 63% traveled less than 200 miles a day. For sleeper cabs, 10% traveled less than 200 miles a day and roughly one third (34%) traveled less than 500 miles a day.

While the VIUS represents the most comprehensive source, it is reporting data that is more than 20 years old. The California Air Resources Board (CARB) collected data operational practices from 2019 in 2021 via an online portal. This report included 61,782 tractors. They asked the fleets responding to estimate the daily mileage for their vehicles. CARB found 31% of day cabs traveled less than 100 miles a day, 49% traveled less than 150 miles a day, 62% traveled less than 200 miles a day, and 78% traveled less than 300 miles a day. Additionally, their results found that 14% of sleeper cabs traveled less than 200 miles a day and 28% traveled less than 300 miles a day.

The lines in Figure 8 shows the relationship between percent of trips for VIUS and CARB day and sleeper cabs with daily mileage. There is fairly large agreement between the two datasets and in particular the shape of the curves, day cabs as concave and sleeper cabs as convex, is the same between the two datasets.

Figure 8: Percent of tractor trips at or below the specific daily miles



Source: EDF Analysis based on data from U.S. Department of Transportation’s 2002 Vehicle Inventory and Use Survey (VIUS) and the California Air Resources Board’s Large Entity Fleet Reporting

The Roush report includes two battery sizes for each of the three types of tractors considered: Class 7, Class 8 day cabs, and Class 8 sleeper cabs. Since Roush does not include temperature considerations in their analysis, we have reduced the battery range by 10% to be conservative. We used two datasets discussed above, VIUS and CARB, to calculate the % of each tractor and battery size combination could cover based on their daily mileages. Table 6 below, includes the ranges from the Roush report, the conservative battery range, and the % of vehicles each tractor could cover. The VIUS dataset allows for differentiation between Class 7 and Class 8 vehicles, however the % of trips covered by each mileage category is virtual identical between Class 7 and Class 8 vehicles so the combined category of day cabs was plotted in Figure 8.

Table 6: Roush BEV battery range sizes and the percent of tractor trips covered by mileage range

		Battery Range (mi)	Conservative Battery Range (mi)	% of Vehicles Covered
Class 7	Standard Range	150	135	47%
	Long Range	250	225	66%
Class 8 Day Cab	Standard Range	300	270	72%
	Long Range	450	405	87%
Class 8 Sleeper Cab	Standard Range	400	360	28%
	Long Range	550	495	38%
All Tractors				57%

As shown in Figure 8 and in Table 6, a significant share of tractors, both day and sleeper, are readily electrifiable by 2030. The longer range battery for Class 7 tractors, 225 miles, corresponds with covering 66% of daily mileages day cabs. For Class 8 day cabs, a battery with a range of 405 miles would accommodate 87% of all day cab tractors and their daily mileage requirements. For Class 8 sleeper cabs, 38% of vehicles drive less than 495 miles per day. Combined, this accounts for 57% of all tractors using EPA’s sales estimates for the 12 tractor types included in HD TRUCS.

- ii. Correcting EPA’s assumptions that all sleeper cabs will be FCVs and that all heavy-duty vehicles will be charged in depots supports stronger standards

EPA’s modeling assumes all sleeper cab tractors will exclusively be fuel cell electric vehicles (FCEVs). However, as noted above, a number of sleeper cab tractors travel short enough distances every day that it would be very reasonable for EPA to assume those vehicles could be battery electric starting as early as 2027. The two categories of sleeper cabs EPA modeled had a 90<sup>th</sup> percentile daily mileage of 400 and 550 miles. By only breaking up sleeper cabs into these two categories, EPA is disregarding the share of vehicles that drive fewer daily miles. The 2002 VIUS found 10% of sleeper cabs 5 years or younger drove fewer than 200 miles 90% of the time

and CARB found that 14% of sleeper cabs drove fewer than 200 miles on average.<sup>98</sup> Additionally, CARB found that 28% of sleeper cabs drive fewer than 300 miles a day.<sup>99</sup>

While this does not represent the majority of the sleeper cabs, failing to incorporate these vehicles into EPA's analysis negatively impacts the stringency of the rule. Tractors account for a significant share of on road tailpipe emissions and early decarbonization of even a small portion of this sector is crucial.

EPA's analysis also assumes that all heavy-duty vehicles will be charged in depots. While it is reasonable that a large share of vehicles, particularly vocational vehicles, will be charged where they are domiciled in the evenings, this assumption restricts the extent vehicles can be electrified within the rule.

As demonstrated in Roush's modeling, a 15-minute charge using a 3,000 amp charger will significantly increase the range of a vehicle, taking a battery from 20% to 80% charged.<sup>100</sup> Figure 9 below shows the extent of the battery range increase possible with a 15 min charge.

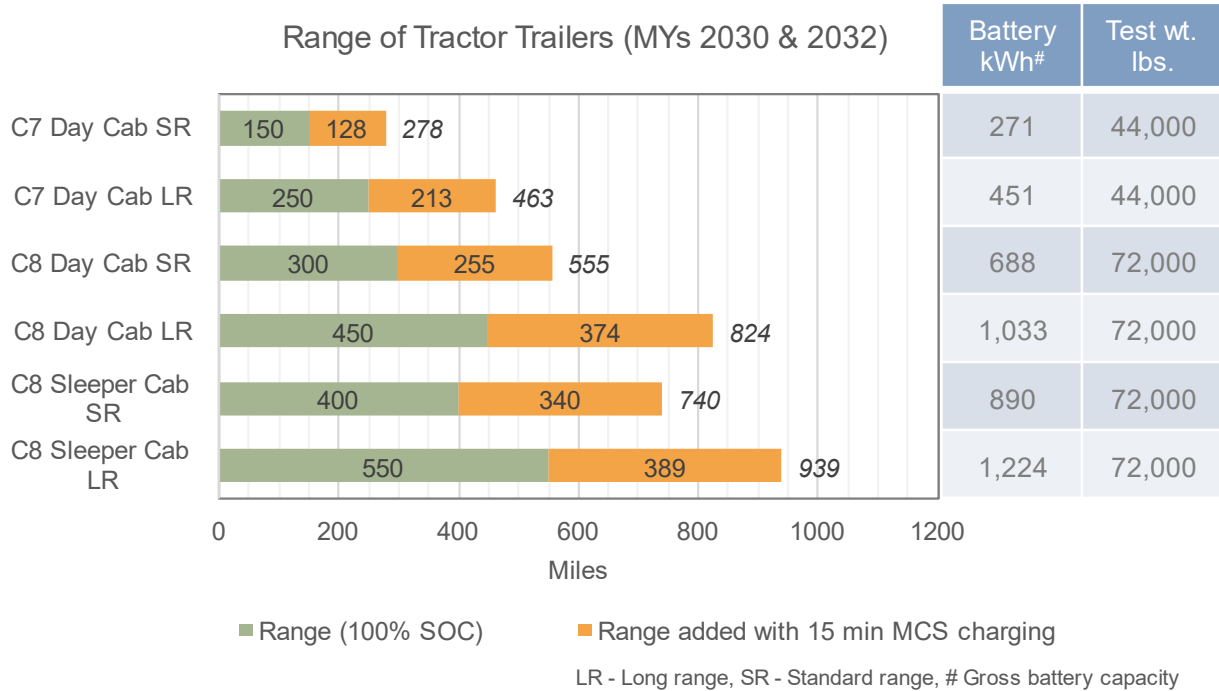
Figure 9: Battery size (kWh), range (miles), Test weight (lb), and the range added with a 15-minute charging session at a Megawatt Charging System (MCS) station.

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<sup>98</sup> Vehicle Inventory and Use Survey 2002. U.S. Department of Transportation, Bureau of Transportation Statistics, 2004, <https://rosap.ntl.bts.gov/view/dot/42632>

<sup>99</sup> California Air Resources Board. 2022. *Large Entity Fleet Reporting: Statewide Aggregated Data*. [https://ww2.arb.ca.gov/sites/default/files/2022-02/Large\\_Entity\\_Reporting\\_Aggregated\\_Data\\_ADA.pdf](https://ww2.arb.ca.gov/sites/default/files/2022-02/Large_Entity_Reporting_Aggregated_Data_ADA.pdf)

<sup>100</sup> Vishnu Nair, Himanshu Saxena, Sajit Pillai. 2023. *Class 7 and Class 8 Tractor-Trailer Electrification for MYs 2030 and 2032*, Roush for Environmental Defense Fund.



Source: Roush, *Class 7 and Class 8 Tractor-Trailer Electrification for MYs 2030 and 2032*

These types of high-powered chargers would not be required everywhere in the U.S. but instead would need to be located at intervals along major highway routes. Companies such as TeraWatt have already begun development on charging networks to meet this need. TeraWatt has raised \$1 billion to place chargers along I-10 spaced 150 miles apart across California, Arizona, and New Mexico.<sup>101</sup>

By incorporating high speed chargers, vehicles could drive more miles and have smaller batteries. This is particularly relevant for tractors where the daily mileage of the vehicles can exceed 500 miles. By incorporating such assumption, the feasibility of BEV tractors would be greatly expanded past what our recommendation contemplates.

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<sup>101</sup> Emma Newburger, *TeraWatt Announces First Interstate EV Charging Network for Trucks*, CNBC (Oct. 20, 2022), <https://www.cnbc.com/2022/10/20/-terawatt-announces-first-interstate-ev-charging-network-for-trucks.html>.

Given the analyses projecting BEV tractor prices to fall and provide significant savings to fleet owners as well as the high percent of tractor trips that could be easily converted to BEVs, we recommend EPA finalize a tractor standard consistent with at least 50% ZEV sales by 2032.

- iii. EPA should set the vocational vehicle standard at a level that reflects the feasibility of greater deployment of school buses and transit buses

There is also a critical opportunity for EPA to strengthen the standards for transit and school buses to ensure that 80% of new school and transit buses are ZEV by 2029 and 90% by 2032. The technology is available today and substantial federal, state and local funding opportunities will make the transition entirely feasible and cost-effective over the timeframe of the rule.

#### 1. Impacts of diesel fumes on children

Nationally, about 26 million children take 480,000 buses to and from school each day. School buses travel about 12,000 miles per year per bus or almost 6 billion cumulative miles per year and over 90 percent of these school buses run on diesel.<sup>102</sup><sup>103</sup> Diesel exhaust is composed of very fine particles of carbon and a mixture of toxic gases and has been named a human carcinogen by the World Health Organization. There is no known safe level of exposure to diesel exhaust for children, especially those with respiratory illness. Evidence shows that school aged children are especially vulnerable to the health harming impacts of diesel pollution and that it can have long term consequences.<sup>104</sup> <sup>105</sup> And as diesel school buses drive their routes, toxic air pollutants remain in the cabin of the vehicle – exposing children for extended periods of time.<sup>106</sup> Research

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<sup>102</sup> New York School Bus Contractors Association, *School Bus Fast Facts*, <https://www.nysbca.com/fastfacts>.

<sup>103</sup> Lydia Freehafer and Leah Lazer. The State of Electric School Bus Adoption in the US, World Resources Institute, (April 26, 2023). <https://www.wri.org/insights/where-electric-school-buses-us> (Attachment T)

<sup>104</sup> Liu NM, Grigg J. Diesel, children and respiratory disease. *BMJ Paediatr Open*. 2018 May 24;2(1):e000210. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5976105/#R4>

<sup>105</sup> Beatty T.K.M., Shimshack J.P. School buses, diesel emissions, and respiratory health *J. Health Econ.*, 30 (5) (2011), pp. 987-999. <https://www.sciencedirect.com/science/article/abs/pii/S0167629611000701#preview-section-references>

<sup>106</sup> Emissions From School Buses Increase Pollution Levels Inside the Bus, EDF. [https://www.edf.org/sites/default/files/5342\\_School\\_bus\\_pollution\\_studies.pdf](https://www.edf.org/sites/default/files/5342_School_bus_pollution_studies.pdf) (Attachment U).

conducted by Environment & Human Health Inc. has shown that harmful PM2.5 pollution levels on school buses can exceed surrounding areas by five to 10 times.<sup>107</sup>

Students from low-income families are particularly exposed to the dangers of diesel exhaust because 60% ride the bus to school, compared to 45% of students from families with higher incomes.<sup>108</sup> EPA also finds that, of the 10 million students who attend schools within 200 meters of major roadways, “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. 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.”<sup>109</sup>

Recent studies have shown that reducing student exposure to diesel school bus pollution can have a meaningful impact on student health and cognitive functioning, including test score gains in math and English.<sup>110</sup> Zero-emitting electric school buses reduce students’ exposure to harmful air pollutants, while reducing climate pollution and saving school districts money on fuel and maintenance costs.

## 2. Significant federal and state funding supports more protective standards for buses

There are already thousands of zero-emitting school buses on our roads and across our school districts today, in large part because of significant federal and state funding opportunities. According to WRI, there are more than 5,600 electric school buses in the U.S either on order,

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<sup>107</sup> John Wargo, Children’s Exposure to Diesel Exhaust on School Buses, EEHI (February 2022).

<sup>108</sup> Bureau of Transportation Statistics, *The Longer Route to School* (Jan. 12, 2021), <https://www.bts.gov/topics/passenger-travel/back-school-2019>.

<sup>109</sup> 88 Fed. Reg. 26067.

<sup>110</sup> Austin W., Heutel G., Kreisman D. School bus emissions, student health and academic performance *Econ. Educ. Rev.*, 70 (2019), pp. 109-126. <https://www.sciencedirect.com/science/article/abs/pii/S0272775719301530#preview-section-cited-by>



delivered or operating.<sup>111</sup> Many of these commitments and orders have come in the last year and much of the growth is due to EPA's Clean School Bus Program. With funding from the Bipartisan Infrastructure Law, EPA's Clean School Bus Program provides \$5 billion over five years (FY 2022-2026) to replace existing school buses with zero-emission and low-emission models.<sup>112</sup> The program has already awarded over \$900 million for more than 2,400 electric school buses across 389 school districts.<sup>113</sup> As a result of federal, state and local funding and incentives, there are now electric school bus commitments in all 50 states, Washington, D.C., American Samoa, Guam, Puerto Rico the U.S. Virgin Islands and four tribal nations including the Morongo Band of Mission Indians, Mississippi Band of Choctaw Indians, Lower Brule Sioux Tribe and the Soboba Band of Luiseño Indians.

States municipalities are also helping create momentum toward electrification of the bus sector. California's Innovative Clean Transportation (ICT) regulation was adopted in December 2018 and requires all public transit agencies to gradually transition to a 100 percent zero-emission bus (ZEB) fleet.<sup>114</sup> Beginning in 2029, 100% of new purchases by transit agencies must be ZEBs, with a goal for full transition by 2040. Through the deployment of zero-emission technologies, the ICT regulation will provide significant benefits across the state, including reducing NO<sub>x</sub> and GHG emissions, especially in transit-dependent and disadvantaged communities. California is also helping to fund the transition to ZEBs. The 2022-23 State Budget included a total of \$150 million for incentives for the procurement of zero-emission school buses and associated infrastructure, \$135 million of which will be administered through CARB's Clean Truck and Bus Voucher Incentive Project (HVIP), and \$15 million of which will be administered through the California Energy Commission's Energy Infrastructure Incentives for Zero-Emission

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<sup>111</sup> Lydia Freehafer and Leah Lazer. The State of Electric School Bus Adoption in the US, World Resources Institute, (April 26, 2023). <https://www.wri.org/insights/where-electric-school-buses-us>

<sup>112</sup> EPA, *Clean School Bus Program*, <https://www.epa.gov/cleanschoolbus>.

<sup>113</sup> Electric School Bus Initiative, *All About the Clean School Bus Program*, <https://electricschoolbusinitiative.org/all-about-clean-school-bus-program>.

<sup>114</sup> California Air Resources Board, *Innovative Clean Transit Regulation Fact Sheet* (My 16, 2019), <https://ww2.arb.ca.gov/resources/fact-sheets/innovative-clean-transit-ict-regulation-fact-sheet>.

Commercial Vehicles (EnergyIIIZE) Project.<sup>115</sup> WRI estimates that HVIP has funded 1,032 zero-emitting school buses to date.<sup>116</sup>

New York has also set commitments and invested significantly in electrifying buses. In their 2022-2023 budget, New York State established a commitment of purchasing only zero emission school buses starting in 2027 with the intention of transitioning their entire fleet by 2035. New York State currently has 42,000 school buses and transports 2.3 million students annually.<sup>117</sup> Transit authorities across the U.S. have set 100% zero-emission bus fleet commitments. The transit agencies for New York City (MTA), Chicago (CTA), and Philadelphia (SEPTA) have all committed to transitioning their entire bus fleets to zero-emission vehicles by 2040.<sup>118 119 120</sup> In Washington, D.C., WMATA has set a target of a fully zero-emission fleet by 2045 with only zero-emission bus purchases starting in 2030.<sup>121</sup> King County Metro which serves Seattle and CapMetro which serves Austin plan to have 100% zero-emission fleets by 2035.<sup>122 123</sup> A strong final rule must leverage this momentum and ensure that 90% of new school and transit buses are zero-emitting by 2032.

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<sup>115</sup> California Energy Commission, *Work Group Meeting #2 to Discuss the FY-22-23 Incentives for Zero Emission Public School Buses and Supporting Infrastructure*, <https://www.energy.ca.gov/event/workshop/2023-05/work-group-meeting-2-discuss-fy-22-23-incentives-zero-emission-public-school>.

<sup>116</sup> Lydia Freehafer and Leah Lazer. The State of Electric School Bus Adoption in the US, World Resources Institute, (April 26, 2023). <https://www.wri.org/insights/where-electric-school-buses-us>

<sup>117</sup> New York State Energy Research and Development Authority, *Electric School Buses*, <https://www.nyserda.ny.gov/All-Programs/Electric-School-Buses#:~:text=New%20York%20State's%20fiscal%20year,to%20be%20electric%20by%202035>.

<sup>118</sup> Metropolitan Transportation Authority, *MTA Zero-Emission Bus Transition Plan*, <https://new.mta.info/document/91336>.

<sup>119</sup> Chicago Transit Authority, *Electric Buses: We're Electrifying Our Bus Fleet*, <https://www.transitchicago.com/electricbus/>.

<sup>120</sup> Tom MacDonald, *SEPTA Gets \$24 Million for Adapting Bus Depots for Electric and Hybrid Vehicles*, WHYY (Sep. 6, 2022), <https://whyy.org/articles/philadelphia-septa-bus-depot-upgrades-electric-hybrid-vehicles/#:~:text=SEPTA%20General%20Manager%20Leslie%20Richards,by%202040%2C%E2%80%9D%20Richards%20said>.

<sup>121</sup> Washington Metropolitan Area Transit Authority, *Zero-Emission Buses*, <https://www.wmata.com/initiatives/plans/zero-emission-buses.cfm>

<sup>122</sup> King County Metro, *Transitioning to a Zero-Emissions Fleet*, <https://kingcounty.gov/depts/transportation/metro/programs-projects/innovation-technology/zero-emission-fleet.aspx>.

<sup>123</sup> City of Austin, *Transportation Electrification Goals*, <https://data.austintexas.gov/stories/s/Transportation-Electrification-Goal-1/99ez-x3te/>.

3. When likely lower battery costs relative to EPA’s modeling are taken into consideration, a more protective school and transit bus standard is reasonable and readily justified.

In the medium- and heavy-duty electrification study performed for EDF in early 2022,<sup>124</sup> Roush projected that by 2027, battery electric (BE) school buses and transit buses would have lower up-front costs than their diesel counterparts.<sup>125</sup> This was prior to the IRA tax credits for battery production and vehicle purchase.

The BE school bus examined by Roush had a relatively small 60 kWh battery. This was deemed sufficient for many applications that involve the local transport of students. EPA’s methodology assumes school bus segments have larger batteries, 102-166 kWh.<sup>126</sup> Using Roush’s battery cost estimates, and accounting for these larger batteries, BE school buses would still have lower up-front costs than diesel school buses again without any tax credits. Even accounting for the cost of the charger and installation leaves the BE school bus cheaper for the 102 kWh battery and only \$1000 more expensive with a 166 kWh battery. The IRA vehicle tax credit would not apply in these cases, but the battery production and charging infrastructure credits could, making it highly likely that the BE school bus would have an immediate payback.

The BE transit bus examined by Roush had a smaller battery (400 kWh) than those evaluated by EPA in this proposal (605-649 kWh).<sup>127</sup> Again, using Roush’s cost estimates and accounting for these larger batteries, Roush’s BE transit bus would only cost \$8,000-\$11,000 more than a diesel transit bus, again without any tax credits. The IRA vehicle tax credit brings the BE transit bus to price parity with the diesel. The cost of the charger and installation is more substantial for a BE

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<sup>124</sup> Vishnu Nair, Sawyer Stone, Gary Rogers, Sajit Pillai. 2022. *Medium and Heavy-Duty Electrification Costs for MY 2027- 2030*, Roush Industries for Environmental Defense Fund. See [http://blogs.edf.org/climate411/files/2022/02/EDF-MDHD-Electrification-v1.6\\_20220209.pdf](http://blogs.edf.org/climate411/files/2022/02/EDF-MDHD-Electrification-v1.6_20220209.pdf).

<sup>125</sup> Vishnu Nair, Sawyer Stone, Gary Rogers, Sajit Pillai. 2022. *Medium and Heavy-Duty Electrification Costs for MY 2027- 2030*, Roush for Environmental Defense Fund.

<sup>126</sup> See supra pg. 55.

<sup>127</sup> Vishnu Nair, Sawyer Stone, Gary Rogers, Sajit Pillai. 2022. *Medium and Heavy-Duty Electrification Costs for MY 2027- 2030*, Roush for Environmental Defense Fund.

transit bus, \$130,000 per bus without the IRA tax credit and \$90,000 with the tax credit. However, the annual fuel and maintenance savings are substantial, resulting in a 1-2 year payback period with either battery size.

When these significant cost reductions relative to EPA's current modeling are taken into consideration, a more protective school and transit bus standard is reasonable and easily justified.

4. The benefits of bi-directional charging from buses should also be considered

EPA's rulemaking should consider the potential benefits of using school buses for bi-directional charging. Electric school buses can function as large batteries to support the power grid, providing energy to municipalities through the use of vehicle-to-grid (V2G) technologies. According to WRI, at least 15 utilities across 14 states have committed to pilot electric school bus V2G programs, which allow electricity to be stored in the bus batteries and later discharged onto the grid.<sup>128</sup> The bus batteries' stored power "can help stabilize fluctuating energy conditions, alleviate the need to start up additional power generation sources by shaving peak energy needs and provide mobile emergency power to shelters and other essential facilities. Because school buses operate on set daily schedules and often sit idle in the summer and during portions of the school day when electricity demand is high, they are ideal for this purpose. The power they can provide to the grid or buildings could offer revenue to help pay for the buses, a win-win for schools and the utility or other entity using the electricity."<sup>129</sup>

- c) Key EPA assumptions related to ZEV costs and deployment are overly conservative and when corrected, support more protective standards

In sections a) and b), above, we present data and analyses, including new studies, that support more protective standards consistent with the ACT standards nationwide along with even deeper

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<sup>128</sup> Norma Hutchinson and Gregory Kresge, "3 Design Considerations for Electric School Bus Vehicle-to-Grid Programs," World Resources Institute (February 14, 2022). <https://www.wri.org/insights/electric-school-bus-vehicle-grid-programs>

<sup>129</sup> Id.

deployment of ZEVs in key categories, including tractors and buses. This section addresses key EPA assumptions that are overly conservative and that directly informed the stringency of EPA's proposal. When updated with more reasonable values, EPA's own analysis likewise supports more protective standards consistent with our recommendations in sections a) and b). We discuss several of these assumptions in more detail, below.

- i. EPA's ZEV technology and adoption modeling assumptions are too conservative

EPA's ZEV assumptions are too conservative and more reasonable assumptions would result in higher ZEV deployment projections, especially in key categories.

1. EPA's underlying component costs are high

While EPA includes the Commercial Clean Vehicle Credit and the production tax credit for batteries, it fails to include the Alternative Fuel Refueling Property Credit in its assessment of cost. The IRS has not published guidance yet on how this credit will be applied, but the language from the IRA indicates that businesses could receive up to a 30% credit on up to \$100,000 of EVSE. Roush, in a recent report, showed that this also could save vehicle owners \$1,064 for a 25 kW charger to \$26,000 for a 100 kW charger.<sup>130</sup>

In their modeling, EPA has a maximum of two vehicles per charger even if many more vehicles could be charged in the 12 hours of dwell time EPA assumes. This results in a high estimate of number of EVSE ports needed, driving up the EVSE costs and driving down the stringency of the rule.

EPA is overestimating battery prices. In 2030, EPA assumes batteries without the IRA production tax credits will cost \$120/kWh falling to \$111/kWh by 2032. In their recent report on tractors, Roush projects that absent IRA credits HDV batteries will cost \$98/kWh in 2030 and

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<sup>130</sup> H. Saxena, S. Pillai, "Impact of the Inflation Reduction Act of 2022 on Medium- and Heavy-Duty Electrification on MYs 2024 and 2027," 2023. Roush.

\$88/kWh in 2032.<sup>131</sup> Batteries make up the bulk of the powertrain costs for BEVs. As a result, if EPA were to adjust the battery costs used in this proposal, it would have a significant impact on BEV price, payback period, and the final rule stringency.

Additionally, EPA's projection of motor costs are too high. In the same Roush study they project motor and inverter costs will be \$8/kW in 2030 and 2032. EPA projects in their proposal these costs will be \$16/kW and \$15/kW for 2030 and 2032 respectively.

## 2. EPA's battery-related assumptions are too conservative

In the HD TRUCS model, EPA makes a number of assumptions related to EV batteries that result in unnecessarily large, and artificially costly, batteries. First, EPA uses an unrealistically high daily mileage to size the battery. Second, EPA underestimates the average percent from full capacity that a battery will discharge per charge cycle, and overestimates deterioration over a battery's lifetime. Third, EPA does not consider the average decrease in annual mileage over a vehicles' lifetime. Fourth, EPA's values for battery specific energy (Wh/kg) and energy density (Wh/L) are overly conservative.

*Daily mileage.* EPA uses the 90<sup>th</sup> percentile daily mileage to set the battery size but only assumes that vehicles will travel the 50<sup>th</sup> percentile annual miles.<sup>132</sup> While battery size impacts the upfront cost of the vehicle, the annual miles dictate how quickly the fuel and maintenance savings from ZEVs will pay back the upfront costs. The stringency of the standards, which is determined in part by the payback period, is directly impacted by these assumptions. In the Draft RIA, EPA alludes to the assumption that vehicle manufacturers will make only one ZEV for each of the 101 categories EPA has identified. This is not the current reality of the market nor is it expected to be in the future. Vehicle manufacturers currently make the same vehicle with multiple battery size options to allow fleet or vehicle owners to select the best vehicle for them. As can be seen in Appendix C of the ERM EV Market Update from April 2023, many of the current BEV HD

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<sup>131</sup> Roush conducted their study in 2022\$. The prices presented from their study were deflated by 8% to adjust to 2021\$ to be consistent with EPA.

<sup>132</sup> Section 2.2.1.2.1 Sizing VMT and Section 2.2.1.2.2 Operational VMT in Greenhouse Gas Emission Standards for Heavy-Duty Vehicles: Phase 3 Draft Regulatory Impact Analysis

offerings come in multiple battery sizes.<sup>133</sup> For instance, the Kenworth Class 7 box truck can be purchased with a 141 kWh or 282 kWh battery.

While it is reasonable to assume that some vehicles will not drive the exact same number of miles per day, many vehicles drive similar numbers of miles per day as they carry out similar duty cycles (e.g., school buses drive the same route every day). EPA's current assumption that vehicle owners would pay for such a large battery when their vehicles do not need it most of the time is inconsistent with good business practices and reality.

*Discharge and deterioration percentage.* EPA assumes only 80% of the battery will be able to be discharged and over the lifetime of the battery there will be 20% deterioration. Both of these values are conservative. They represent current battery technologies and assume no improvement between now and 2027-2032. Given the fast pace of battery chemistry development it is unreasonable to assume a static industry. In their February 2022 report, Roush found that newer battery technologies are allowing vehicle owners to discharge more of their battery in every charge cycle and increase the battery lifetime.<sup>134</sup> In their recent report on the electrification of tractors, Roush sets the discharge limit at 90% and projects 10% degradation over the lifetime of the battery.<sup>135</sup> We recommend EPA adopt similar assumptions for the final rulemaking.

*Mileage decreases.* In its HD TRUCS model, EPA assumes vehicles will travel between 29% and 35% fewer miles in their 10<sup>th</sup> year of service compared to their first. This decrease lines up with the assumed deterioration of the battery. Even if the usable battery decreased by 20% over the lifetime of the vehicle, that more than matches the decrease in the mileage traveled by the vehicle.

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<sup>133</sup> Rachel MacIntosh, Harrison Branner, Kayla Escobar, and Sophie Tolomiczenko. 2023. Electric Vehicle Market Update: Manufacturer & Commercial Fleet Electrification Commitments Supporting Electric Mobility in the United States, ERM for EDF, Appendix C.

<sup>134</sup> Vishnu Nair, Sawyer Stone, Gary Rogers, Sajit Pillai. 2022. Medium and Heavy-Duty Electrification Costs for MY 2027- 2030, Roush for Environmental Defense Fund. See [http://blogs.edf.org/climate411/files/2022/02/EDF-MDHD-Electrification-v1.6\\_20220209.pdf](http://blogs.edf.org/climate411/files/2022/02/EDF-MDHD-Electrification-v1.6_20220209.pdf)

<sup>135</sup> Vishnu Nair, Himanshu Saxena, Sajit Pillai. 2023. *Class 7 and Class 8 Tractor-Trailer Electrification for MYs 2030 and 2032*, Roush for Environmental Defense Fund

*Battery specific energy.* Additionally, EPA’s values for the battery specific energy (Wh/kg) and energy density (Wh/L) used in the HD TRUCS modeling are overly conservative. In 2027, EPA’s modeling assumes batteries will have a specific energy of 199 Wh/kg increasing to 223 Wh/kg in 2032 and a energy density of 496 Wh/L increasing to 557 Wh/L by 2032. In contrast, studies put current batteries at 250 to 300 Wh/kg and energy density at 600 to 700 Wh/L.<sup>136</sup> Next generation batteries are expected to be even more energy dense. The Battery500 consortium out of the Pacific Northwest National Laboratory have established a cell design that could achieve up to 500 Wh/kg.<sup>137</sup> Battery developer SES has created their Apollo battery cell with an energy density of 417 Wh/kg and 935 Wh/L with plans to start commercialization of the batteries by 2025.<sup>138</sup>

Since the eligibility of vehicles to have any BEV adoption in HD TRUCS depends on the batteries being less than 30% of the payload weight and smaller than 12 feet across, the specific energy and energy density of the batteries impacts the stringency of the rule. EPA should use less conservative energy density values in their modeling to better account for the projected improvement in battery science that will occur in the next decade.

### 3. EPA’s ZEV adoption curve is overly conservative

Compounding the agency’s conservative cost assumptions, discussed above, several additional factors result in EPA’s modeled rate of ZEV adoption being overly conservative. First, EPA relies on an overly conservative estimation of the relationship between payback period and technology adoption percentage. Second, EPA artificially caps ZEV adoption at 80% even for vehicle types for which the upfront cost is lower for ZEVs than ICE vehicles.

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<sup>136</sup> Shuru Chen, Fang Dai, and Mei Cai, ACS Energy Letters 2020 5 (10), 3140-3151, DOI: 10.1021/acseenergylett.0c01545

<sup>137</sup> Liu, J., Bao, Z., Cui, Y. et al. Pathways for practical high-energy long-cycling lithium metal batteries. Nat Energy 4, 180–186 (2019). <https://doi.org/10.1038/s41560-019-0338-x>

<sup>138</sup> Doll, Scooter. *SES shares plans for world’s largest lithium-metal facility to build 107 amp-hour EV batteries.* November 3, 2021. Electrek. <https://electrek.co/2021/11/03/ses-shares-plans-for-worlds-largest-lithium-metal-facility-to-build-107-amp-hour-ev-batteries/>



One of the crucial elements in EPA’s estimation of ZEV adoption in HD TRUCS is the relationship between payback period and adoption percentage. This equation has a first order impact on the stringency of the rule. In the DRIA, EPA identifies numerous studies that project the rate of zero-emission technology adoption in MHDVs. EPA surveyed this data though appear to have largely adopted a curve based on an ACT Research report.<sup>139</sup>

In addition, in their modeling, EPA caps adoption for any one of the 101 vehicle types at 80% even if the upfront cost of the ZEV is cheaper than the ICE vehicle. No other study, including the ACT Research equation included in the DRIA, makes such an assumption. EPA offers several rationales for the cap, including their choice to size the batteries to the 90<sup>th</sup> percentile of daily VMT, as well as the assumption that some uses or fleet owners may not be able to electrify their vehicles due to their need to operate the vehicles 24 hours per day or their inability to install EVSE.<sup>140</sup> While it is a reasonable assumption, particularly in the first few years of increased HD ZEV adoption, that some vehicles would be less suited to electrification even with a short payback period, that impact should decrease as fleet owners become more familiar with the technology, business practices surrounding ZEVs become more robust, and a wider range of ZEV models become available. As such, we believe the imposed cap on ZEV adoption should lessen through the rule years and be substantially higher by 2032.

Additionally, an 80% cap in 2027 is too high. The same vehicles that need to operate 24 hours a day are presumably the ones with higher daily mileage. EPA provides no supporting evidence for the assumption that on top of the daily mileage concerns, there are an additional 10% of each vehicle type that could not be electrified in the next decade.

Central to establishing this relationship is an understanding of the impact of payback period on fleet owners’ decisions to purchase vehicles with higher capital costs but lower operating costs

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<sup>139</sup> Section 2.7.9 Technology Adoption in Greenhouse Gas Emission Standards for Heavy-Duty Vehicles: Phase 3 Draft Regulatory Impact Analysis

<sup>140</sup> Ibid.

such as many ZEVs. In their March 2022 study, NREL assumed the financial horizon for Class 3 vehicles is 3 years, Class 4-6 vehicles is 4 years, and Class 7-8 vehicles is 5 years.<sup>141</sup> In a 2019 report by the National Academies of Sciences, Engineering, and Medicine, authors stated they “heard from manufacturers and purchasers that they look for 1.5- to 2-year paybacks or, in other cases, for a payback period that is half the expected ownership period of the first owner of the vehicle.”<sup>142</sup> With EPA’s proposed rule, the assumed adoption of ZEVs drops from 80% if the payback period is less than 0 years to 55% if the payback period is between 0 and 1 years. In practice, this means that for vehicles with a payback period of one day only around half of vehicle purchasers would select the ZEV even though they would see savings starting on day 2 of the vehicle’s life. This is inconsistent with the literature around financial horizons for vehicle owners. The adoption rate should remain high through at least a two-year payback period at which time a decline in adoption after that point would be more reasonable.

In both cases, studies stated one of the reasons vehicle owners might require shorter payback periods was uncertainty connected to the new technology. As a result, it should be expected that the adoption curve based on payback period EPA is utilizing will evolve between the beginning and end of the rule.

EDF acquired the inputs and results from a study on HD ZEV adoption conducted by NREL using their TEMPO model, referenced above, to create an alternative adoption curve based on

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<sup>141</sup> Muratori, Matteo et al. 2022. Decarbonizing Medium- and Heavy-Duty On-Road Vehicles: Zero-Emission Vehicles Cost Analysis, NREL Transforming Energy. <https://www.nrel.gov/docs/fy22osti/82081.pdf>.

<sup>142</sup> National Academies of Sciences, Engineering, and Medicine 2019. Reducing Fuel Consumption and Greenhouse Gas Emissions of Medium- and Heavy-Duty Vehicles, Phase Two: Final Report. Washington, DC: The National Academies Press. <https://doi.org/10.17226/25542> . (Attachment V)

payback period.<sup>143</sup> <sup>144</sup> Additional details about the methodology used to establish this curve are in Appendix BA.<sup>145</sup>

Figure 10 shows the TEMPO data points, the curve based on the data, the two step-wise functions used by EPA in HD TRUCS, and the ACT Research curve from Equation 2-61 of the DRIA. The curve based on TEMPO data (the solid red curve) projects 100% adoption of ZEVs when the ZEV and ICE vehicle are the same price or the ZEV is cheaper (i.e., a payback period of less than 0 years). The ACT Research curve assumes only a 71% adoption of ZEVs when there is purchase price parity. While the adoption begins to decrease once there is a non-zero payback period, it declines at a slower rate than ACT Research's curve, particularly up to one year of payback. Analysis of the TEMPO model outputs indicates that the general shape of the ACT Research curve is reasonable but the adoption levels assumed for low payback periods is far too modest. Particularly for short payback periods (less than 2 years), this analysis shows that EPA is profoundly underestimating the resulting ZEV adoption. High adoption rates for technologies that start providing meaningful savings to vehicle owners after only a few years is also consistent with the available literature.

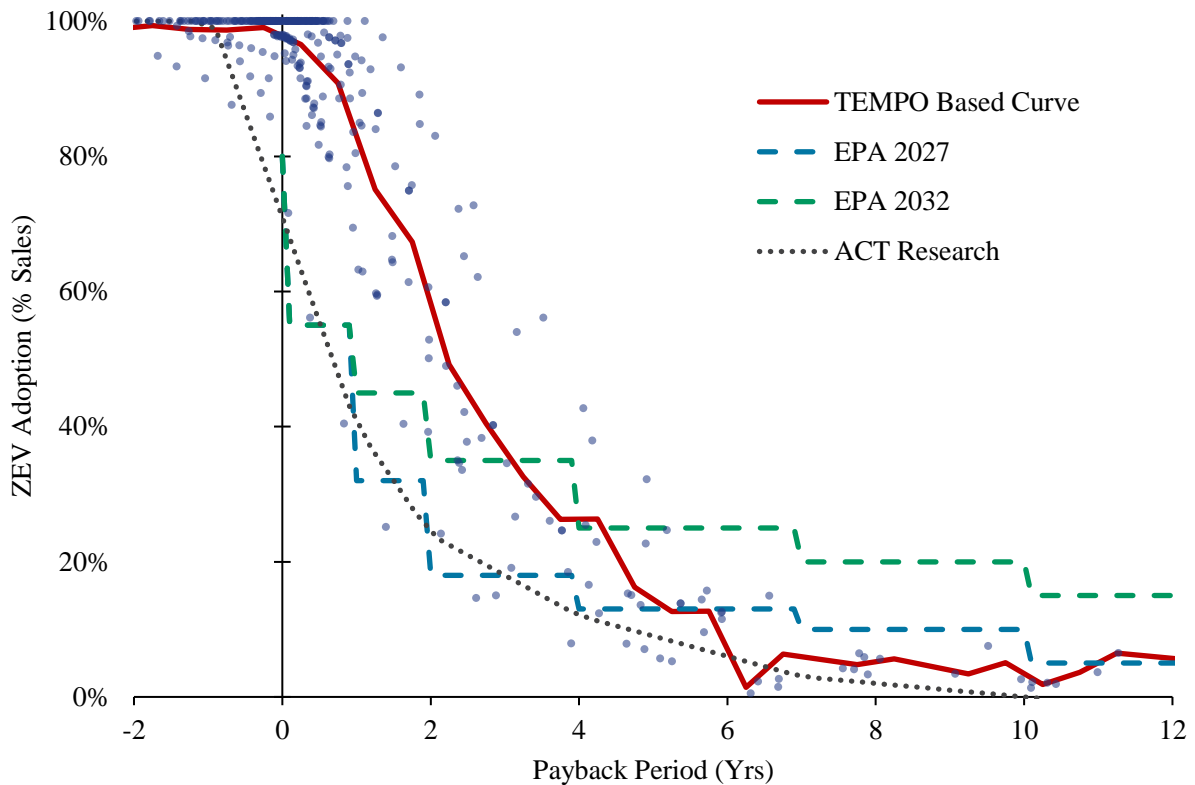
Figure 10: Relationship between payback period and technology adoption

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<sup>143</sup> Catherine Ledna et al. 2022. Decarbonizing Medium- and Heavy-Duty On-Road Vehicles: Zero-Emission Vehicles Cost Analysis, NREL Transforming Energy. <https://www.nrel.gov/docs/fy22osti/82081.pdf>  
<https://www.nrel.gov/docs/fy22osti/82081.pdf>

<sup>144</sup> Matteo Muratori et al. 2021. *Exploring the future energy-mobility nexus: The transportation energy & mobility pathway options (TEMPO) model*. Transportation Research Part D, <https://doi.org/10.1016/j.trd.2021.102967>

<sup>145</sup> The interpretation of the results and opinions stated are EDF's alone. EDF would like to thank NREL and Catherine Ledna for providing the underlying data and inputs.



Source: EDF Analysis based on Ledna et al, Decarbonizing Medium- and Heavy-Duty On-Road Vehicles and Section 2.7.9 Technology Adoption in the Draft RIA.

EPA must reassess their technology adoption curve and better align the values they are using to curves such as the TEMPO model based curve presented here that have strong scientific backing and better align with the existing literature on financial horizons of fleet owners.

- d) EPA's primary proposal reflects a conservative assessment of ZEV deployment in the coming years.

EPA uses a reference case that assumes ACT levels of ZEV sales in California and the five states that had already adopted ACT at time the proposal was issued: Oregon, Washington, New York, New Jersey, and Massachusetts. The reference case does not assume any additional ZEV sales as a result of regular market trends. EPA's primary proposal sets a stringency level roughly equivalent to ZEV adoption projected under ACT Research's adoption curve based on payback period.

EPA's reference case should more accurately reflect ZEV deployment that will occur due not only to ACT but to the landscape of factors that will facilitate ZEV sales, including market trends, other state actions like ACF, the NESCAUM MOU, and federal government and private investments. The payback period analysis discussed above, which EPA relies on in setting its proposed stringency level, is better suited to inform the reference case. EPA's proposed standards should build on this improved baseline to achieve emissions reductions consistent with ACT-level ZEV deployment nationally and additional reductions in the tractor and bus categories.

#### **IV. Sufficient infrastructure, electric grid capacity, and policies exist to support strong standards.**

EPA reasonably considered additional factors, including ZEV infrastructure, in projecting ZEV deployment in its proposal. Recent analyses indicate that buildout of EV infrastructure and the electric grid distribution capacity are sufficient to support even more protective standards. Significant federal, state, and private investments are already being made to grow the HDV infrastructure. States and utilities are initiating processes to ensure adequate infrastructure to meet demand.

##### a) Federal, state, local and private investments support fast-growing infrastructure

Investment in the infrastructure required to support rapid medium- and heavy-duty ZEV proliferation has already begun. Federal, state, and private parties have directed substantial resources into developing widespread charging networks and driving technological innovation. Together, these investments are laying the groundwork for protective standards.

The federal government has made significant investments towards building the infrastructure necessary for a ZEV future with The Inflation Reduction Act (IRA) and Bipartisan Infrastructure Law (BIL). Both laws are putting billions of dollars towards building out charging networks and updating the grid to support the transition to light-, medium- and heavy-duty ZEVs.

Multiple provisions of the IRA will boost the development of infrastructure to support medium- and heavy-duty ZEVs. The Alternative Fuel Refueling Property Credit will directly fund charging infrastructure in low-income and rural areas. Qualifying businesses and individuals can be reimbursed for up to 30 percent of the cost of installing charging equipment in these areas, substantially reducing the costs of this equipment.<sup>146</sup> The Congressional Joint Committee on Taxation estimates this credit will cost almost \$2 billion over its lifetime, demonstrating the sizeable impact it will make in driving additional investments from private parties.<sup>147</sup> The Advanced Energy Project Credit allocates \$10 billion for facilities manufacturing advanced energy technologies, which includes manufacturing of charging and refueling infrastructure for ZEVs as well as grid modernization components.<sup>148</sup> Other provisions allocate funding that can help build infrastructure at ports,<sup>149</sup> fund grants for infrastructure buildout in nonattainment areas,<sup>150</sup> and fund improvements to electricity generation and transmission.<sup>151</sup>

The BIL is another source of considerable federal investment in infrastructure development. Through its National Electric Vehicle Infrastructure (NEVI) and Charging and Fueling Infrastructure (CFI) discretionary grant programs, the law allocates \$7.5 billion in funding explicitly towards building out ZEV charging and refueling infrastructure.<sup>152</sup> The NEVI program directs the Federal Highway Administration (FHWA) to provide funding to states to deploy EV charging stations to build an interconnected and reliable charging network. The FHWA has already announced its first set of plans under the program, which includes investment in all 50 states plus the District of Columbia and Puerto Rico.<sup>153</sup> This first round of NEVI investment is

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<sup>146</sup> Inflation Reduction Act of 2022, P.L. 117-169, § 13404.

<sup>147</sup> 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 Representative on August 12, 2022, JCX-18-22, <https://www.jct.gov/publications/2022/jcx-18-22/>.

<sup>148</sup> Inflation Reduction Act of 2022, P.L. 117-169, § 13501.

<sup>149</sup> Inflation Reduction Act of 2022, P.L. 117-169, § 60102.

<sup>150</sup> Inflation Reduction Act of 2022, P.L. 117-169, § 60101.

<sup>151</sup> Inflation Reduction Act of 2022, P.L. 117-169, § 50144, 50145, 50151, 50152.

<sup>152</sup> Infrastructure, Investment and Jobs Act of 2021, P.L. 117-58, 135 Stat. 445, 1421.

<sup>153</sup> U.S. Department of Transportation, Historic Step: All Fifty States Plus D.C. and Puerto Rico Greenlit to Move EV Charging Networks Forward, Covering 75,000 Miles of Highway (Sep. 27, 2022), <https://www.transportation.gov/briefing-room/historic-step-all-fifty-states-plus-dc-and-puerto-rico-greenlit-move-ev-charging>.

set to bring EV charging to 75,000 miles of highway across the country.<sup>154</sup> The CFI program provides additional funding for FHWA administered grants to state and local authorities for development of publicly accessible charging infrastructure.<sup>155</sup>

On top of these programs, an additional \$2.5 billion each year through FY 2026 could be allocated towards charging infrastructure through the Congestion Mitigation and Air Quality Management (CMAQ) program, which the BIL amended to include the purchase of medium- and heavy-duty ZEV charging equipment.<sup>156</sup> Additional funding from the BIL is directed towards reducing truck emissions at ports<sup>157</sup> and funding grants to states and local governments for reducing transportation carbon pollution,<sup>158</sup> both of which will fund additional infrastructure investments.

The ambition of these federal investments is being matched by infrastructure funding in many states, especially in states that have adopted, or are planning to adopt, California's Advanced Clean Trucks (ACT) rule.

For example, in California, the California Energy Commission's (CEC) Clean Transportation Program announced a \$2.9 billion investment plan to accelerate ZEV charging and refueling availability that includes \$1.7 billion of funding for medium- and heavy-duty ZEV infrastructure.<sup>159</sup> The CEC estimates the plan will result in 90,000 new EV chargers across the

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<sup>154</sup> U.S. Department of Transportation, Historic Step: All Fifty States Plus D.C. and Puerto Rico Greenlit to Move EV Charging Networks Forward, Covering 75,000 Miles of Highway (Sep. 27, 2022), <https://www.transportation.gov/briefing-room/historic-step-all-fifty-states-plus-dc-and-puerto-rico-greenlit-move-ev-charging>.

<sup>155</sup> U.S. Department of Transportation, Biden-Harris Administration Opens Applications for First Round of \$2.5 Billion Program to Build EV Charging in Communities & Neighborhoods Nationwide, <https://www.transportation.gov/briefing-room/biden-harris-administration-opens-applications-first-round-25-billion-program-build>.

<sup>156</sup> Infrastructure, Investment and Jobs Act, P.L. 117-58, § 1115.

<sup>157</sup> Infrastructure, Investment and Jobs Act, P.L. 117-58, § 11402, 11403.

<sup>158</sup> Infrastructure, Investment and Jobs Act, P.L. 117-58, § 114023.

<sup>159</sup> California Energy Commission, CEC Approves \$2.9 Billion Investment for Zero-Emission Transportation Infrastructure (Dec. 14, 2022), <https://www.energy.ca.gov/news/2022-12/cec-approves-29-billion-investment-zero-emission-transportation-infrastructure>.

state.<sup>160</sup> The state has also approved its three major-investor owned utilities to invest \$686 million over five years in medium- and heavy-duty infrastructure projects to support electrification.<sup>161</sup>

Colorado has likewise made significant investments in preparing for a transition to ZEVs. The state's Community Access Enterprise provides funding and support to operators of medium- and heavy-duty fleets by installing charging infrastructure and providing public fast charging capable of supporting medium- and heavy-duty vehicles. The Community Access Enterprise is expected to receive approximately \$310 million in its first decade.<sup>162</sup> Colorado also has the Clean Transit Enterprise, which includes grant programs towards purchase and installation of charging infrastructure.<sup>163</sup>

Investments by state and local governments are being matched and exceeded by private investments. Multiple companies have announced expansive plans for developing charging networks for medium- and heavy-duty vehicles. For example, Greenlane is a joint venture between Daimler, NextEra Energy Resources, and BlackRock Alternatives, which will put \$650 million towards designing, developing, and installing, charging and hydrogen-fueling infrastructure along various freight routes.<sup>164</sup> Volvo and Pilot Group have also announced an

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<sup>160</sup> California Energy Commission, CEC Approves \$2.9 Billion Investment for Zero-Emission Transportation Infrastructure (Dec. 14, 2022), <https://www.energy.ca.gov/news/2022-12/cec-approves-29-billion-investment-zero-emission-transportation-infrastructure>.

<sup>161</sup> State of California Air Resources Board, Advanced Clean Trucks Initial Statement of Reasons, I-16 (Oct. 22, 2019), <https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2019/act2019/isor.pdf>.

<sup>162</sup> Colorado Energy Office, *Community Access Enterprise*, <https://energyoffice.colorado.gov/about-us/boards-commissions/community-access-enterprise>.

<sup>163</sup> Colorado Department of Transportation, *Clean Transit Enterprise*, <https://www.codot.gov/programs/innovativemobility/cte>. See also <https://energyoffice.colorado.gov/zero-emissions-vehicles/dcfp-plazas>; [https://leg.colorado.gov/sites/default/files/2023a\\_1272\\_signed.pdf](https://leg.colorado.gov/sites/default/files/2023a_1272_signed.pdf).

<sup>164</sup> Electrek, *Daimler Just Announced a \$650M US-Wide EV Charging Network for Trucks*, <https://electrek.co/2023/04/27/daimler-just-announced-a-650m-us-wide-ev-charging-network-for-trucks/> (Apr. 27, 2023).



intent to offer public charging for medium- and heavy-duty BEVs at over 750 Pilot and Flying J travel center locations.<sup>165</sup>

b) The electric grid can support widespread HD ZEV adoption

The U.S. electric grid has provided reliable, cheap, instantaneous power to millions of homes and businesses every second of every day for well over a century. For so many end uses, electrification represents the cheapest and most attainable decarbonization pathway.

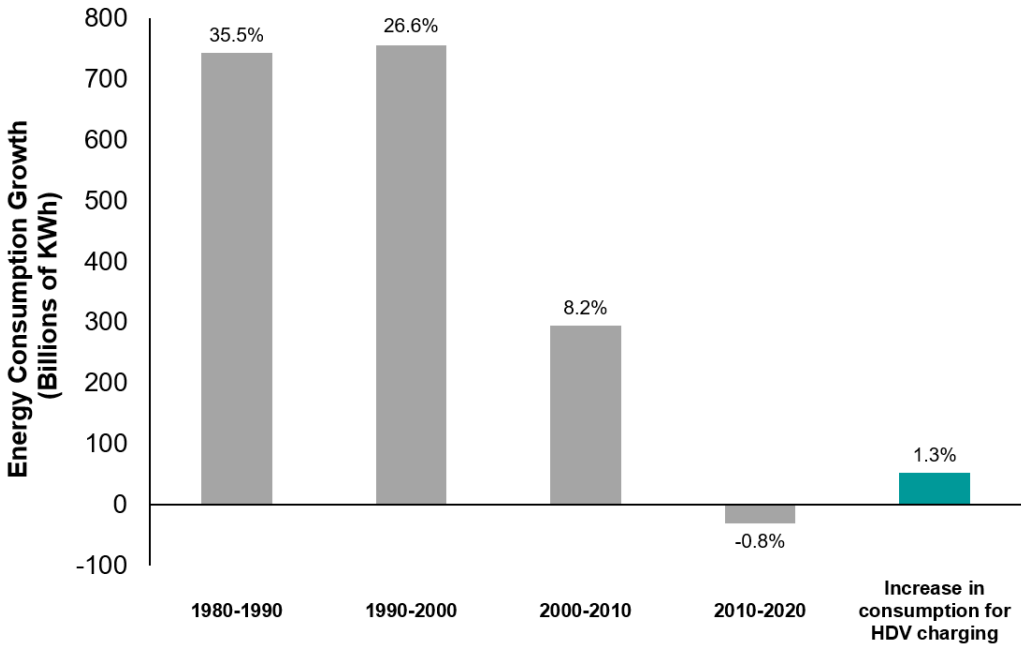
Growing the electric grid to meet increased demand is nothing new. Since 1960, about a third of the year over year increases in state electricity sales have been higher than 5% with 7% of those years having increases higher than 10% annual growth.<sup>166</sup> The compound annual growth rate for the entire grid since 1960 is 2.8%. The total increase in electricity consumption as a result of the proposed rule is expected to be 1.3%, less than half of the average *annual* increase that has occurred since 1960. Research shows that, with planning, utilities will meet the demand for additional electricity needed to charge our nation's fleet of heavy-duty vehicles, and those vehicles may improve the reliability of the grid.

Figure 11: Historic growth in annual energy consumption and projected growth required for HDV charging

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<sup>165</sup> Cision, *Pilot Company and Volvo Group Partner to Build Charging Network for Medium and Heavy-Duty Electric Trucks* (Nov. 15, 2022), <https://www.prnewswire.com/news-releases/pilot-company-and-volvo-group-partner-to-build-charging-network-for-medium--and-heavy-duty-electric-trucks-301678542.html>.

<sup>166</sup> U.S. Energy Information Administration, *EIA-861: Annual Electric Power Industry Report, 1960-2021*, <https://www.eia.gov/electricity/data/state/>



Source: Analysis Group, *Heavy Duty Vehicle Electrification: Planning for and Development of Needed Power System Infrastructure*.

EDF commissioned a report by Analysis Group to understand how the expected growth in HDV charging will impact the grid and what processes are in place or need to be added to enable the grid to meet the increased demand.<sup>167</sup> Their main findings include:

- (1) The overall magnitude of growth in demand that would result from EPA’s proposed rule is very small relative to historic periods of growth in the electric industry, and will not pose a challenge from the perspectives of power system generation or transmission infrastructure needs.
- (2) Charging station needs that may result from EPA’s proposed rule range greatly in size and location; most counties and utilities in the U.S. analyzed in ICCT’s report will likely

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<sup>167</sup> Paul Hibbard et al. *Heavy Duty Vehicle Electrification: Planning for and Development of Needed Power System Infrastructure*. 2023. Analysis Group, <https://blogs.edf.org/climate411/wp-content/blogs.dir/7/files//Analysis-Group-HDV-Charging-Impacts-Report.pdf>. Analysis Group, <https://blogs.edf.org/climate411/wp-content/blogs.dir/7/files//Analysis-Group-HDV-Charging-Impacts-Report.pdf>. (Attachment W).

not face new distribution system infrastructure needs due to charging load different from past experience.

- (3) Some utilities will need to plan for the development of new distribution system infrastructure to accommodate fairly large point sources of new charging station demand.
- (4) Adding significant new distribution system infrastructure is not a new experience for states, public utility commissions, or electric companies, and there are long-standing policies and practices in place to process development of infrastructure needed to ensure system reliability.
- (5) The need for a high level of certainty around the timely integration of charging stations and associated distribution system infrastructure at the scale and speed needed for HDV electrification warrants – and has already prompted – proactive action on behalf of some states and utilities to engage and expand planning and regulatory practices at the scale necessary to ensure timely readiness of the power system.
- (6) There are many emerging technologies, ratemaking practices, and distributed resource solutions that have the potential to significantly and efficiently reduce the expected impacts on distribution systems associated with vehicle electrification.

Evolution of distribution systems to meet the potential increase in charging station demand associated with EPA’s proposed Phase 3 rule for HDVs is eminently achievable.

Additionally, they found that 83% of utility service territories would not see more than 5 MW of increased load from HDV charging based on a study done by ICCT. The localized nature of the expected growth of HDV charging demand presents unique challenges but also allows for focused action.

- i. Utilities and states have already begun to implement programs to support HD ZEV charging

Using data provided by Atlas that tracks public utility commission filings, 29 investor-owned utilities (IOUs) in 17 states have already gotten programs approved to support HDV charging

infrastructure build out which account for \$1.6 billion in investment.<sup>168</sup> These utilities account for 34% of IOU electricity sold in the U.S. and 40% of IOU customers. Since municipally owned and cooperative utilities are not subject to the same rate making processes that IOUs go through, this represents a conservative estimate of the investment by utilities that is already underway.

Additionally, states have begun implementing HD charging infrastructure funding programs. Six states, California, Oregon, Pennsylvania, Colorado, New York, and New Jersey, all have statewide funding programs for HD charging infrastructure, with all except California and New York being finalized in the last year.<sup>169 170 171 172 173 174</sup> Five of these states have adopted the Advanced Clean Trucks Rule. And both New York and New Jersey have ongoing proceedings to further address barriers to HDV electrification.<sup>175 176</sup>

- ii. Robust solutions exist and are being implemented to ensure rapid interconnection and widespread vehicle electrification

The main concern that has been raised by OEMs and other parties related to the grid is the ability to build out infrastructure quickly enough to meet demand.<sup>177</sup> In addition to the existing policies and practices around upgrading distribution systems that have served to build things like data centers which have high load requirements, additional practices have been developed and are being implemented in some areas to address specific challenges around HD ZEV charging.

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<sup>168</sup> Database of approved utility programs tagged with “MHDV Charging” from Atlas Public Policy’s EVHub provided by Atlas Public Policy on June 2, 2023.

<sup>169</sup> Energy Infrastructure Incentives for Zero-Emission. <https://www.energiize.org/>

<sup>170</sup> <https://www.oregon.gov/deq/aq/programs/Pages/OZEF.aspx>

<sup>171</sup> <https://www.ahs.dep.pa.gov/NewsRoomPublic/articleviewer.aspx?id=22232&typeid=1>

<sup>172</sup> <https://energyoffice.colorado.gov/fleet-zero>

<sup>173</sup> <https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={6238DD07-3974-4C4E-9201-3E339E311916}>

<sup>174</sup> [https://njcleanenergy.com/files/file/EV/RGGI\\_MHD\\_Application\\_Final\\_1\\_12.pdf](https://njcleanenergy.com/files/file/EV/RGGI_MHD_Application_Final_1_12.pdf)

<sup>175</sup> <https://documents.dps.ny.gov/public/MatterManagement/CaseMaster.aspx?MatterCaseNo=23-E-0070&CaseSearch=Search>

<sup>176</sup> [https://publicaccess.bpu.state.nj.us/CaseSummary.aspx?case\\_id=2110570](https://publicaccess.bpu.state.nj.us/CaseSummary.aspx?case_id=2110570)

<sup>177</sup> <https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={D05A8E88-0000-CE16-8EA2-97D9432AAEE9}>

These include practices and policies that maximize the existing grid capacity, proactively building the grid, and updating planning procedures.

By maximizing the existing grid capacity, fleet owners can transition to ZEVs without requiring immediate grid upgrades allowing more time for utilities to build out infrastructures. Techniques such as leveraging non-wires alternatives (managed charging, onsite storage and generation, and energy efficiency programs) have had great success in minimizing the upgrades required, and allowing for continued load growth while waiting for a necessary upstream grid upgrade. One clear example of this is Con Edison' BQDM program which resulted in a 7-year grid upgrade deferral.<sup>178</sup> A report by the Smart Electric Power Alliance (SEPA) found a wide range of non-wires alternatives succeeded at enabling rapid interconnection and HDV electrification.<sup>179</sup>

Where fleets install managed charging software and/or onsite storage and solar generation to minimize charging costs including demand charges, their net load can be significantly lower than the utility-assigned capacity requirements for the site. To connect to the grid, they may be required to undergo site and utility upgrades to provide significantly higher capacity than what is actually needed and in some cases these solutions result in some sites never exceeding the existing capacity on their site making the upgrades unnecessary. Flexible interconnection, where customers agree to limit their peak load to a specified level below that of the cumulative nameplate capacity of their equipment, is one solution to energize chargers while those grid upgrades are ongoing. This mitigates any site and upstream grid upgrades in the short term in exchange for early energization of their charging equipment, and can even lower long-term upgrade needs. EPRI has shown the benefits of flexible interconnections for broader grid decarbonization.<sup>180</sup>

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<sup>178</sup> Coley Girouard. BQDM program demonstrates benefits of non-traditional utility investments. 2019. Utility Dive, <https://www.utilitydive.com/news/bqdm-program-demonstrates-benefits-of-non-traditional-utility-investments/550110/>

<sup>179</sup> Brenda Chew et al. *Non-Wires Alternatives: Case studies from leading U.S. projects*. 2018, Smart Electric Power Alliance, <https://sepapower.org/resource/non-wires-alternatives-case-studies-from-leading-u-s-projects/>

<sup>180</sup> Chris Warren. *Can allowing curtailment speedup DER growth?* EPRI Journal, <https://eprijournal.com/getting-flexible-about-interconnection/>

States are working towards allowing utilities, with guardrails in place to protect ratepayers, to proactively build the grid to need ahead of interconnection requests for new load, such as EV charging.

There are legislative efforts that are paving the way for this solution. California's AB 2700, which in addition calls for the collection of fleet electric vehicle deployment plans, also allows for utilities to submit pro-active grid expansion proposals to the utility commission in areas with identified future congestion using fleet deployment data.<sup>181</sup> SB 410 in California would take this a step further, setting requirements for utilities to have their grid ready for interconnection requests and calls for utilities to plan and evaluate potential grid impact of Advanced Clean Fleets (ACF) and Advanced Clean Trucks (ACT) rules as well as submit plans to address potential areas of congestion to meet energization timelines. This bill also requires utilities to report interconnection requests and delays to better track progress and hold utilities accountable.<sup>182</sup>

Other states have also taken steps to ensure utilities are able to proactively build infrastructure. New York senate bill S4830, which recently passed both houses of the New York legislature, directs the New York State Energy Research and Development Authority (NYSERDA) to identify the number and location of fleet charging zones and highway charging hubs where significant demand from EV charging, including electric HDVs, is expected in line with meeting state and federal transportation sector emissions regulations, and the associated grid impact of that charging.<sup>183</sup>

Efforts to update planning processes have also improved the ability for the grid to meet demand from HDV charging. If utilities have accurate forecasts well in advance of when grid needs arise,

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<sup>181</sup> Transportation electrification: electrical distribution grid upgrades. AB2700. 2021-2022 Regular Session, (California 2022) <https://legiscan.com/CA/bill/AB2700/2021>

<sup>182</sup> Powering Up Californians Act, SB410, 2023-2024 Regular Session, (California, 2023) <https://legiscan.com/CA/text/SB410/id/2813946>

<sup>183</sup> Establishing a highway and depot charging action plan, Senate Bill S4830A, 2023-2024 Legislative Session. (New York, 2023) <https://www.nysenate.gov/legislation/bills/2023/S4830>

they can complete needed upgrades without as great a need for mitigating solutions like grid deferral and flexible interconnection. In a recent article, Southern California Edison (SCE) emphasized the importance of planning for utilities: “On the forecasting and planning side, utilities and energy system planners must adapt planning efforts to reflect expected EV growth, including impacts from proposed and adopted policies and incentives. For example, to account for the new developing needs of the Advanced Clean Cars II and Advanced Clean Fleets policies in California, SCE and the other California investor-owned utilities were recently approved to use higher forecasts for transportation electrification than previously used.”<sup>184</sup>

The New York Joint Utilities’ Coordinated Grid Planning Process and California PUC’s Freight Infrastructure Planning Framework, both currently under development, also represent examples of improved planning processes to enable accelerated HDV electrification and grid interconnection.<sup>185 186</sup>

- iii. Upgrade costs for charging HD ZEVs can help more efficiently use the grid and drive down costs

Large-scale electrification of medium- and heavy-duty vehicles will require grid upgrades, largely at the distribution grid level, to support the added load from charging. But, research shows that EVs can help strengthen the grid, and the costs of the needed upgrades can be covered by the additional revenue from fleets charging without raising consumers’ electricity rates.<sup>187</sup>

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<sup>184</sup> Pamela MacDougall and Katie Sloan, *As the electric truck transition shifts into high gear, utilities must lead the charge*. 2022. Utility Dive, <https://www.utilitydive.com/news/electric-truck-bus-ev-utilities-sce-edison-edf/634214/>

<sup>185</sup> <https://documents.dps.ny.gov/public/MatterManagement/CaseMaster.aspx?MatterCaseNo=20-e-0197&CaseSearch=Search>

<sup>186</sup> Zero-Emissions Freight Infrastructure Planning. California Public Utilities Commission, <https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/infrastructure/transportation-electrification/freight-infrastructure-planning>

<sup>187</sup> Lucy Metz, Melissa Whited, Paul Rhodes and Ellen Carlson. Distribution System Investments to Enable Medium- and Heavy-Duty Vehicle Electrification: A Case Study of New York, Synapse Energy Economics, Inc., prepared for EDF. (April 2023). (Attachment X) <https://acrobat.adobe.com/link/track?uri=urn%3Aaaid%3Ausc%3Ab0fd0780-9882-3a25-9ef2-f8c73bd80c92&viewer%21megaVerb=group-discover>

According to electricity company executives, EVs can boost grid reliability.<sup>188</sup> EVs are schedulable loads that typically charge off peak (at night). Utilities can encourage EV owners to charge when and where they want, leading to more efficient use of existing grid infrastructure.<sup>189</sup>

EV charging can also finance and justify needed grid updates. Recent analysis conducted by Synapse Energy Economics for EDF finds that if U.S. utilities ratebase the cost of infrastructure upgrades needed for fleet charging, the utilities will see increased revenue without the need to raise consumers' electricity rates.<sup>190</sup> The analysis used two New York State utilities as case studies and found that if utilities cover the "make-ready" cost for both private and municipal medium- and heavy-duty fleets at the pace necessary for 100 percent electrification by 2045, the investment will pay off for utilities and have a positive to neutral impact on ratepayers in both utility service areas. The analysis' findings are applicable beyond New York to states across the country due to the varying grid costs, geography and electricity demand profiles of the utilities studied. Con Edison primarily serves New York City, while National Grid provides electricity to portions of upstate New York.

The study finds that if fleets are assumed to engage in modest managed charging (shifting charging times by only two hours at night), Con Edison's make-ready program could generate \$690 million in net revenue between 2023-2045, while National Grid's program could generate \$89 million in the same time period. Even without managed charging, investing in make-ready programs was shown to have a positive to neutral impact on ratepayers in both utility service areas. As more fleets are incentivized to plug in - and therefore spend more of their operating

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<sup>188</sup> Tomlinson, Chris. "Will electric vehicles crash the Texas grid? It's not complicated." Houston Chronicle (April 10, 2023). <https://www.houstonchronicle.com/business/columnists/tomlinson/article/electric-vehicles-ercot-grid-reliability-17880578.php>

<sup>189</sup> Jennifer Chen. 2023. Leveraging Locational and Temporal Flexibility in Transportation Electrification to Benefit Power Systems. Energy Systems Integration Group. <https://www.esig.energy/leveraging-locational-and-temporal-flexibility-in-transportation-electrification-to-benefit-power-systems/>

<sup>190</sup> Metz et al Distribution System Investments to Enable Medium- and Heavy-Duty Vehicle Electrification: (April 2023).



budget on electricity and less on diesel - utilities can invest a portion of that revenue on grid upgrades elsewhere that would have otherwise been paid for by all ratepayers.

- iv. Managed charging represents an opportunity for fleet owners to reduce their costs and to increase grid benefits from HDV electrification

Medium- and heavy-duty fleets can experience short but high energy demand events that can significantly increase their grid impact and energy bills. When these fleets go beyond merely managing charging to leveraging onsite distributed energy resources (DERs) such as solar and battery storage, they can benefit from an even more powerful lever for reducing charging costs. A GNA study examined two types of clean DERs: on-site solar panels and batteries. When combined with managed charging, DERs produced additional annual electric savings of \$625,000 (Schneider) and \$835,000 (NFI) for fleets of 40-50 electric HDVs. Moreover, managed charging and DERs together reduced annual on-peak load by 611 kW for the Schneider fleet and 4 MW for the NFI fleet.<sup>191</sup> Thus, such techniques would not only reduce costs for the truck companies, but the utility and ratepayers as a whole as well owing to the reduced need for grid buildout. If scaled to all trucks in a utility's territory, these load reductions could drastically decrease the amount of grid upgrades needed to accommodate electric fleets.

A recent New Jersey study evaluated the statewide grid impact of meeting ACT, as well as the grid savings when implementing managed charging and utilizing on-site solar and storage for all Class 3-7 vehicles in the state. Avoided peak load ranges from ~8,400 MW for managed charging, to ~10,000 MW for managed charging with solar + battery. Total avoided

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<sup>191</sup> Gladstein, Neandross & Associates, California Heavy-Duty Fleet Electrification Summary Report, March 2021, <http://blogs.edf.org/energyexchange/files/2021/03/EDF-GNA-Final-March-2021.pdf> Gladstein, Neandross & Associates, California Heavy-Duty Fleet Electrification Summary Report, March 2021, <http://blogs.edf.org/energyexchange/files/2021/03/EDF-GNA-Final-March-2021.pdf>. (Attachment Y)

infrastructure costs are between \$320 million and \$1.80 billion for managed charging, and between \$382 million and \$2.15 billion for managed charging with solar + battery.<sup>192</sup> Furthermore, these largely avoided infrastructure costs are sure to be an underestimate for HDV electrification as a whole for the state since they do not account for the benefits of electrifying Class 8 vehicles with managed charging or managed charging with solar + battery.

The flexibility associated with vehicle charging is also extremely valuable to the grid operator. A study by the Midwest ISO shows the untapped potential of EV load flexibility as a DER resource in the wholesale markets. This study evaluated the impact of expected electrification of both MHDVs as well as LDVs in the MISO footprint. A key factor in this study was determining the potential flexibility of these vehicles when applying managed and bidirectional charging tactics to mitigate ramp and peak load. It showed that at any given hour this additional load can provide a minimum of 10 GW of combined ramp up capacity and just under 10 GW of ramp down or generation capacity using the flexibility of EV charging alone. To reiterate, this ramp capacity was based on vehicle charging alone and would be even greater if combined with other on-site DERs.<sup>193</sup>

Of critical importance, this load flexibility also comes at a fraction of the cost of traditional fixed battery storage. A study by Lawrence Berkeley National Lab shows that managed charging of EVs—modulating when and at what rate the EVs are charged—can provide reliable storage at approximately a tenth of the cost of equivalent storage provided by single-purpose, stationary batteries. When scaled to California’s projected 1.5 million light-duty EVs by 2025, the storage potential of managed charging alone is 1 GW, resulting in savings of approximately \$1 billion

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<sup>192</sup> Jeffery Greenblatt. *New Jersey Medium Duty Fleet Electrification Infrastructure Summary Report*. 2022. Emerging Futures, [https://blogs.edf.org/energyexchange/files/2022/05/New\\_Jersey\\_Medium\\_Duty\\_Fleet\\_Electrification\\_Infrastructure\\_Summary\\_Report.pdf](https://blogs.edf.org/energyexchange/files/2022/05/New_Jersey_Medium_Duty_Fleet_Electrification_Infrastructure_Summary_Report.pdf) Emerging Futures, [https://blogs.edf.org/energyexchange/files/2022/05/New\\_Jersey\\_Medium\\_Duty\\_Fleet\\_Electrification\\_Infrastructure\\_Summary\\_Report.pdf](https://blogs.edf.org/energyexchange/files/2022/05/New_Jersey_Medium_Duty_Fleet_Electrification_Infrastructure_Summary_Report.pdf) (Attachment Z)

<sup>193</sup> Greenblatt, Jeff and Margaret McCall, Exploring enhanced load flexibility from grid-connected electric vehicles on the Midcontinent Independent System Operator grid (Feb. 2021), available at <https://cdn.misoenergy.org/Exploring%20enhanced%20load%20flexibility%20from%20grid%20connected%20EVs%20on%20MISO%20grid543291>

compared to investments needed for equivalent stationary storage. This number also does not include the thousands of MHDVs such as buses and trucks expected to be electrified in the near future.<sup>194</sup> By leveraging the flexibility of newly electrified resources, stakeholders can significantly reduce grid management costs ultimately, resulting in savings for end-customers and mitigating grid upgrade needs, further supporting accelerated HDV electrification.

c) EPA must design the final rule to limit infrastructure related off-ramps

EPA has sought comment on whether the agency “should consider undertaking any future actions related to the Phase 3 standards, if finalized, with respect to the future growth of the charging and refueling infrastructure for ZEVs”<sup>195</sup>

As discussed above and shown in EPA’s own assessment in the proposal and supporting technical documents, the record supports the feasibility of standards that will result in significant ZEV deployment. Indeed, as these standards provide a clear market signal of future infrastructure needs and as ZEV deployment ramps up over a period of five years beginning in 2027, so too will the necessary charging infrastructure and the foregoing discussion and separate report from the Analysis Group both demonstrate that generation and transmission do not pose challenges for heavy-duty ZEV deployment and solutions related to distribution enhancements either already are or are being developed.<sup>196</sup>

Including an offramp in the rule is inconsistent with this record evidence and would frustrate the important pollution reductions outcomes the rule will deliver. EPA has regularly considered issues related to the success of its standards on an ongoing basis, including, for example, periodic technical progress reviews. EPA could similarly here consider the development of infrastructure at future intervals to ensure it is continuing to develop at a pace and scale consistent with EPA’s

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<sup>194</sup> Jonathan Coignard et al., Clean vehicles as an enabler for a clean electricity grid, 13 Environmental Research Letters 54031 (2018).

<sup>195</sup> 88 Fed. Reg. 25934.

<sup>196</sup> See supra note 166

projections. However, we strongly encourage EPA not to attempt to directly integrate infrastructure related reviews in its standards setting.

**V. The supply chain for electric vehicle batteries and critical minerals is capable of safely and equitably meeting the demands of strong standards**

Domestic production of batteries and battery components is growing rapidly. Analysis by EDF and WSP found that there has been over \$79.7 billion in investment in U.S. battery and battery component production announced within the past 8 years, resulting in almost 70,000 new jobs.<sup>197</sup> In 2026, these already announced investments will be capable of producing batteries sufficient to supply the equivalent of 11.2 million new passenger vehicles per year.<sup>198</sup>

Much of this investment has occurred within the last year as a result of the IRA's incentives for domestic battery production, which will continue to spur production growth and reduce battery costs throughout the timeframe of this rule.<sup>199</sup> The Advanced Manufacturing Production credit, for instance, provides up to \$45 per kilowatt-hour for the production of battery cells and modules as well as up to 10% of the cost of critical minerals through 2032.<sup>200</sup> Additionally, the IRA's amendments to the Clean Vehicle Credit includes provisions requiring that qualifying vehicles source an increasing percentage of their critical minerals and battery components domestically, which will further incentivize increased domestic production capacity.<sup>201</sup>

The extraction, processing, and recycling of the critical minerals necessary to support rapid ZEV proliferation is also ramping up and supports the feasibility of protective emission standards. EDF has conducted a review of investments in the critical minerals supply chain, including new investments and expansion of existing capacities in raw minerals extraction (mining), materials

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<sup>197</sup> U.S. Electric Vehicle Manufacturing Investments and Jobs, Characterizing the Impacts of the Inflation Reduction Act after 6 Months, WSP for EDF, (March 2023). <https://blogs.edf.org/climate411/files/2023/03/State-Electric-Vehicle-Policy-Landscape.pdf>. (Attachment AA).

<sup>198</sup> Ibid.

<sup>199</sup> Ibid.

<sup>200</sup> Inflation Reduction Act of 2022, P.L. 117-1698, 136 Stat. 1971-81 (2022).

<sup>201</sup> Inflation Reduction Act of 2022, P.L. 117-1698, 136 Stat. 1956-57 (2022).

separation and processing, and recycling efforts in the U.S, based on publicly available information from company websites and announcements issued by investors, government agencies, and news media on the operators, materials, locations, annual capacities, and timelines of the projects.<sup>202</sup> The compilation of projects includes the scale and date of any announced investments in the projects, including OEM investments, as well as the details of partnership agreements. We have also compiled information on specific funding levels secured under the BIL.

The numerous projects and partnerships identified demonstrate a growing effort—that is supported by the BIL and motivated by the IRA—to develop a secure supply of the critical minerals. In October 2022, the White House announced \$2.8 billion in funding under the BIL for projects to support "new, retrofitted, and expanded commercial-scale domestic facilities to produce battery materials, processing, and battery recycling and manufacturing demonstrations."<sup>203</sup> The funding is the first phase of a total \$7 billion investment by the federal government to develop domestic supply chains for electric vehicle battery production.<sup>204</sup> According to project announcements, these investments in critical minerals projects have been spurred on by downstream consumer tax benefits under the IRA.<sup>205</sup>

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<sup>202</sup> The compilation is attached to this comment as an Excel file titled "Domestic Critical Minerals Projects." We are expanding the review to include countries with which the U.S. has free trade agreements. (Attachment HH)

<sup>203</sup> U.S. DOE Office of Manufacturing and Energy Supply Chain Bipartisan Infrastructure Law: Battery Materials Processing and Battery Manufacturing Recycling Selections, *available at*: <https://www.energy.gov/mesc/bipartisan-infrastructure-law-battery-materials-processing-and-battery-manufacturing-recycling>

<sup>204</sup> U.S. DOE, October 19, 2022 Biden-Harris Administration Awards \$2.8 Billion to Supercharge U.S. Manufacturing of Batteries for Electric Vehicles and Electric Grid, *available at*: <https://www.energy.gov/articles/biden-harris-administration-awards-28-billion-supercharge-us-manufacturing-batteries>

<sup>205</sup> *E.g.*, General Motors announced that, "[m]aterial sourced from Lithium Americas [Thacker Pass mine in Nevada] will help support EV eligibility for consumer incentives under the U.S. clean energy tax credits." Ford noted, in its announcement of a long-term agreement with Nemaska Lithium, that its lithium hydroxide should help qualify Ford vehicles for consumer tax benefits under the IRA. And Livent Corporation, in its announcement of the expansion of its largest lithium hydroxide production site in the U.S. said that its, "leading footprint in North America positions the company to take advantage of long-term growth opportunities and downstream incentives from the recently enacted Inflation Reduction Act (IRA), which encourages use of lithium produced or processed in North America."

In all, our review identified 74 domestic mining, processing, and recycling projects. Investment levels are not known for all projects but announced investments total over \$25 billion, including \$1 billion funded under the BIL.

It is vital that any increase in minerals mining and processing be undertaken in a way that does not increase pollution burdens on underserved communities, which have historically faced disproportionate harms from these processes. Projects undertaken must be carried out in a way that affirmatively prioritizes the needs of these communities.

**VI. EPA should ensure rigorous accenting and protective safeguards are in place related to the production and use of hydrogen**

- a) EPA should ensure its assessment of hydrogen is rigorous, comprehensive, and fully accounts for potential adverse climate and health impacts associated with hydrogen production and use
  - i. The method of hydrogen production impacts whether hydrogen fueled vehicles decrease the vehicle's associated emissions when compared to diesel vehicles or increases them.

In the proposal, EPA assumes all of the hydrogen used to fuel FCEVs will be produced through grid electrolysis. Currently, 95% of hydrogen is produced from natural gas in a process called steam methane reformation (SMR).<sup>206</sup> SMR emits CO<sub>2</sub> as a byproduct of the hydrogen production resulting in a carbon intensity of between 8 and 12 kg of CO<sub>2</sub>/kg H<sub>2</sub>. Hydrogen produced using electricity from the current U.S. average grid has a carbon intensity of 21 kg of CO<sub>2</sub>/kg H<sub>2</sub>.<sup>207</sup>

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<sup>206</sup> DRIA page 80

<sup>207</sup> Thomas Koch Blank and Patrick Molly. *Hydrogen Decarbonization Impact for Industry: Near-term challenges and long-term potential*. 2020. RMI, [https://rmi.org/wp-content/uploads/2020/01/hydrogen\\_insight\\_brief.pdf](https://rmi.org/wp-content/uploads/2020/01/hydrogen_insight_brief.pdf) (Attachment BB)

EDF assessed the emissions associated with vehicles using different sources of hydrogen, calculating the difference in CO<sub>2</sub> emissions of BEVs, FCEVs, and H<sub>2</sub>ICE vehicles, and conventional diesel ICE vehicles with the carbon intensities of the fuels along with the powertrain efficiencies taken into consideration. We used the vehicle efficiencies from ICCT's report on decarbonizing tractors. The efficiencies used in that study are similar to those assumed by EPA in HD TRUCKS with the exception that ICCT also includes H<sub>2</sub> ICE vehicles allowing for an equal comparison.<sup>208</sup> We included the combustion emissions from diesel, the production emissions from electricity and SMR hydrogen, and the electricity production emissions for grid electrolysis hydrogen. We included hydrogen produced using the current grid, EPA's modeled incremental 2035 grid, and linearly extrapolated to calculate the grid emissions in 2027.<sup>209</sup> <sup>210</sup>The results of this analysis are plotted below in Figure 12, which importantly does not include any additional upstream emissions (i.e. methane emissions from natural gas production).

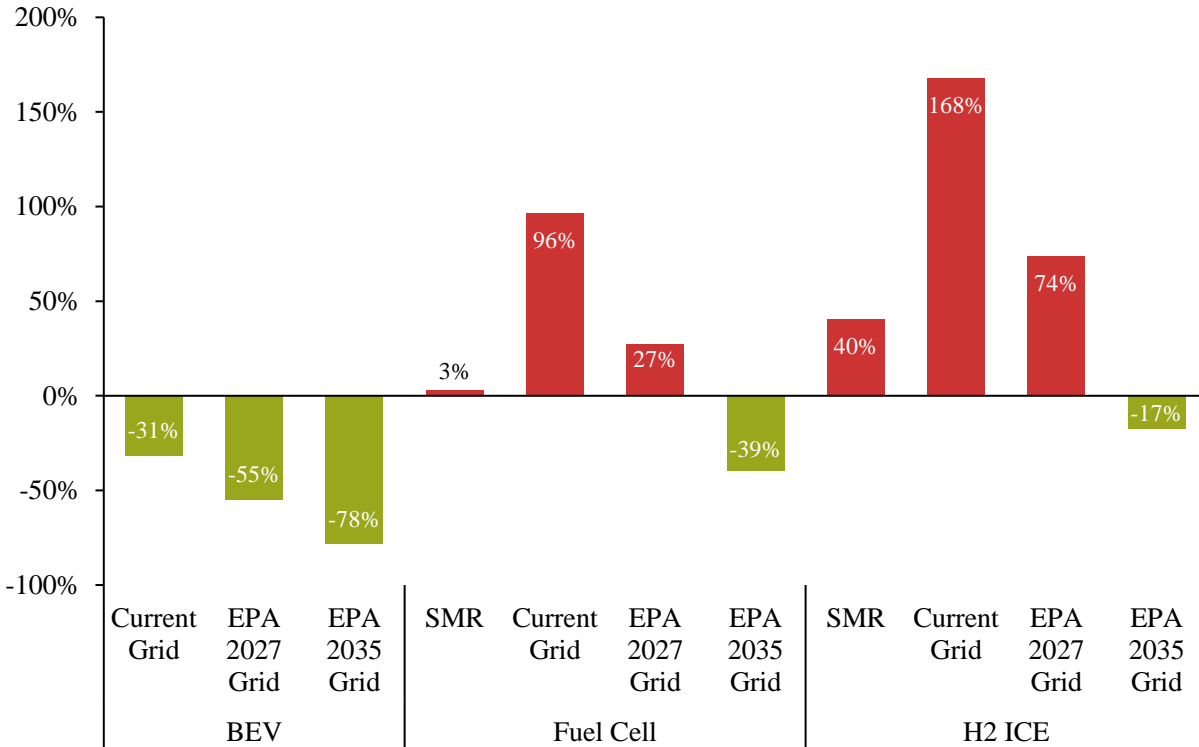
Figure 12: CO<sub>2</sub> emissions differences relative to diesel ICE vehicle

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<sup>208</sup> Hussein Basma et al. *Total Cost of Ownership of Alternative Powertrain Technologies for Class 8 Long-Haul Trucks in the United States*. 2023. ICCT, <https://theicct.org/publication/tco-alt-powertrain-long-haul-trucks-us-apr23/>

<sup>209</sup> Frequently Asked Questions: How much carbon dioxide is produced per kilowatt-hour of U.S. electricity generation? 2022. U.S. Energy Information Administration, <https://www.eia.gov/tools/faqs/faq.php?id=74&t=11>

<sup>210</sup> Section 4.3.3.2 EGU Emissions Modeling Methodology from Draft RIA



Source: EDF analysis using data from EPA’s HD TRUCS, ICCT. *Total Cost of Ownership of Alternative Powertrain Technologies for Class 8 Long-Haul Trucks in the United States and RMI, Hydrogen Decarbonization Impact for Industry.*

Regardless of the grid, the emissions from the electricity needed to power BEVs is lower than the combustion emissions from a diesel vehicle. Using the current grid, BEVs represent a decrease of roughly a third and by 2035, they reduce emissions by almost 80%. This analysis shows that the emission reductions from FCEVs and H2ICE vehicles are highly dependent on the production method of the hydrogen and increase emissions relative to diesel vehicles when the hydrogen is produced by SMR, the current grid, and even the projected 2027 grid. Additionally, assuming EPA’s 2035 grid mix, the emission benefits of BEVs are roughly twice those of FCEVs and four times those of H2ICE vehicles.

Moreover, FCEVs and ICE vehicles are much less efficient than BEVs. Additionally, 40% of the energy from the electricity used to make hydrogen using electrolysis is lost in the process. When the inefficiencies of both processes are combined, it takes 2.6 times as much electricity to



power a FCEV as a BEV. When considerations like compression and transportation of the hydrogen are included, three to four times more energy is needed for hydrogen road transportation.<sup>211</sup> When considerations like compression and transportation of the hydrogen are included, three to four times more energy is needed for hydrogen road transportation compared to battery electric vehicles.<sup>212 213</sup>

Unless hydrogen fueled vehicles use low-GHG hydrogen, they do not substantially reduce climate emissions. While switching to BEVs reduces emissions relative to diesel vehicles using today's grid, the same cannot be said for FCEVs or H2ICE vehicles using hydrogen produced from SMR or grid electrolysis – both of which increase emissions relative to diesel vehicles. Indeed, even in 2030, emissions associated with grid electrolysis hydrogen fueled vehicles are higher than diesel vehicles.

- ii. EPA should consider the impacts of hydrogen leakage given recent science demonstrating climate impacts.

While EPA accounts for the EGU emissions associated with hydrogen production from grid electrolysis in the assessments of costs and benefits, the impact of hydrogen leakage is not accounted for in the proposal. A recent but growing body of evidence clearly shows that hydrogen gas in the atmosphere causes global warming and EPA must consider these impacts when setting standards.

Hydrogen is a short-lived, indirect GHG that causes warming by increasing the concentration of other GHGs in the atmosphere. It is a small and slippery molecule that can easily escape from all parts of the value chain. Recent studies have found hydrogen's warming power is over 30 times

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<sup>211</sup> Eriko Shrestha and Tianyi Sun. Rule #1 of deploying hydrogen: Electrify first. 2023. EDF Blog Energy Exchange, <https://blogs.edf.org/energyexchange/2023/01/30/rule-1-of-deploying-hydrogen-electrify-first/> EDF Blog Energy Exchange, <https://blogs.edf.org/energyexchange/2023/01/30/rule-1-of-deploying-hydrogen-electrify-first/> (Attachment GG)

<sup>212</sup> Eriko Shrestha and Tianyi Sun. Rule #1 of deploying hydrogen: Electrify first. 2023. EDF Blog Energy Exchange, <https://blogs.edf.org/energyexchange/2023/01/30/rule-1-of-deploying-hydrogen-electrify-first/>

<sup>213</sup> Hydrogen vehicles fueled with low-GHG hydrogen would provide substantial climate benefits relative to diesel vehicles. They would also require substantially more low carbon electricity than a BEV.

larger than CO<sub>2</sub> pound for pound over the 20 year period after it is emitted, and about 10 times larger over 100 years – values that are 2-6 times higher than previously thought.<sup>214</sup> EDF research shows that if the hydrogen emissions rate is high across the value chain, it can severely undermine the intended benefits of clean hydrogen.<sup>215</sup>

Currently, estimates of hydrogen leakage rates range considerably, due to a lack of empirical data on leakage from specific infrastructure such as electrolyzers, pipelines, and storage. Hydrogen emissions associated with production include both unintended leakage and intentional purging/venting (which can be controlled by incorporating technology that recombines purged and vented hydrogen back into the production process). Overall, estimates of emissions associated with electrolytic hydrogen production currently range from 0.1% to 9.2%. Blue hydrogen production is estimated to have less than 1.5% hydrogen emissions, since waste gas is likely to be flared or used for process heat. Hydrogen also has the potential to leak from various delivery segments of the value chain, including compression, liquefaction, storage, and transportation via pipelines or trucks. Overall, current estimates of leakage rates for the full hydrogen value chain, including production, processing, storage and delivery, range up to 20%.<sup>216</sup>

Studies on hydrogen leakage often rely on natural gas supply chain leakage as a proxy, and there is a high degree of uncertainty in existing methane emission estimates. Moreover, the patterns of hydrogen leakage can be different from that of methane, with fluid dynamics theory suggesting

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<sup>214</sup> Ocko, Ilissa and Hamburg, Steve (2022). “Climate consequences of hydrogen leakage.” *Atmospheric Chemistry and Physics*. Vol. 22, Issue 14. <https://acp.copernicus.org/articles/22/9349/2022/> (Attachment CC); *See also* Warwick et al., (2022). “Atmospheric Implications of Increased Hydrogen Use”. Department for Business, Energy & Industrial Strategy. <https://www.gov.uk/government/publications/atmospheric-implications-of-increased-hydrogen-use> (Attachment DD).

<sup>215</sup> *Id.*

<sup>216</sup> Estimates include Cooper et al., (2022). “Hydrogen emissions from the hydrogen value chain-emissions profile and impact to global warming”. *Science of the Total Environment*. Vol. 830. <https://linkinghub.elsevier.com/retrieve/pii/S004896972201717X>; Frazer-Nash Consultancy (2022). “Fugitive Hydrogen Emissions in a Future Hydrogen Economy”. <https://www.gov.uk/government/publications/fugitive-hydrogen-emissions-in-a-future-hydrogen-economy>; Arrigoni, A. and Bravo Diaz, L. (2022). “Hydrogen emissions from a hydrogen economy and their potential global warming impact”. Publications Office of the European Union, Luxembourg. doi:10.2760/065589, JRC130362; and Schultz et al., (2003). “Air Pollution and Climate-Forcing Impacts of a Global Hydrogen Economy”. *Science*, Vol. 302. <https://www.science.org/doi/10.1126/science.1089527>

that hydrogen can leak 1.3 to 3 times faster than methane, and experimental studies suggest different leak rates for different leak regimes.<sup>217</sup> However, development of appropriate sensor technologies is currently underway which would enable such measurement.

No estimates currently exist of the potential for leakage that would result from FCEVs or H2ICE vehicles fueling or the potential leakage that could result from vehicles while they are in use. Given the nature of hydrogen (small and as a result leak prone) and the necessary widespread infrastructure needed to enable vehicle refueling, the potential for leakage is a large source of concern for EDF. Accordingly, we urge EPA to consider the impact of hydrogen leakage in impacting the greenhouse gas emissions profile of H2 ICE vehicles and fuel cell vehicles.

- b) EPA should adopt a protective framework that helps to minimize any potentially adverse climate and health impacts associated with hydrogen usage.

Under the proposal's current framework, hydrogen powered vehicles are incentivized both through credit multipliers and their treatment as having zero-emissions for compliance with the standards. These incentives are misguided given that, as shown above, hydrogen powered vehicles' emissions impacts are worse than diesel vehicles using current, dominant forms of hydrogen production and, in many certain scenarios, using projected future grid electricity. We encourage EPA to strengthen its standards by removing blanket incentives and adopting protections that do not credit or incentivize hydrogen fueled vehicles as having zero-emissions when that is not the case. Instead, EPA should tailor its standards to encourage use of low-GHG hydrogen.<sup>218</sup> We offer a few two specific suggestions related to these issues below.

Removing credit multipliers. EPA should remove credit multipliers for hydrogen fueled vehicles — which, as proposed, provide greater incentives for the production of FCEVs than for lower-emitting BEVs. EPA proposes to retain its existing Advanced Technology Credit Multipliers for

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<sup>217</sup> Ibid.

<sup>218</sup> In their assessment of low-GHG hydrogen, EPA should be consistent with standards set in the IRA production tax credit for clean hydrogen as well as other EPA standards such as the recently proposed Greenhouse Gas Standards and Guidelines for Fossil Fuel-Fired Power Plants.

FCEVs (which are higher than the multipliers for BEVs) through 2027, even though it will remove these same incentives for BEVs in 2026.<sup>219</sup> Given that the emissions benefits of hydrogen powered vehicles vary widely — and are, in all cases, worse than that of BEVs — these incentives are counterproductive. EPA should phase out these credit multipliers for FCEVs by 2026, just as they have for BEVs. If EPA is going to maintain these incentives, it should do so only for manufacturers that can demonstrate their vehicles are producing real world emissions benefits by certifying they are running on green hydrogen.<sup>220</sup> As the above analysis demonstrates, EPA must not allow any credits for vehicles fueled with hydrogen produced using SMR or grid electrolysis – both of which produce emissions outcomes worse than diesel vehicles in the 2027 timeframe.

Apply a Utility / Correction Factor to Vehicles Fueled with Hydrogen. We also urge EPA to account for the wide variation in hydrogen fueled vehicles’ emissions benefits in measuring their emissions for compliance with the standards. EPA proposes to count hydrogen powered vehicles as having zero emissions, similar to how it has treated BEVs in the past. However, EPA’s prior justifications for treating BEVs this way do not apply to hydrogen powered vehicles.<sup>221</sup> Not only do hydrogen powered vehicles not provide clear emissions benefits absent further controls on where the hydrogen they operate on comes from, but due to potential leakage of hydrogen from the vehicles and criteria pollutant emissions from H2ICEVs, they do have vehicle and tailpipe emissions that must be accounted for. Additionally, EPA has previously noted the existence of other emissions reduction programs or controls related to upstream emissions as justifying its

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<sup>219</sup> 88 Fed. Reg. 26012.

<sup>220</sup> In passing the IRA, Congress recently recognized the importance of an approach to hydrogen powered vehicles that incentivizes clean hydrogen production through its tax credits for clean hydrogen production, which increase with lower lifecycle emissions. 26 U.S.C. §45V.

<sup>221</sup> EPA’s decision to treat BEVs as having zero-emissions was based on a careful consideration of the emissions benefits associated with BEVs because the original purpose of this approach was to “recognize the benefits of . . . dedicated alternative-fueled vehicles.” 76 Fed. Reg. 57123. Because of the emissions issues associated with hydrogen powered vehicles, including the fact that they likely do have tailpipe emission through hydrogen leakage, this same justification cannot justify their parallel treatment. Additionally, EPA has previously considered it important to its focus on tailpipe emissions that the upstream emissions are regulated by other rules.

focus on tailpipe emissions.<sup>222</sup> However, emissions from hydrogen production are currently unregulated, making it especially important that EPA adopt an approach that considers and reflects how hydrogen fueled vehicles are powered and operated.

In this regard, EPA should not treat hydrogen fueled vehicles like BEVs but instead similarly to how the agency treats PHEVs,<sup>223</sup> where EPA recognizes that sometimes PHEVs operate on battery power with real emissions benefits and other times the vehicle is powered by its ICE engine with emissions profiles more similar to fossil-powered vehicles.<sup>224</sup> For hydrogen fueled vehicles, EPA could adopt an approach to calculating their GHG emissions that includes a conservative low- GHG utility factor representing emissions attributable to hydrogen fueled vehicles assuming those vehicles are fueled using average, current forms of hydrogen production. For instance, a current factor would need to reflect the fact that most hydrogen is produced using SMR and does not result in real-world emission benefits when compared to diesel vehicles.<sup>225</sup>

EPA could, of course, update this factor over time as the relative mix of hydrogen production sources changes. Moreover, as with the credit multipliers, EPA should incentivize manufacturers who can demonstrate their hydrogen fueled vehicles are driving actual emissions benefits. It can do so by allowing manufacturers to adjust the low-GHG utility factor applied to their vehicles where they can show they are resulting in real world emissions benefits through emissions testing or certifying the vehicles run exclusively on low-GHG hydrogen.

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<sup>222</sup> 76 Fed. Reg. 51705 (Aug. 27, 2012) (“There is no good reason to consider [the lifecycle emission of different types of fuels] here, especially where there already is a separate fuel based program, the RFS program, that is directly aimed at achieving the result POP Diesel seeks--a fuel program that achieves a reduction in lifecycle GHG emissions associated with the diesel fuel used by motor vehicles, through a mandate to use certain renewable diesel fuels.”).

<sup>223</sup> See 40 CFR § 600.116-12.

<sup>224</sup> 88 Fed. Reg. 29253 (May 5, 2023) (“Because the tailpipe CO<sub>2</sub> produced from PHEVs varies significantly between [charge depleting] and [charge sustaining] operation, both the charge depleting range and the utility factor curves play an important role in determining the magnitude of CO<sub>2</sub> that is calculated for compliance.”).

<sup>225</sup> This utility factor should also differ for H<sub>2</sub>ICEs, and FCEVs, which have differing emissions benefits.

We emphasize the importance of EPA adopting these protections and guardrails now, given the potential near term proliferation of hydrogen fuels and the absence of regulatory structures to ensure any hydrogen produced is done so in a way that minimize climate and health harming pollution. At the same time, we urge EPA to adopt future leakage standards related hydrogen fueled vehicles and explore and pursue all other regulatory authorities to reduce and eliminate harmful pollution associated with hydrogen production and use.

- c) H2 ICE vehicles emit NOx and should not be considered full ZEVs.

While BEVs and FCEVs do not generate any intended emissions at the tailpipe, H2-ICE vehicles still emit nitrogen oxides (NOx) and should be required to employ aftertreatment devices analogous to those required for diesel engines (primarily SCR). Even if EPA considers H2-ICE vehicles as a carbon-free technology, they should not be considered a full ZEV.

## **VII. EPA's Assessment of Benefits is Overly Conservative**

EPA has projected that its standards will deliver overwhelming net benefits, including significant climate and pollution reduction benefits. We agree with that assessment and identify several conservative assumptions and approaches EPA has taken that, when adjusted, demonstrate that the standards would deliver even greater benefits.

- a) EPA's benefit-per-ton methodology for calculating the health and air quality benefits of this rule is conservative and underestimates the ultimate benefits

EPA uses the benefit per ton (BPT) approach to estimate the economic savings from health-related impacts of the proposal. EPA estimates the present value of PM2.5-related benefits of the proposed program to be \$140 to \$280 billion at a 3% discount rate and \$63 to \$130 billion at a 7% discount rate.<sup>226</sup> BPT approaches provide important insights into the value of pollution reductions and we encourage EPA to consider pairing this assessment with a fuller health impact assessment. A health impact assessment takes into consideration the spatial distribution of air

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<sup>226</sup> RIA at 7-36.

pollutant concentrations and the spatial distribution of baseline disease of the population, both of which influence the magnitude of the health benefits estimated.

EDF has also taken a number of approaches to quantify the health benefits attributable to transportation electrification scenarios in a number of different studies. For example, in 2022, EDF completed a white paper documenting the reasonableness and feasibility of performance-based standards that ensure 40 percent of new Class 4-7 and Class 8 short haul tractors and 80 percent of school and transit bus sales are ZEVs by 2029.<sup>227</sup> The paper analyzed the climate, health, and economic benefits of standards that achieve these goals and found such standards would avoid more than 1.6 billion tons of GHG emissions and 840,000 - 2.2 million tons of ozone-forming NO<sub>x</sub> pollution through 2050. This pollution reduction would prevent between 7,500 and 9,600 premature deaths through 2050 and provide the nation with up to \$34 billion in economic benefits annually in 2040, with a cumulative savings of \$650-680 billion through 2050. The New York and Atlanta studies discussed above also use fine spatial resolution modeling approached to ascertained localized disparities in health impacts.<sup>228</sup> We encourage EPA to consider the results of these approaches and employ a variety of assessment methodologies, including fine scale modeling, to better understand the benefits of its standards.

EDF has also taken a number of approaches to quantify the health benefits attributable to transportation electrification scenarios in a number of different studies. For example, in 2022, EDF completed a white paper documenting the reasonableness and feasibility of performance-based standards that ensure 40 percent of new Class 4-7 and Class 8 short haul tractors and 80

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<sup>227</sup> EDF Comments on Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards, 87 Fed. Reg. 17414. May 16, 2022. EPA-HQ-OAR-2019-0055-1265. Attachment A. Available at: <https://www.regulations.gov/comment/EPA-HQ-OAR-2019-0055-1265>. Environmental Defense Fund, The Opportunity for Near-Term Electrification of Medium- and Heavy-Duty Vehicles (May 2022), <https://blogs.edf.org/climate411/wp-content/blogs.dir/7/files/2022/05/FINAL-EDF-HD-ZEV-report-5.17.22.pdf>. Environmental Defense Fund, The Opportunity for Near-Term Electrification of Medium- and Heavy-Duty Vehicles (May 2022), <https://blogs.edf.org/climate411/wp-content/blogs.dir/7/files/2022/05/FINAL-EDF-HD-ZEV-report-5.17.22.pdf>. (Attachment EE)

<sup>228</sup> See supra note 7.

percent of school and transit bus sales are ZEVs by 2029.<sup>229</sup> The paper analyzed the climate, health, and economic benefits of standards that achieve these goals and found such standards would avoid more than 1.6 billion tons of GHG emissions and 840,000 - 2.2 million tons of ozone-forming NO<sub>x</sub> pollution through 2050.<sup>230</sup> This pollution reduction would prevent between 7,500 and 9,600 premature deaths through 2050 and provide the nation with up to \$34 billion in economic benefits annually in 2040, with a cumulative savings of \$650-680 billion through 2050. The New York and Atlanta studies discussed above also use fine spatial resolution modeling approached to ascertained localized disparities in health impacts.<sup>231</sup> We encourage EPA to consider the results of these approaches and employ a variety of assessment methodologies, including fine scale modeling, to better understand the benefits of its standards.

i. Direct NO<sub>2</sub> emissions

EPA's benefits analysis reflects only the PM<sub>2.5</sub>-related benefits associated with reductions in NO<sub>x</sub>, SO<sub>2</sub>, and direct PM<sub>2.5</sub> emissions.<sup>232</sup> This approach underestimates the total health benefits of the Proposed Rule by not quantifying the health benefits of reductions in air pollutants other than PM<sub>2.5</sub> and PM<sub>2.5</sub> precursors. Accordingly, we encourage EPA to incorporate the significant health impacts of nitrogen dioxide (NO<sub>2</sub>) to more accurately estimate the benefits of the Proposed Rule. In the studies described above in New York City and Atlanta<sup>233</sup>, NO<sub>2</sub>-attributable health impacts were a significant portion of the health benefits of the analyzed electrification scenarios and excluding NO<sub>2</sub> would have resulted in significantly underestimated benefits. In New York City, 85 percent of the air pollutant-attributable deaths and 97 percent of childhood asthma ED visits are attributable to NO<sub>2</sub> exposure.<sup>234</sup> The study found that 12 percent

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<sup>229</sup> EDF Comments on Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards, 87 Fed. Reg. 17414. May 16, 2022. EPA-HQ-OAR-2019-0055-1265. Available at: <https://www.regulations.gov/comment/EPA-HQ-OAR-2019-0055-1265>. Environmental Defense Fund, The Opportunity for Near-Term Electrification of Medium- and Heavy-Duty Vehicles (May 2022), <https://blogs.edf.org/climate411/wp-content/blogs.dir/7/files/2022/05/FINAL-EDF-HD-ZEV-report-5.17.22.pdf>.

<sup>230</sup> Attachment A. EDF Comments on Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards, 87 Fed. Reg. 17414. May 16, 2022. EPA-HQ-OAR-2019-0055-1265. Available at: <https://www.regulations.gov/comment/EPA-HQ-OAR-2019-0055-1265>.

<sup>231</sup> See *supra* note 7.

<sup>232</sup> RIA at 7-36.

<sup>233</sup> See *supra* note 7.

<sup>234</sup> See *supra* note 7.



of NO<sub>2</sub> impacts could be preventable in the first scenario (which assumed 100 percent EV sales for transit and school buses by 2030 and 30 percent EV sales by 2030 and 100 percent sales by 2040 for all other heavy-duty vehicles) and 23 percent of NO<sub>2</sub> impacts could be preventable in the second scenario (which assumed 100 percent electrification of all vehicles by 2040). In Atlanta, though PM<sub>2.5</sub> reductions account for 68 percent of the estimated mortality benefits, full electrification of heavy-duty vehicles by 2040 (Scenario 2) could reduce up to 71 percent of total NO<sub>2</sub> impacts. Using a high-resolution chemical transport model, another recent study in Chicago found that 30 percent electrification of all heavy-duty vehicles could prevent 580 deaths annually as a result of NO<sub>2</sub> emissions reductions and prevent 70 deaths per year from reduced PM<sub>2.5</sub>.<sup>235</sup>

In comments on EPA's March 28, 2022 Proposed Rule, commenters similarly raised the importance of quantifying health benefits of NO<sub>2</sub>, and EPA indicated it “**intends to continue to consider how best to quantify this endpoint in future regulatory actions.**”<sup>236</sup> Accordingly, we urge EPA to quantify the health impacts for NO<sub>2</sub>.

ii. Near-roadway impacts

It is also important that EPA capture pollution exposure disparities in its analysis so it can better estimate the neighborhood-level impacts of the rulemaking. Use of fine spatial resolution results in higher estimates for exposures in urban areas and among historically marginalized populations.<sup>237</sup> EPA's current analysis uses a coarse spatial scale of 12km x 12km that is less suitable for capturing exposure disparity and near-road transportation emissions. Use of this

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<sup>235</sup> Camilleri S, Montgomery A, Visa M, Schnell J, Adelman Z, Janssen M, Grubert E, Anenberg S, Horton D. 2023. Air quality and health implications of electrifying heavy-duty vehicles assessed at equity-relevant neighborhood-scales. Pre-print available at : <https://assets.researchsquare.com/files/rs-2399309/v1/50dfcf1856da6c10964ae70.pdf?c=1674171815>

<sup>236</sup> Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards Response to Comments at 1216. Available at: <https://www.regulations.gov/document/EPA-HQ-OAR-2019-0055-2993>

<sup>237</sup> Paoletta, D. A., Tessum, C. W., Adams, P. J., Apte, J. S., Chambliss, S., Hill, J., Muller, N. Z., & Marshall, J. D. (2018). Effect of Model Spatial Resolution on Estimates of Fine Particulate Matter Exposure and Exposure Disparities in the United States. *Environmental Science & Technology Letters*, 5(7), 436–441. <https://doi.org/10.1021/acs.estlett.8b00279>.

coarse resolution smooths clusters of minority populations and reduces the number of attributable cases in urban areas.<sup>238</sup>

Various commenters to EPA's March 28, 2022, Proposed Rule pointed out that much more highly resolved data is available for EPA to use, and that this data better captures the spatial variation of air pollutants than the 12km x12km resolution model employed by EPA at the time.<sup>239</sup> EPA responded:

“We agree that the chemical transport model simulations that were conducted at a 12km x 12km grid cell spatial resolution are too coarse to capture neighborhood-scale impacts. **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.**”<sup>240</sup>

In the current Proposed Rule, EPA has not included better estimates of near-roadway air quality impacts by refining its photochemical air quality modeling, rather, EPA has employed a reduced form model with limited quantification of the spatial impacts (i.e., the BPT approach). Use of equity relevant spatial scales is crucial. In our research in both NYC and Atlanta discussed above, EDF observed wide variation in the distribution of air quality benefits from electrification of medium- and heavy-duty across census tracts. By a single BPT approach, EPA does not account for variation in benefits of the Proposed Rule and therefore fails to fully identify the areas and neighborhoods that would most benefit from this rulemaking.

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<sup>238</sup> Korhonen, A., Lehtomäki, H., Rumrich, I., Karvosenoja, N., Paunu, V.-V., Kupiainen, K., et al. (2019). Influence of spatial resolution on population PM2.5 exposure and health impacts. *Air Quality, Atmosphere & Health*, 12(6), 705–718. <https://doi.org/10.1007/s11869-019-00690-z>.

<sup>239</sup> EPA-HQ-OAR-2019-0055-1220. Available at: <https://www.regulations.gov/comment/EPA-HQ-OAR-2019-0055-1220>.

<sup>240</sup> EPA, Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards Response to Comments, Page 1215. Available at: <https://www.regulations.gov/document/EPA-HQ-OAR-2019-0055-2993>

- b) EPA significantly underestimated upstream emissions from the production, transportation and distribution of gasoline and diesel fuel

EPA underestimates upstream emissions from the production, transportation and distribution of gasoline and diesel fuel. Using more reasonable assumptions to characterize these emissions would increase the benefits of EPA's heavy-duty standards. In particular, there are several areas we encourage EPA to more fully consider, to provide a more comprehensive assessment of the final rule's benefits.

1) Production of raw materials used in the production of gasoline and diesel fuel. EPA has not, but should, consider upstream emissions impacts associated with changing crude oil production and in doing so, should consider differences in pollution profiles associated with specific types and source of crude oil no longer being used by U.S. refineries as well as emissions associated with other potential refinery inputs (for instance natural gas or natural gas liquids.) These emissions are included in GREET and we encourage EPA to likewise include them in its analysis.

2) Transportation of gasoline and diesel fuel to the refinery. EPA likewise did not consider emissions associated with transportation of gasoline and diesel fuels to refineries. GREET addresses the emissions from transporting the other raw materials used by refineries, such as natural gas and natural gas liquids and EPA should include their reduction (including both greenhouse gases and other air pollutants) in its benefit analyses of the Final Rule.

3) Refinery Emissions. EPA does consider refinery emissions but consideration appears limited to 2055 and is not reflected in the agency's cost-benefit analysis. We encourage EPA to remedy both of these issues, extending the analysis and ensuring the pollution reduction benefits are part of EPA's cost-benefit analysis. EDF estimated the health benefits of reductions in upstream fossil fuel emissions using EPA's projections of the reduction in gasoline and diesel fuel use for this proposal.<sup>241</sup> We applied the upstream

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<sup>241</sup> Table 6-2 of the Draft RIA

emission factors that EPA used in its recent light-duty GHG rule for MYs 2023-2026 to these emission reductions.<sup>242</sup> EDF then applied the benefit per ton estimates for a 3% discount rate for refinery emissions for the year 2040 to these emission reductions.<sup>243</sup>

This “benefit per ton” analysis was the most recent we could readily find. It only presents a point estimate for each pollutant, while past studies, including EPA’s analysis of emissions from vehicles and electricity generating units in this Proposal typically present a range. We found a net present value in 2027 (discounted at 3% per year) for upstream fossil fuel health benefits of \$29 billion. Comparing these point estimates of the benefits per ton of refinery emissions to those developed by EPA in 2018 implies that they represent a mid-point of the typical range.<sup>244</sup> This \$29 billion estimate of the health benefits of reduced upstream fossil fuel emissions exceeds the mid-point of EPA’s total estimate of health benefits of the proposal of \$15-\$29 billion.<sup>245</sup> Though this estimate is approximate, it underscores the magnitude of these benefits and the importance of EPA considering them in its final rule.

4) Finished fuel distribution and production and transportation of ethanol to retail fuel stations. EPA likewise failed to consider these impacts and doing so is possible using existing tools, including GREET.

5) Emissions from the production and transportation of ethanol used in U.S. gasoline should also be considered. EPA makes no mention of these emissions.

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<sup>242</sup> Row 29 of the UE\_Gasoline and Row 29 of the UE\_Diesel worksheets of the “parameters\_FW-OEMs\_YearShift.xlsx” file used to estimate emission impacts of the final standards. Changes in CNG use (in terms of gasoline equivalent gallons) were added to those of gasoline.

<sup>243</sup> Table 14, Technical Support Document, Estimating the Benefit per Ton of Reducing Directly-Emitted PM2.5, PM2.5 Precursors and Ozone Precursors from 21 Sectors, U.S. Environmental Protection Agency Office of Air and Radiation Office of Air Quality Planning and Standards Research Triangle Park, NC 27711, April 2023

<sup>244</sup> Technical Support Document, Estimating the Benefit per Ton of Reducing PM2.5 Precursors from 17 Sectors U.S. Environmental Protection Agency Office of Air and Radiation, Office of Air Quality Planning and Standards Research Triangle Park, NC 27711, February 2018

<sup>245</sup> Table 7-18 of the Draft RIA.

In each of these areas, EPA has either failed to consider or underestimated emissions associated with production and distribution of gasoline and diesel fuel. A more comprehensive assessment of these impacts would only further strengthen the benefits of final heavy-duty vehicle standards.

### **VIII. EDF supports EPA’s proposal to revise the locomotive preemption regulations**

The Proposal includes a proposed change to EPA’s regulations that interpret the scope of preemption under CAA section 209(e)(1)(B), which precludes state or local “standard[s] or other requirement[s] relating to the control of emissions from ... [n]ew locomotives or new engines used in locomotives.” 42 U.S.C. § 7543(e)(1)(B); *see* 88 Fed. Reg. at 26,092-96. Specifically, EPA proposes to eliminate a longstanding regulation, 40 C.F.R. § 1074.12(b), that specifies a “preemption period” equivalent to 133% of the useful life of a new locomotive and that enumerates examples of preempted requirements. *See id.* As discussed below, we strongly support the proposed change, which would align EPA’s regulations with the text of the Clean Air Act and reflect the proper scope of state and local authority to regulate non-new locomotives. EDF has separately joined comments to this docket from the Moving Forward Network and allied organizations, which likewise support EPA’s proposed change to the preemption regulations.

As EPA has recognized, pollution from locomotives contributes significantly to unhealthy air quality and climate change and interferes with state and local governments’ ability to achieve and maintain compliance with air quality standards.<sup>246</sup> Locomotives directly emit multiple dangerous air pollutants, including particulate matter, nitrogen oxides, volatile organic compounds, sulfur dioxide, carbon monoxide, air toxics, and greenhouse gases, as well as harmful noise.

Locomotive pollution is a substantial and growing problem for many regions; cargo volume and intermodal rail traffic have increased in recent decades and are projected to continue to grow.<sup>247</sup>

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<sup>246</sup> *See, e.g.*, 73 Fed. Reg. 37,095, 37,099-100 (June 30, 2008).

<sup>247</sup> *See, e.g.*, THE Impact Project, *Tracking Harm: Health and Environmental Impacts of Rail Yards* 3 (2012), <https://envhealthcenters.usc.edu/wp-content/uploads/2016/11/Tracking-Harm.pdf>.

Recent data show that the in-service locomotive fleet continues to be dominated by older, dirtier locomotives subject to EPA’s less stringent emissions standards. Less than a quarter of today’s fleet meets Tier 3 or Tier 4 standards (the most protective standards that were adopted in 2008).<sup>248</sup>

Locomotive pollution is also an environmental justice issue. Those living, working, and attending school near railyards, ports, railways, and other major sources of locomotive pollution are disproportionately low-income and people of color.<sup>249</sup> Research shows, for instance, that young children of color and low-income children living near a major freight railyard are more likely to experience asthma-related emergency room visits.<sup>250</sup> Locomotive pollution also adversely affects the health of railroad industry workers.<sup>251</sup>

Although EPA has regulated emissions from new locomotives and engines since 1998, the agency recognizes that “[l]ocomotives remain a significant source of emissions, often disproportionately impacting the health of communities that are located near railyards and ports.”<sup>252</sup> This is due in part to the fact that “the very slow natural fleet turnover of this sector results in older locomotives and locomotive engines remaining in use for decades.”<sup>253</sup> Indeed, “the service life of a locomotive can extend to 40 years and beyond.” 88 Fed. Reg. at 26,093. As such, state and local governments have expressed increasing interest “in addressing emissions from non-new locomotives for areas located along high traffic rail lines and/or in communities with environmental justice concerns.” *Id.* But EPA’s decades-old preemption regulations

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<sup>248</sup> Proposal at 26093.

<sup>249</sup> See, e.g., Andrea Hricko et al., *Global Trade, Local Impacts: Lessons from California on Health Impacts and Environmental Justice Concerns for Residents Living near Freight Rail Yards*, 11 Int’l J. Env’t. Res. Pub. Health 1914 (2014).

<sup>250</sup> R. Spencer-Hwang et al., *Association of major California freight railyards with asthma-related pediatric emergency department hospital visits*, 13 Preventive Med. Rep. 73 (2019).

<sup>251</sup> See, e.g., Eric Garsick et al., *Lung cancer in railroad workers exposed to diesel exhaust*, 112 Env’t. Health Perspectives 1539 (2004).

<sup>252</sup> Press Release, EPA Responds to Petitions to Address Harmful Emissions from Locomotives (Nov. 9, 2022), <https://www.epa.gov/newsreleases/epa-responds-petitions-address-harmful-emissions-locomotives>.

<sup>253</sup> EPA, *Petitions to Address Harmful Emissions from Locomotives* (Jan. 4, 2023), <https://www.epa.gov/regulations-emissions-vehicles-and-engines/petitions-address-harmful-emissions-locomotives>.

remain a barrier to innovative state regulations that could protect public health from dangerous locomotive emissions consistent with the CAA. *Id.* at 26,092.

Specifically, in a 1998 rulemaking, EPA established and defined a “preemption period” equivalent to 133% of the useful life of a new locomotive. 63 Fed. Reg. 18,978 (Apr. 16, 1998); 40 C.F.R. § 1074.12(b). “Useful life” is separately defined as “the period during which the locomotive engine is designed to properly function in terms of reliability and fuel consumption, without being remanufactured, specified as work output or miles”—approximately 10 years, in practice. 40 C.F.R. § 1033.901. EPA’s regulations specify that the preemption period applies to requirements that “include, but are not limited to ... emission standards, mandatory fleet average standards, certification requirements, retrofit and aftermarket equipment requirements, and nonfederal in-use testing requirements.” *Id.* § 1074.12(b). The preemption period is unique to locomotives; “EPA’s regulations do not set an equivalent period of preemption for any other class of nonroad engines.” 88 Fed. Reg. at 26,092, n.1012.

Now, EPA proposes to find that its existing regulations, including the regulatory definition of a preemption period, “extend[] preemption well beyond the CAA language ... to an extended point at which locomotives and engines are no longer new,” and therefore are “impeding states from adopting innovative programs to reduce locomotive emissions that may be permissible under CAA section 209(e)(2).” 88 Fed. Reg. at 26,092. We agree EPA should finalize its proposal to delete 40 C.F.R. § 1074.12(b).

The scope of CAA preemption of locomotive requirements is clear. The text of CAA section 209 plainly preempts only state and local regulation of “new” locomotives and engines, for which EPA sets emission standards, while preserving state and local authority to regulate *non-new* locomotives and engines. *See* 42 U.S.C. § 7543(e); *see also id.* § 7547(a)(5) (EPA “shall promulgate regulations containing standards applicable to emissions from new locomotives and new engines used in locomotives”). Congress’ intent to preserve state and local authority over non-new locomotives and engines is evident from the structure of CAA section 209(e), which requires EPA, under certain criteria, to waive preemption of California emission standards or

requirements for non-new locomotives and authorizes other states to adopt standards identical to California's standards. *Id.* § 7543(e)(2)(A)-(B).

EPA's existing regulations, however, prohibit state and local requirements that do not significantly affect the design or manufacture of new locomotives or locomotive engines. EPA's regulations are misaligned with the CAA in two key ways. First, 40 C.F.R. § 1074.12(b) enumerates examples of state requirements, including "retrofit and aftermarket equipment requirements," that do not necessarily affect the design and manufacture of new locomotives in every case and therefore are not categorically preempted. The overbreadth of EPA's list of enumerated examples has become particularly evident in light of "rapid technological development" since EPA promulgated the regulations in 1998. 88 Fed. Reg. at 26,096.

Second, 40 C.F.R. § 1074.12(b) defines a preemption period equivalent to 133% of the useful life of a new locomotive—which, by its very terms, exceeds the point at which a locomotive is "new" and inappropriately intrudes on state and local authority over non-new locomotives.<sup>254</sup> It would be unreasonable for EPA to retain a preemption period that impedes beneficial state regulation Congress authorized, and that is disconnected from EPA's authority over new locomotives.

Second, 40 C.F.R. § 1074.12(b) defines a preemption period equivalent to 133% of the useful life of a new locomotive—which, by its very terms, exceeds the point at which a locomotive is "new" and inappropriately intrudes on state and local authority over non-new locomotives.<sup>255</sup> It would be unreasonable for EPA to retain a preemption period that impedes beneficial state regulation Congress authorized, and that is disconnected from EPA's authority over new locomotives.

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<sup>254</sup> See EPA, Summary and Analysis of Comments on the Notice of Proposed Rulemaking for Emission Standards for Locomotives and Locomotive Engines, EPA-420-R-97-101, at 19 & app. C (Dec. 1997).

<sup>255</sup> See EPA, Summary and Analysis of Comments on the Notice of Proposed Rulemaking for Emission Standards for Locomotives and Locomotive Engines, EPA-420-R-97-101, at 19 & app. C (Dec. 1997).



For all of the above reasons, we welcome and support EPA's proposed change, and we urge the agency to finalize deletion of 40 C.F.R. § 1074.12(b).

## **IX. Conclusions**

Thank you for your consideration of these comments.

Respectfully submitted,

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## List of Attachments

Attachment A: EDF’s comments on the Proposed Rule, *Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards*, 87 Fed. Reg. 17414 (Mar. 28, 2022) dated May 16, 2022. Accessible at <https://www.regulations.gov/comment/EPA-HQ-OAR-2019-0055-2855>.

Attachment B: Aileen Nowlan, *Making the Invisible Visible*, EDF, April 2023.

<https://globalcleanair.org/files/2023/04/EDF-Proximity-Mapping-2023.pdf>

Attachment C: Presentation by Jonathan Buonocore, Chet France, Rick Rykowski, Brian Naess, Komal Shukla, Catherine Seppanen, Dylan Morgan, Frederica Perera, Katie Coomes, Ananya Roy, Sarav Arunachalam. 2022. “Distribution of Air Quality Health Benefits of MHEV policies: New York and Atlanta,” University of North Carolina, Harvard Chan School of Public Health, Columbia University Mailman School of Public Health and Environmental Defense Fund.

Attachment D: Brief of Amici Curiae Margo Oge and John Hannon in Support of Respondents, *Texas v. EPA*, No. 22-1031, 24-31 (D.C. Cir, Mar. 2, 2023), *Texas v. EPA*, No. 22-1031, 33 (D.C. Cir, Mar. 2, 2023).

Attachment E: EPA’s Answering Brief, *Texas v. EPA*, No. 22-1031, 15-16 (D.C. Cir, Apr. 27, 2023), <https://www.edf.org/sites/default/files/2023-05/Texas%20-%20EPA%20Final%20Brief.pdf>.

Attachment F: Brief of Senator Thomas R. Carper and Representative Frank Pallone, Jr. as Amici Curiae in Support of Respondents, *Texas v. EPA*, No. 22-1031, 32 (D.C. Cir, Mar. 2, 2023).

Attachment G: Greg Dotson and Dustin J. Maghamfar, The Clean Air Act Amendments of 2022: Clean Air, Climate Change, and the Inflation Reduction Act, 53 ENV'T L. REP. 10017, 10030 (2023).

Attachment H: Vishnu Nair, Sawyer Stone, Gary Rogers, Sajit Pillai. 2022. *Medium and Heavy-Duty Electrification Costs for MY 2027- 2030*, Roush Industries for Environmental Defense Fund. See [http://blogs.edf.org/climate411/files/2022/02/EDF-MDHD-Electrification-v1.6\\_20220209.pdf](http://blogs.edf.org/climate411/files/2022/02/EDF-MDHD-Electrification-v1.6_20220209.pdf)

Attachment I: Muratori, Matteo et al. “Decarbonizing Medium- and Heavy-Duty On-Road Vehicles: Zero-Emission Vehicles Cost Analysis.” NREL Transforming Energy. March 2022. <https://www.nrel.gov/docs/fy22osti/82081.pdf>.

Attachment J: Burnham et al. 2021. Comprehensive Total Cost of Ownership Quantification for Vehicles with Different Size Classed Powertrains, Argonne National Laboratory, Energy Systems Division, ANL/ESD-21/4.

Attachment K: Dana Lowell and Jane Culkin, “Medium- and Heavy-duty Vehicles: Market Structure, Environmental Impact, and EV Readiness,” (July 2021) MJ Bradley & Assoc. for EDF. <http://blogs.edf.org/climate411/files/2021/08/EDFMHDVEVFeasibilityReport22jul21.pdf>

Attachment L: ERM: Inflation Reduction Act Supplemental Assessment: Analysis of Alternative Medium- and Heavy-Duty Zero-Emission Vehicle Business-As-Usual Scenarios (August 2022), <https://www.erm.com/contentassets/154d08e0d0674752925cd82c66b3e2b1/edf-zev-baseline-technical-memo-addendum.pdf>.

Attachment M: Roush, H. Saxena, S. Pillai, Impact of the Inflation Reduction Act of 2022 on Medium and Heavy-Duty Electrification on MYs 2024 and 2027 (2023),

[https://www.edf.org/sites/default/files/2023-05/Impact\\_of\\_IRA\\_MHD\\_Electrification\\_Costs\\_MYs\\_2024\\_and\\_2027\\_Roush.pdf](https://www.edf.org/sites/default/files/2023-05/Impact_of_IRA_MHD_Electrification_Costs_MYs_2024_and_2027_Roush.pdf).

Attachment N: ERM, Rachel MacIntosh, Harrison Branner, Kayla Escobar, and Sophie Tolomiczenko,. Electric Vehicle Market Update: Manufacturer & Commercial Fleet Electrification Commitments Supporting Electric Mobility in the United States, Appendix C (April 2023).

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Attachement Q : Vishnu Nair, Himanshu Saxena, Sajit Pillai. 2023. *Class 7 and Class 8 Tractor–Trailer Electrification for MYs 2030 and 2032*, Roush for Environmental Defense Fund,

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Attachment R: Chad Hunter, Michael Penev, Evan Reznicek, Jason Lustbader, Alicia Birky, and Chen Zhang. 2021. Spatial and Temporal Analysis of the Total Cost of Ownership for Class 8 Tractors and Class 4 Parcel Delivery Trucks, Nation Renewable Energy Lab, Technical Report.

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Attachment T: Lydia Freehafer and Leah Lazer. The State of Electric School Bus Adoption in the US, World Resources Institute, (April 26, 2023). <https://www.wri.org/insights/where-electric-school-buses-us>.

Attachment U: EDF, Emissions From School Buses Increase Pollution Levels Inside the Bus, [https://www.edf.org/sites/default/files/5342\\_School\\_bus\\_pollution\\_studies.pdf](https://www.edf.org/sites/default/files/5342_School_bus_pollution_studies.pdf)

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Attachment W: Analysis Group, Heavy Duty Electrification: Planning for and Development of Needed Power System Infrastructure (June 2023), <https://blogs.edf.org/climate411/wp-content/blogs.dir/7/files/Analysis-Group-HDV-Charging-Impacts-Report.pdf>

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Attachment Y: Gladstein, Neandross & Associates, California Heavy-Duty Fleet Electrification Summary Report, March 2021, <http://blogs.edf.org/energyexchange/files/2021/03/EDF-GNA-Final-March-2021.pdf>

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Attachment CC: Ocko, Ilissa and Hamburg, Steve (2022). “Climate consequences of hydrogen leakage.” *Atmospheric Chemistry and Physics*. Vol. 22, Issue 14.

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Attachment DD: Warwick et al., (2022). “Atmospheric Implications of Increased Hydrogen Use”. Department for Business, Energy & Industrial Strategy.

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Attachment EE: Environmental Defense Fund, *The Opportunity for Near-Term Electrification of Medium- and Heavy-Duty Vehicles* (May 2022), <https://blogs.edf.org/climate411/wp-content/blogs.dir/7/files/2022/05/FINAL-EDF-HD-ZEV-report-5.17.22.pdf>.

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Attachment GG: Eriko Shrestha and Tianyi Sun. Rule #1 of deploying hydrogen: Electrify first. 2023. EDF Blog Energy Exchange, <https://blogs.edf.org/energyexchange/2023/01/30/rule-1-of-deploying-hydrogen-electrify-first/>

Attachment HH: EDF, Domestic Critical Minerals Projects. 2023. Attached as excel.

Attachment II: Ellen Robo and Dave Seamonds, “Analysis of Alternative Medium- and Heavy duty Zero-Emission Vehicle Baseline Scenarios,” Technical memo by ERM for EDF (May 12, 2022), <https://www.erm.com/contentassets/154d08e0d0674752925cd82c66b3e2b1/edf-zev-baseline-technical-memo-16may2022.pdf>.

**Appendix A: EDF Authored or Commissioned Reports and Analytics on Medium- and Heavy-duty ZEVs (as of June 2023)**

<b>Author</b>	<b>Title and Link</b>	<b>Description</b>	<b>Release Date</b>
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EDF	Domestic Critical Minerals Projects and Partnerships	EDF spreadsheet that summarizes investments in the critical minerals supply chain, including new investments and expansion of existing capacities in raw minerals extraction (mining), materials separation and processing, and recycling efforts in the U.S. The review identified 74 domestic mining, processing, and recycling projects and announced investments totaling over \$25 billion, including \$1 billion funded under the BIL, and \$700 million in OEM investments.	June 2023
Analysis Group	<a href="#">Heavy Duty Electrification: Planning for and Development of Needed Power System Infrastructure</a>	Analysis Group looked at how heavy-duty ZEV charging will impact the grid and what processes are in place or needed to enable the grid to meet the increased demand. The report found the overall magnitude of growth in demand that would result from EPA's proposed rule is very small relative to historic periods of growth in the electric industry and should not pose a challenge from the perspectives of power system generation or transmission infrastructure needs.	June 2023
Roush	<a href="#">Class 7 and Class 8 Tractor-Trailer Electrification for MYs 2030 and 2032</a>	Roush report evaluates the upfront and ongoing costs of electrifying a range of Class 7-8 tractors. The report finds powertrain costs of most battery-electric vehicles (BEVs) are the same or less than diesel vehicles in 2030-32 timeframe and TCO of BEVs is significantly lower than diesels across all segments in 2030-32.	June 2023
Roush	<a href="#">Impact of the Inflation Reduction Act of 2022 on Medium- and Heavy-Duty Electrification Costs for MYs 2024 and 2027</a>	Roush report that assesses and quantifies the key impacts of the 2022 Inflation Reduction Act on the cost of electrifying medium and heavy-duty vehicles. The analysis found that IRA credits help absorb the near-term higher upfront cost of BEVs and will accelerate the purchase parity so that all segments analyzed will now meet parity with their diesel counterparts if purchased as early as MY 2024, assuming reasonable economies of scale for BEV production. The new IRA credits for BEVs and chargers will also reduce the amount of time needed for BEVs to achieve TCO parity with diesels by an additional 1-2 years so that many segments analyzed will see TCO parity at the time of purchase as early as 2024.	May 2023
ERM	<a href="#">Electric Vehicle Market Update</a>	ERM update on the status of manufacturer and commercial fleet electrification commitments, updating prior work.	April 2023



Synapse	<a href="#">Distribution System Investments to Enable Medium- and Heavy-Duty Vehicle Electrification: A Case Study of New York</a>	Synapse analysis prepared for EDF finds widespread benefits when utilities cover the initial cost of grid upgrades for medium- and heavy-duty vehicle charging – utilities will see increased revenue without raising consumers’ electricity rates.	April 2023
WSP	<a href="#">U.S. Electric Vehicle Manufacturing Investments and Jobs: Characterizing the Impacts of the Inflation Reduction Act After 6 Months.</a>	WSP characterization of the impacts of the IRA after 6 months on investments and jobs. Finding \$120 billion in investment; 143,000 new jobs and extensive new EV manufacturing capacity.	March 2023
ERM	<a href="#">Inflation Reduction Act Supplemental Assessment: Analysis of Alternative Medium- and Heavy-Duty Zero-Emission Vehicle Business-As-Usual Scenarios</a>	ERM update to previous assessment of projected business-as-usual MHD ZEV sales in the U.S. incorporating the impacts of the IRA. Finds that the IRA will boost supply and demand of MHD ZEVs and averaging across its five scenarios, ZEVs could constitute 29% of total MHD sales in 2029.	August 2022
ERM	<a href="#">Analysis of Alternative Medium- and Heavy-Duty Zero-Emission Vehicle Business-As-Usual Scenarios</a>	ERM analysis that projects a range of possible M/HD ZEV baseline adoption scenarios, incorporating state policies, funding from the Infrastructure Investment and Jobs Act (IIJA), and market growth.	May 2022
EDF	<a href="#">The Opportunity for Electrification of Medium- and Heavy-Duty Vehicles</a>	EDF completed a white paper documenting the reasonableness and feasibility of performance-based standards that ensure 40 percent of new class 4-7 and class 8 short haul tractors and 80 percent of school and transit buses are ZEVs by 2029.	May 2022
Roush	<a href="#">Technical Review of: Medium and Heavy-Duty Electrification Costs for MY 2027- 2030</a>	Analysis by Roush Industries for EDF evaluating the cost of electrifying several medium- and heavy-duty market segments. Roush found when considering up front purchase price alone, by 2027 electric freight trucks and buses will be less expensive than their combustion engine counterparts in nearly all categories. All of these electric vehicle categories will also be less expensive on a total cost of ownership basis producing substantial savings in the same timeframe.	February 2022
EDF	<a href="#">Clean Trucks, Clean Air, American Jobs</a>	EDF fact sheet with summary of health burden of dirty trucks, the health and economic benefits of transition to ZEV trucks, fleet and manufacturer commitments to ZEVs, current deployments, and states taking the lead.	February 2022

EDF	<a href="#">Medium- and Heavy-duty Vehicles: Market Structure, Environmental Impact, and EV Readiness</a>	MJ Bradley analysis conducted for EDF that assesses readiness for greater adoption of ZEV technology over the next decade.	August 2021
EDF	<a href="#">Electric Fleet Deployment and Commitment List</a>	EDF generated Google sheet updated periodically to reflect the latest medium- and heavy-duty fleet deployment and commitment numbers.	July 2021
MJ Bradley & Assoc.	<a href="#">Medium- &amp; Heavy-Duty Vehicles: Market structure, Environmental Impact, and EV Readiness</a>	Evaluates the environmental impacts of the current fleet of freight trucks and buses and the near-term opportunities to deploy zero-emitting vehicles in the medium and heavy-duty fleet.	July 2021
EDF	<a href="#">Medium and Heavy Duty Zero Emissions Vehicle Supply Chain Analysis</a>	EDF report that assesses the current supply chain for medium- and heavy-duty ZEVs.	June 2021
EDF, ICCT, and Propulsion Québec	<a href="#">Zero-Emission Bus and Truck Market in the United States and Canada: A 2020 Update</a>	A follow-up to “Race to Zero,” updated analysis by EDF in collaboration with the International Council on Clean Transportation and Propulsion Québec.	May 2021
EDF	<a href="#">Clean Trucks, Clean Air, American Jobs: Eliminating pollution from all new truck and buses by 2040 — and urban and community applications by 2035 — will save thousands of lives, cut climate pollution, and result in shared economic benefits</a>	EDF analysis that estimates the economic savings and reductions in climate and criteria emissions as a result of all new medium and heavy-duty vehicle sales being 100% ZEV by 2040.	March 2021
EDF, ICCT, and Propulsion Québec	<a href="#">Race to Zero: How manufacturers are positioned for zero emission commercial trucks and buses in North America</a>	Joint analysis by EDF, the International Council on Clean Transportation, and Propulsion Québec that looks at the cost and market feasibility of medium- and heavy-duty ZEVs.	October 2020

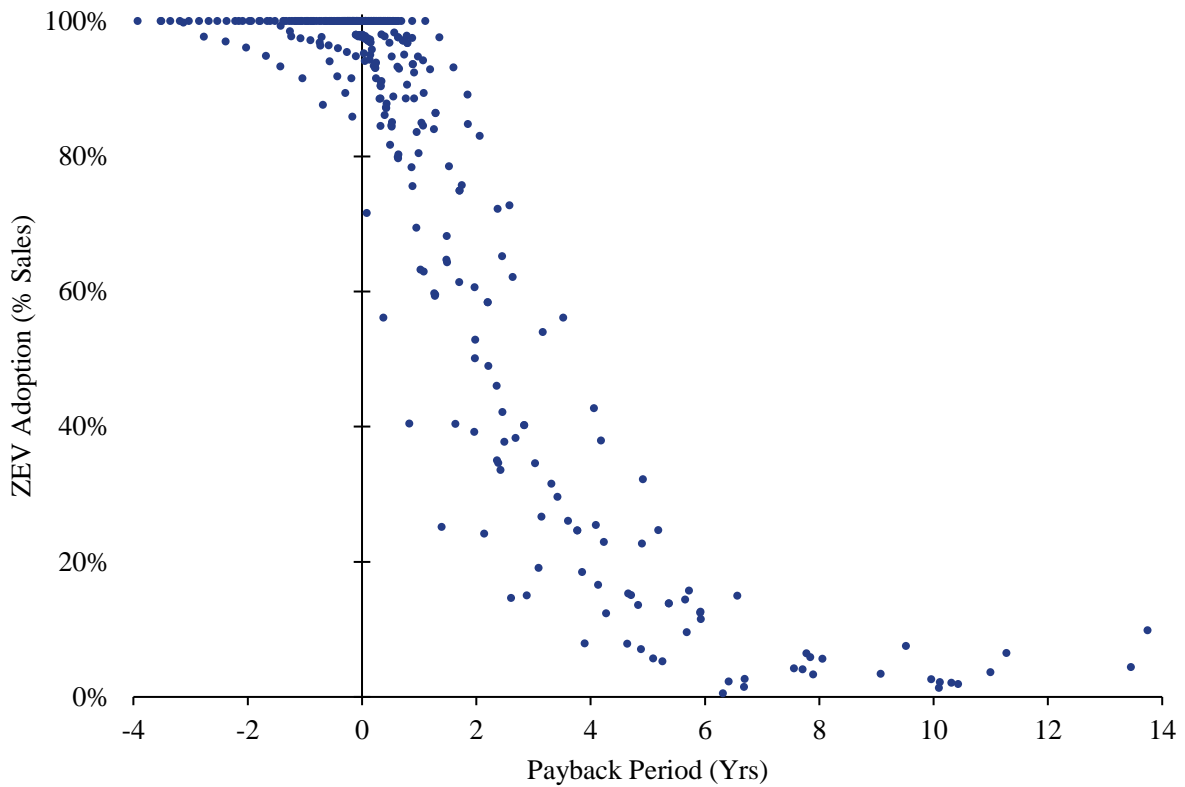
## Appendix B: Methodology to Establish Payback Period to ZEV Adoption Relationship From TEMPO Model Data Outputs

NREL provided EDF with the inputs, outputs, and assumptions from their analysis on HD ZEV adoption using their TEMPO model published March 2022. These included vehicle sales, vehicle prices, fuel prices, maintenance costs, fuel efficiency, charging time costs, and annual mileage for each powertrain (ICE, HEV, BEV-150, BEV-300, BEV-500, FCEV) in each vehicle

subcategory (year, Class, market segment). From this data EDF calculated the annual costs for each vehicle, the incremental upfront cost for each ZEV (ICE vehicle cost – ZEV cost), the incremental annual ZEV savings (annual ZEV costs – annual ICE vehicle costs), and the percent sales of the powertrain within the vehicle subcategory. The payback period for the ZEV was then calculated by dividing the incremental upfront cost by the annual savings using the same methodology EPA employs in the HD TRUCS model.

To accurately encapsulate the trade off between conventional vehicles and ZEVs, the ZEV categories needed to be combined. To do so, the percent sales for each of the ZEV powertrains (BEV-150, BEV-300, BEV-500, and FCEV) were summed and a sales weighted payback period was calculated. For instance, if a vehicle subcategory had 20% BEV-150 sales with a payback period of 2 years, 30% BEV-300 sales with a payback of 1 year, and the remaining sales were ICE vehicles, this would equal 50% ZEV sales with a weighted payback period of 1.4 years.

These values were then plotted (Figure 1) which shows a clear relationship between ZEV adoption and payback period with adoption levels very high when the payback period is less than 0 years, adoption remaining high through the two years of payback and then gradually falls.



To establish a representative curve for this data set, each of the data points within a 0.5 year period was bucketed and averaged to calculate the ZEV adoption for that payback period. Additionally, each data point within a 5% adoption segment was bucketed and averaged to calculate the average payback period for that level of ZEV adoption. Both of these curves are plotted in Figure 2 below. They generally fall on the same line but the bucketing and averaging of the payback period results in a smoother curve and allows for the tails to be plotted so that is the one that was selected.

