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WHITE PAPER

Medium- and Heavy-Duty Electrification: Weighing the Opportunities and Barriers to Zero-Emission Fleets

Zero Emission Transportation Association

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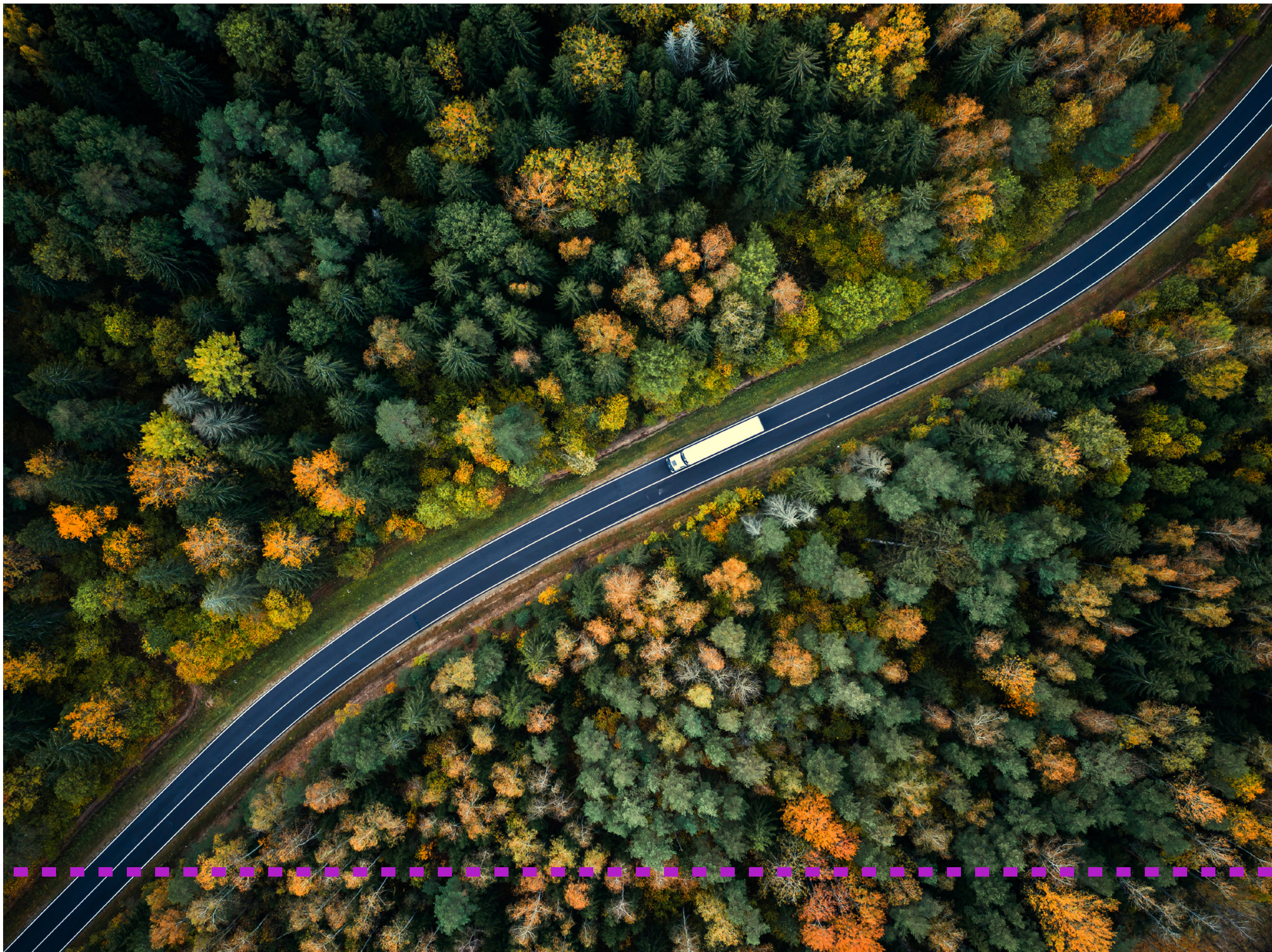
Executive Summary

Securing public and political interest for electrifying medium- and heavy-duty vehicles (MHDVs) is a prerequisite for meeting essential public health, climate, and national security needs of the United States. MHDVs transport people and goods billions of miles across the country each year. Primarily diesel-fueled, these internal combustion engine vehicles (ICEVs) are disproportionately responsible for the country's toxic nitrous oxide (NO_x), particulate matter ($PM_{2.5}$), and carbon dioxide (CO_2) emissions. As these vehicles travel throughout the country, individuals living near roadways, railyards, and ports—often predominantly low-income and/or people of color—experience the worst health and environmental impacts. Though light-duty vehicle electrification is achieving increasingly widespread acceptance, those considering MHDV electrification often cite concerns around high purchase costs and insufficient infrastructure. This white paper addresses these barriers, which have prevented significant electric vehicle (EV) penetration in the MHDV segment, and articulates how they can be overcome to achieve cost savings, sustainability goals, health benefits, and emission reductions. This paper also presents opportunities for successful transitions to electric federal and commercial MHDVs.



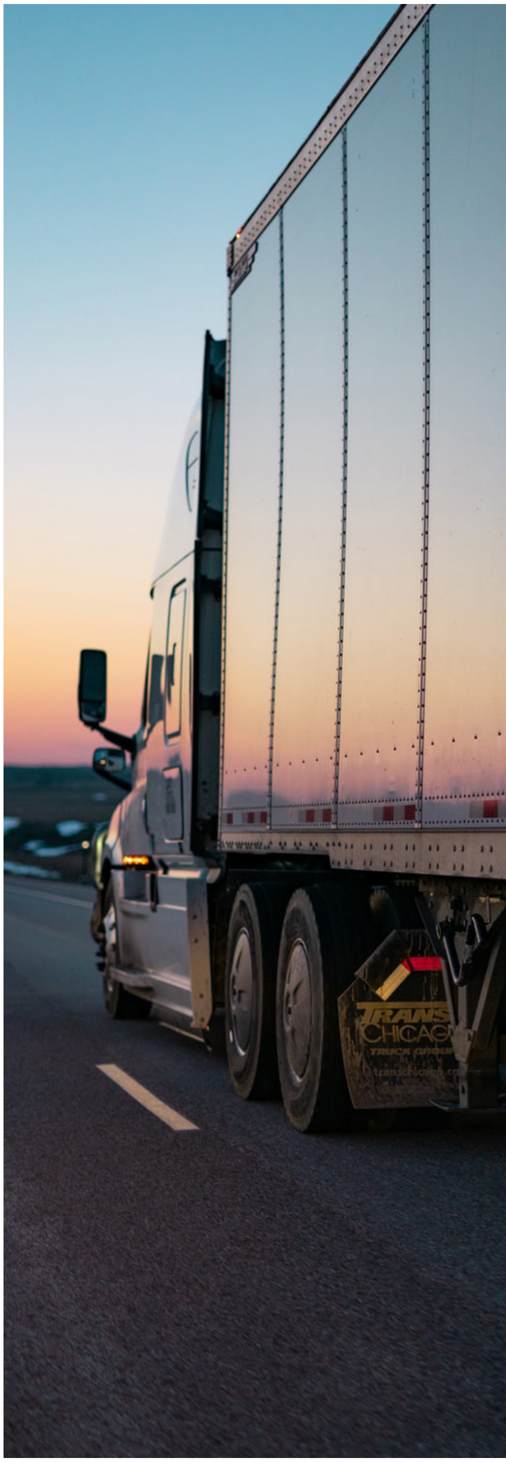
Potential Benefits of Medium- and Heavy-Duty Electrification

- Provide fuel and maintenance cost savings for fleet operators
- Reduce CO_2, NO_x, and $PM_{2.5}$ emissions to improve public health
- Increase domestic energy production and ensure energy security
- Create economies of scale to further drive down unit costs
- Generate new jobs in the vehicle manufacturing, charging installation, and trucking industries
- Enhance equity for frontline communities

Potential Barriers to Medium- and Heavy-Duty Electrification

- Demand for upfront capital to purchase medium- and heavy-duty EVs (MHDEVs)
- Cost of charging infrastructure and installation
- Current lack of electric MHDVs, in comparison to gas-powered vehicle options
- Reduction in payload capacity of commercial vehicles due to battery weight
- Need for a modernized electrical grid

Despite these barriers, fleet managers have the opportunity to transition to MHDEVs *now* to mitigate further negative environmental and health outcomes while also yielding substantial total-cost-of-ownership (TCO) savings. However, this transition will require extensive collaboration between fleets, utility companies, manufacturers, and the government. In addition, it must include a focus on long-term planning and investments, rather than on short-term costs.



Key Takeaways

- Medium-and heavy- duty vehicles account for 24% of all transportation greenhouse gas (GHG) emissions despite comprising merely 4% of vehicles on the road.[1]
- Electrifying school and transit buses, as well as other MHDVs, will not only improve air quality in underserved areas, but will also improve connectivity in rural, urban, and suburban areas.
- Adopting the policies that are necessary to accelerate MHDV electrification—such as creating a federal commercial vehicle tax credit—could create more than 154,000 jobs in the U.S.[2]
- Electrifying federal and commercial MHDV fleets will result in significant TCO reductions in terms of maintenance and fuel costs.
- Preparing the electrical grid includes the use of energy management techniques like vehicle-to-grid integration, time-of-use charging rates coupled with charging management systems to promote consumption during off-peak hours, replacement of older infrastructure, targeted investments in transmission and distribution, and automated smart-charging software.
- Amending the U.S. tax code so that businesses can receive tax credits for commercial EVs equal to 30% of the cost of the vehicle will expand opportunities for private businesses to invest in fleet electrification.
- Federal policymakers should consider legislation that would incentivize the installation of EV charging infrastructure for MHDEVs. In addition to addressing a direct charging shortage, this legislative action would create 12 jobs per million dollars of investment.[3]

Glossary

AC	alternating current
ACF	Advanced Clean Fleets
ACT	Advanced Clean Trucks regulation
BEV	battery electric vehicle
CFS	clean fuel standards
CNG	compressed natural gas
CO	carbon monoxide
DC	direct current
DER	distributed energy resource
DOD	Department of Defense
EPA	Environmental Protection Agency
EV	electric vehicle
EVSE	electric vehicle supply equipment
FERC	Federal Energy Regulatory Commission
GHG	greenhouse gas
GSA	General Services Administration
GVWR	gross vehicle weight rating
ICEV	internal combustion engine vehicle
MHD	medium- and heavy-duty
MHDV	medium- and heavy-duty vehicles
MHDEV	medium- and heavy-duty electric vehicle
MPGe	miles-per-gallon equivalent
NREL	National Renewable Energy Laboratory
TCO	total cost of ownership (in the context of financial analysis)
TOU	time-of-use (in the context of electrical use-rate calculation)
V2G	vehicle-to-grid integration
VMT	vehicle miles traveled
VOC	volatile organic compounds

1. Introduction

Across the United States, more than 12.2 million MHDVs travel 297 billion miles and consume 46 billion gallons of gasoline and diesel fuel every year.[4] Trucks are divided among eight classes based on their gross vehicle weight, which combines the vehicle's weight and payload. This paper will examine the electrification potential for Class 2B through Class 8 vehicles (as classified by the EPA), which include medium- and heavy-duty, commercial, and fleet vehicles, as shown in Figure 1. Classes 1 and 2A are excluded from this report because these categories apply primarily to lighter-duty minivans, pickup trucks, and SUVs, which are not considered medium- or heavy-duty.

Classes of trucks based on their gross vehicle weight rating

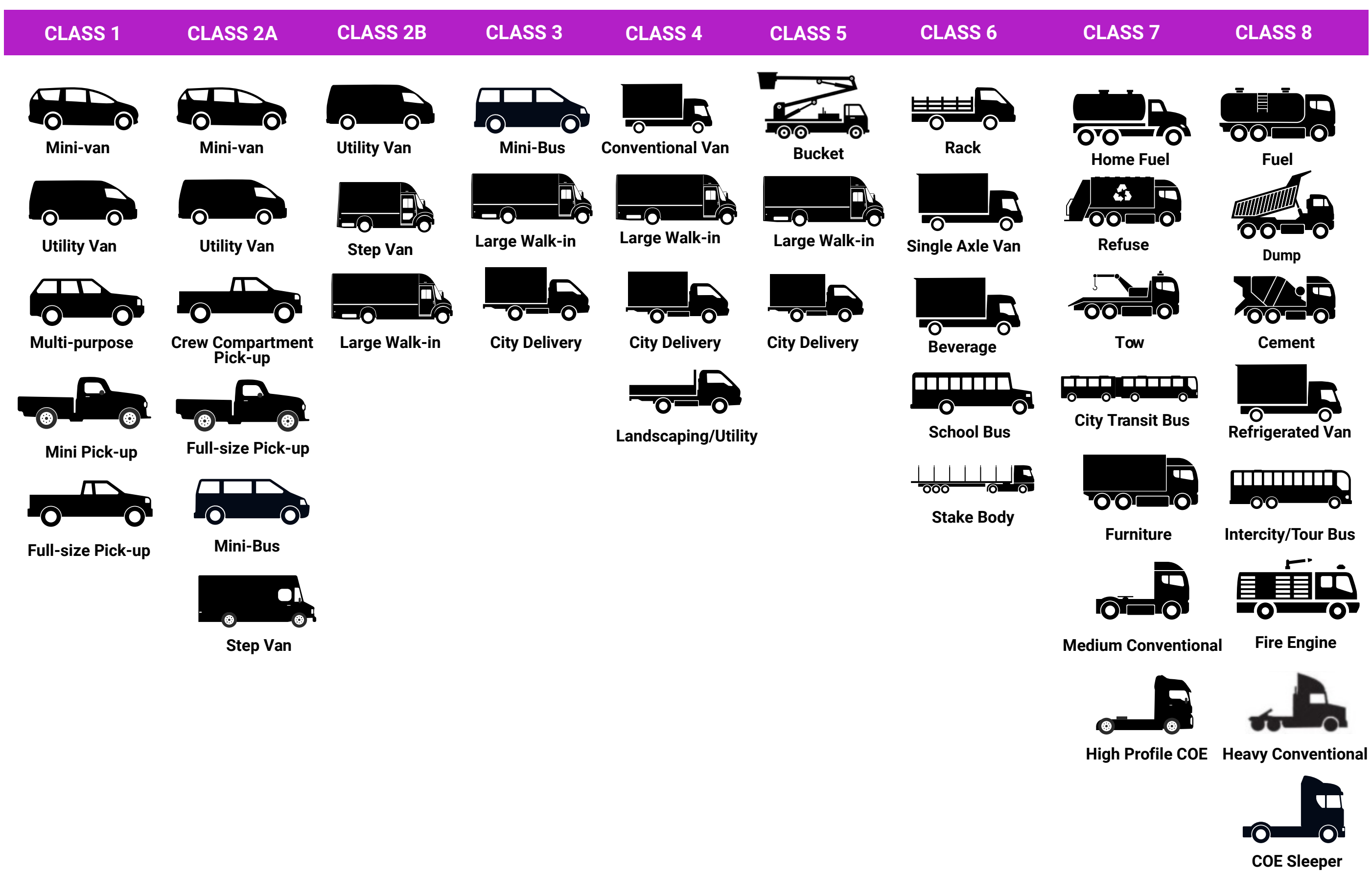


Figure 1: Classes of trucks based on their gross vehicle weight rating (GVWR).

1.1 Diesel Emissions and Their Impacts on Human Health

Commercial MHDVs comprise a mere 4% of vehicles on the road. Yet, they disproportionately contribute to U.S. fuel consumption and resulting air pollution and climate repercussions. Buses and freight trucks alone represent 10% of all vehicle miles traveled (VMT), but they are responsible for 22% of all fuel used.[5] Electrifying this vehicle segment represents a prime opportunity to improve public health, minimize greenhouse gas (GHG) emissions, and reduce the country's fossil fuel reliance and net energy consumption.

MHDVs produce 24.4% of all emissions across the transportation sector, making them the single largest contributors to U.S. GHG emissions. These emissions include $PM_{2.5}$, NO_X, and CO_2, pollutants which are linked to long-term respiratory, cognitive, and autoimmune impairment. Even though transportation already produces a high degree of air pollution, this trend continues to increase: between 1990 and 2019, GHG emissions from MHD trucks and buses grew by 93% and 162%, respectively.[6] Figure 2 shows that MHDVs remain the fastest-growing source of surface level transportation emissions, though this figure does not include COVID-related spikes in e-commerce.[7]

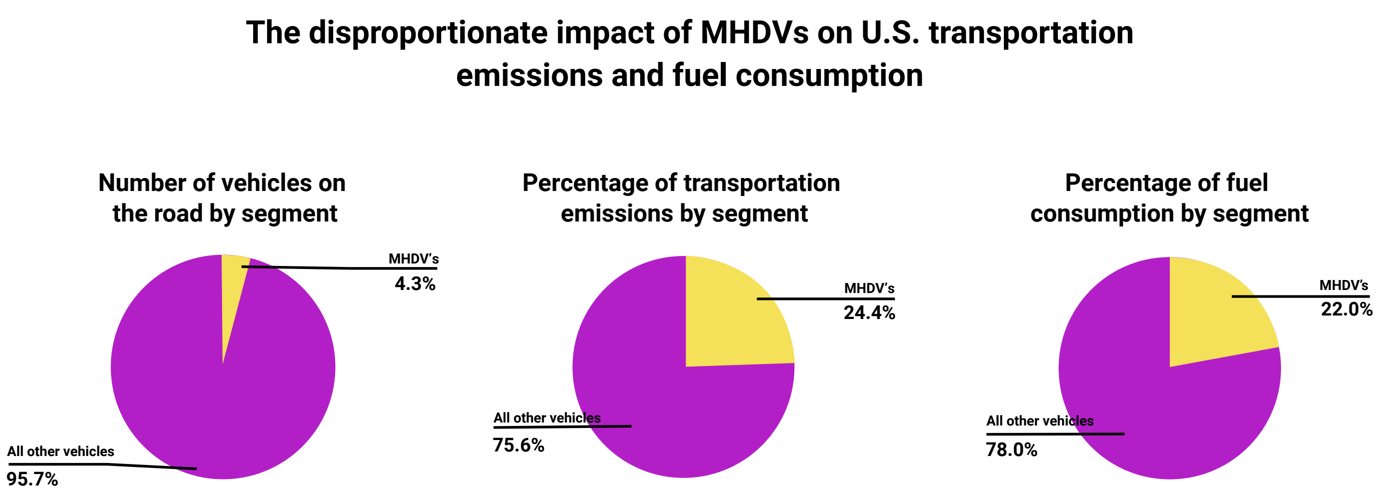


Figure 2: The disproportionate impact of medium- and heavy-duty vehicles on transportation emissions and fuel consumption of the U.S.

Diesel fumes, in particular, pose a substantial risk to human health—and a majority of MHDVs run on diesel. **On-road diesel emissions are responsible for poor air quality, impaired respiratory systems, and cardiovascular issues. Exposure to these toxins has both cancerous and noncancerous health risks, including potential neurological, cardiovascular, respiratory, reproductive, and immune system damage.[8]**

A large degree of the U.S. population remains vulnerable to these dangers. According to the EPA, 45 million people in the United States live within 300 feet of a major traffic facility or corridor.[9]

Proximity to these roadways exposes residents to needless health risks, and replacing older truck and bus fleets with electrified alternatives has the potential to yield robust public health benefits. **According to the American Lung Association, a widespread transition to zero-emission transportation by 2050 can annually produce up to $72 billion in avoided health costs, save approximately 6,300 lives, and prevent more than 93,000 asthma attacks and 416,000 lost workdays.[10]**

Among the vehicles on the road, MHDVs bear a disproportionate degree of responsibility for releasing these pollutants into the air. **Despite comprising only 4% of vehicles on the road, medium- and heavy-duty trucks contribute 57% of deadly particulate matter emissions, and commercial vehicles alone produce more than 60% of on-road NOx emissions.** In addition to emitting higher degrees of pollutants compared to other vehicles, commercial MHDVs also spend more time on roads.[11] The average Class 8 semi truck travels 63,000 miles every year—more than four times the VMT of a single passenger vehicle.[12]

1.2 Opportunities

MHDV electrification would bring a range of public health, environmental, and economic benefits. Clean mobility options often lead to improved property value and investment in communities.[13] Quieter, zero-tailpipe-emission buses used for school and public transit can improve equity in high-traffic corridors. Fleet operators will realize significant savings, and growth in the MHDV industry will create additional jobs in the manufacturing and trucking sector.

1.2.1 Total-Cost-of-Ownership Savings

In addition to the environmental and public health benefits to communities, MHDEVs would bring substantial economic advantages to fleet operators through TCO savings. Fuel and maintenance costs, in particular, are areas with substantial cost reduction potential.

In a survey of fleet managers, the most commonly cited motivation for electrifying their fleets was to meet sustainability goals (83%); lower TCO was the second-most common reason (64%).[14] Already, researchers at researchers from the University of California Berkeley found that existing Class 8 long-haul electric trucks have a 13%

of approximately $525,000 per vehicle from transit bus electrification. These savings are expected to grow in the coming years. By 2030, a fully-electric Class 5 van will have a 22% lower TCO than a diesel van, equating to savings of $47,000 per vehicle. Likewise, by the next decade, an electric day cab is expected to lower the TCO by more than 31% for savings of $239,000.[16]

Fleets that experience the highest fuel and maintenance costs from their diesel trucks would see the greatest cost reductions from an EV transition. Because the upfront cost is paid back via savings on operations mile-by-mile, fleets with higher VMT would see the greatest reductions. A Class 8 electric truck costs 4.7 cents less per mile traveled to maintain in comparison to its diesel counterpart. See Figure 4 for a breakdown of the average yearly VMT by different vehicle segments. These maintenance savings alone can equate to thousands of dollars over the vehicle's lifetime.[17]

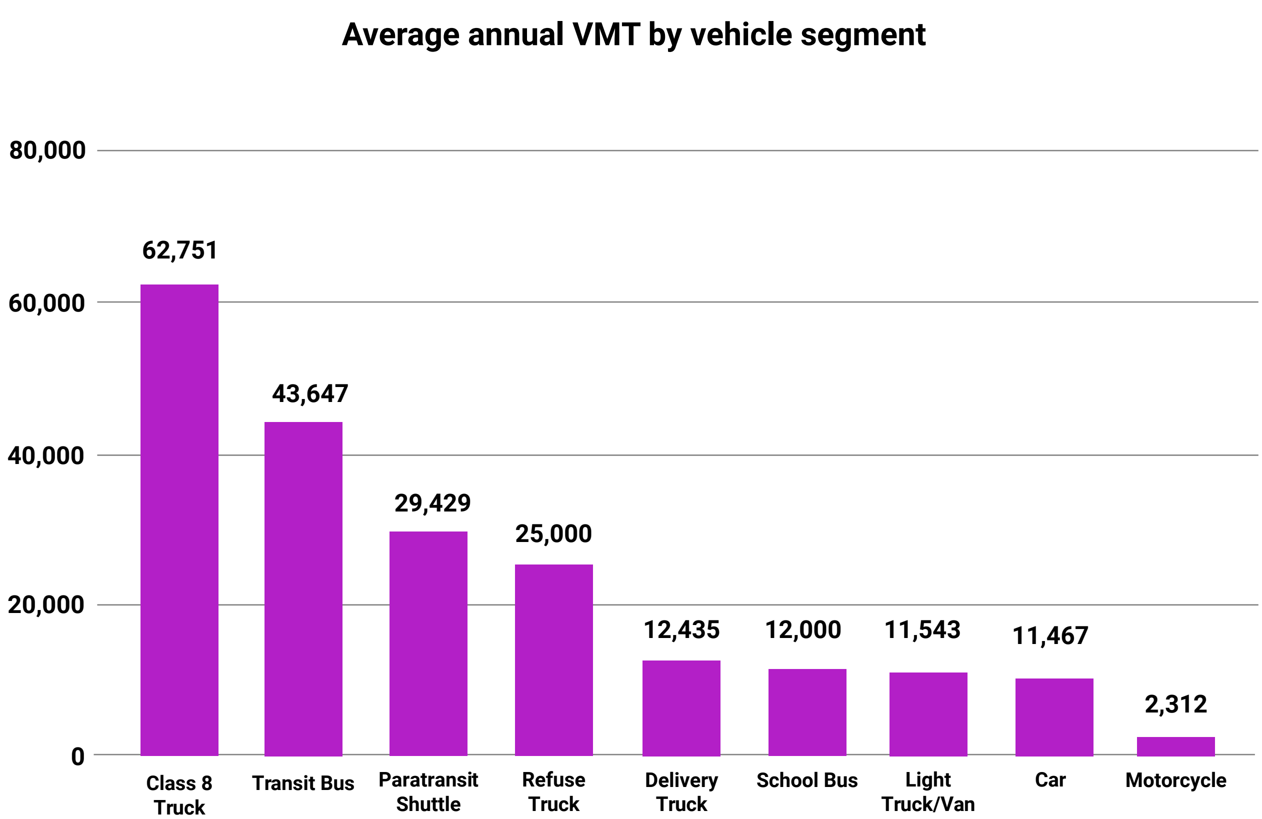


Figure 3: MHDVs have the highest annual VMT throughout all segments, leading to massive amounts of fuel consumption. EVs would improve fuel efficiency and save fleet operators in fuel costs.[18]

1.2.2. Increased Health Impacts for Frontline Communities

Despite state and national efforts to decarbonize the transportation section, progress varies widely throughout the country—and too often, communities that would benefit most from an EV transition, so-called "frontline communities," are the last to experience positive change.

A key benefit of MHDV fleet electrification is the role that this transition can play in creating more equitable health outcomes. A frontline community can be defined as one that is closest to environmental and health threats, like power plants and chemical facilities, or is impacted first and worst by climate impacts such as rising sea levels and extreme weather.[19] Too often, transportation poses an additional major threat to frontline communities' environmental and public health: this sector has historic ties to systemic inequality, and the residents of these frontline communities tend to be lower-income, people of color, or sometimes both.

The federal government maintains more than a million miles of interstate highways, many of which have been designed to run through lower-income neighborhoods and neighborhoods of color.[20] Proximity to commercial traffic correlates directly with poor air quality, and this higher exposure burdens residents with negative health outcomes and higher healthcare costs.

The intersections of these negative health outcomes, their link to transportation-related pollution, and the ties to race are well-documented. In 2019, a national study found that in 2010, people of color experienced 37% more NO_2 exposure than white populations and had 2.7 times higher concentrations of NO_2 within their communities. Furthermore, had these communities of color been exposed to the same level of NO_2 as white populations, 5,000 deaths from heart disease could have been prevented.[21] Likewise, as shown in Figure 3, the American Lung Association

The disproportionate impact of particulate matter emissions on people of color

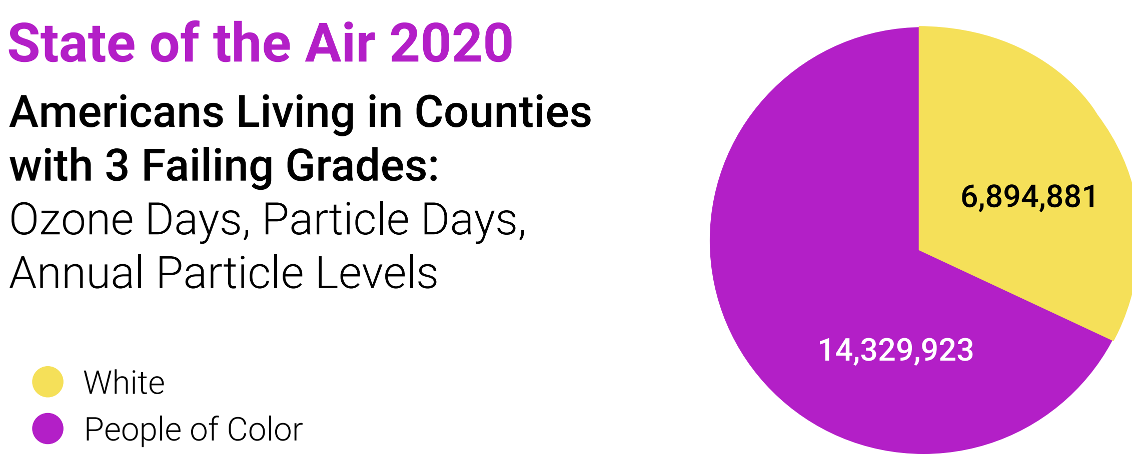
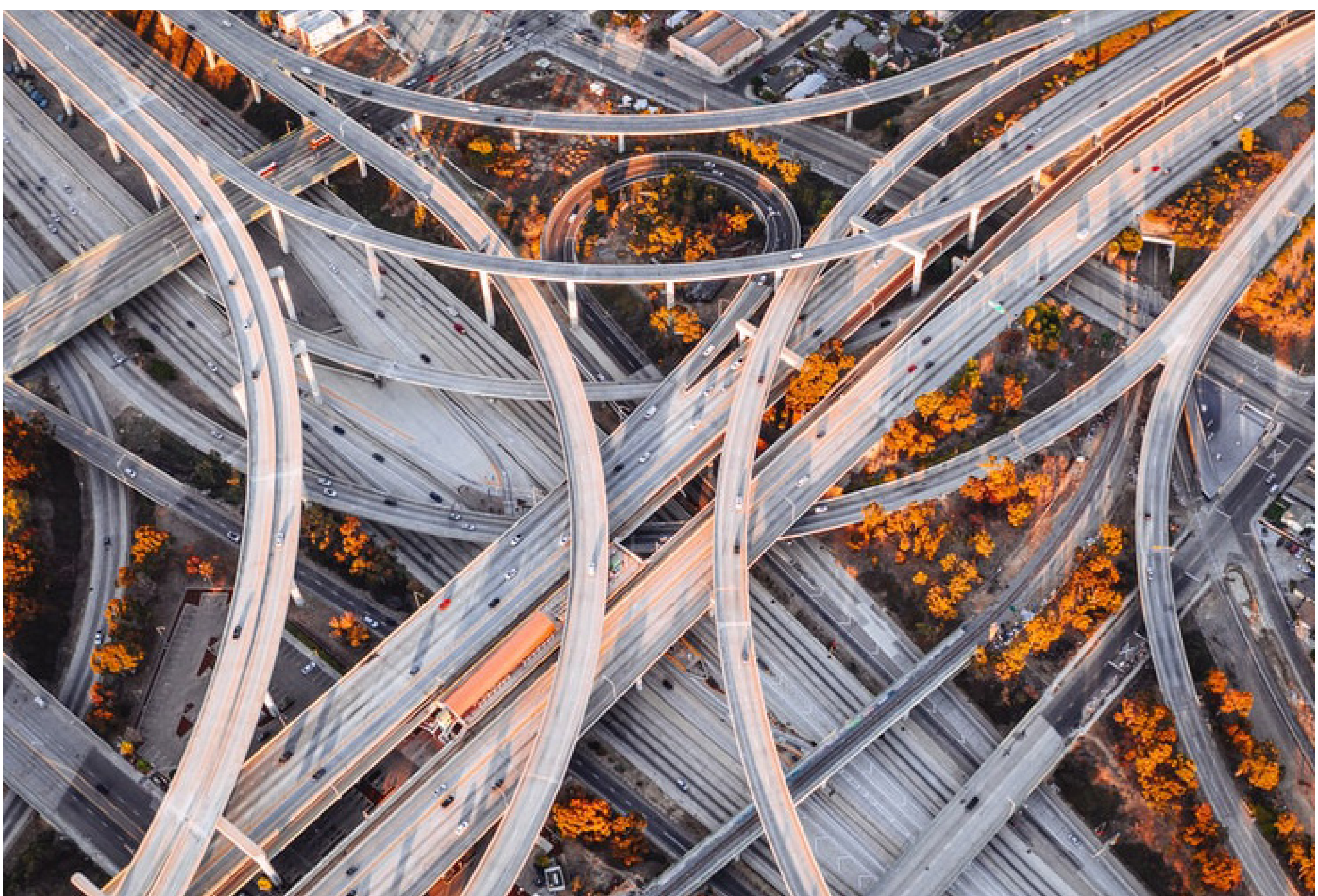


Figure 4: The disproportionate effects of particulate matter emissions are predominantly experienced by people of color across the U.S. (Source: American Lung Association)

estimates that people of color were 1.5 times more likely to live in a county with at least one pollution-related “failing grade” and were 3.2 times more likely to live in a county with three failing grades for unhealthy ozone days, particle pollution days and annual particle levels.[22]

A study conducted in New York State found that on road emissions have a disproportionate impact on both lower-income communities and communities of color. For example, 74% of New York’s African American and Latino populations and 80% of its Asian American population experience higher NO_2 emissions than the state-wide average.[23] Another study found that the New York City metro area experiences 1,400 premature deaths annually, specifically as a result of road emissions. Within the city, vehicle-related $PM_{2.5}$ pollution causes approximately 320 premature deaths from heart disease and other illnesses each year, with truck and bus pollution causing more than half of these deaths. The West Bronx in particular—which is 70% Latino and 29% African American—is home to the Cross Bronx Expressway and has the worst air quality in the state.

MHDVs’ contributions to these negative health outcomes in frontline communities are substantial. Due to the high volumes of traffic in these neighborhoods, members of these communities are exposed to more pollutants and the resulting health consequences. Fortunately, that opens the door for electrification to provide significant positive impacts on the health of these communities. Taking diesel delivery trucks and longer-haul tractors off of the highways will lead to reduced particulates, CO_2, and smog in the air. By transitioning to more MHDEV fleets, these neighborhoods and communities will experience more equitable environmental and health outcomes.



1.2.3 Environmental Benefits

Beyond the negative health effects, transportation-based pollution damages the environment in myriad ways. The VOCs and NO_x emitted by diesel vehicles react to form dangerous ground-level ozone, which leaves agricultural crops and forests particularly susceptible to stunted growth and a decreased ability to sequester CO_2. Likewise, nitric acid, another tailpipe pollutant, forms acid rain that leaches into the ground and waterways. Not only does this harm the aquatic organisms in lakes and streams, but it also directly affects human health when these chemicals enter our bodies via consumption of water, produce, and fish. Perhaps the most dramatic effect of diesel burning is its emission of global warming-causing GHGs. In turn, global warming causes extreme weather patterns, reductions in air quality, a rise in sea levels, and precipitates widespread species extinction.[24]

Corporate and governmental goals to reduce environmental impacts are crucial to accelerating the push to electrify this transportation segment. **With an average lifespan of 33 years, most MHDVs spend more time on the road before retirement than light-duty vehicles do.[25] As a result, failing to convert these fleets now means that diesel-fueled vehicles will remain on the road in 2050 and beyond.**

1.2.4 Impacts on Energy Security

The reduced fuel consumption associated with widespread electrification bolsters the United States' energy security. Heavy-duty trucks have greater energy consumption due to their low fuel efficiencies and high annual VMT; electrifying these vehicles now is critical to reducing national fuel consumption and to begin realizing projected cost savings. As of 2019, 91% of the domestic transportation sector is dependent on petroleum,[26] and MHDVs account for 26% of all fuel use.[27] In 2020, the U.S. used imported crude and petroleum to supplement the domestic supply chain, making the U.S. a net importer of these products.[28] **This reliance on petroleum presents a vulnerability: it forces the United States to rely on imports from countries with potentially unstable supply chains and lax environmental and human rights protections.** EVs are petroleum-free and more efficient: approximately 75% of available battery energy goes to propel and operate a medium-duty electric vehicle, while in a similar medium-duty diesel-powered truck, only about 35% translates to useful propulsion.[29] E-trucks consume about 50% of the energy of their diesel equivalents.[30]

Despite this, U.S. demand for transportation-related energy is expected to grow. Unlike petroleum, electricity can be generated from a diverse portfolio of renewable resources, is generally less expensive than diesel fuel, and is demonstrating potential to establish a new domestic clean energy industry.

1.2.5 Job Creation

Building out the domestic MHDEV sector is closely tied to job creation in the clean energy sector. MHDV electrification will require building out a domestic EV supply chain and charging network, both of which hold considerable economic potential. **A federal commercial vehicle tax credit could create more than 154,000 jobs in the U.S.[31]** The manufacturing and installation of charging infrastructure alone is projected to create more than 29,000 jobs.[32]

Beyond the EV industry itself, electrification could encourage growth in the trucking industry. With the boom in e-commerce during the COVID-19 pandemic, the demand for heavy-duty trucks to transport goods across the country is steadily increasing. In 2020, U.S. e-commerce sales were up 32.4% from the previous year,[33] and estimates project the total VMT by MHDVs will grow 29% by 2050.[34] To meet the growing demand of goods being shipped across the country, fleet managers are deploying a greater number of commercial vehicles. The growth in MHD truck sales is depicted in Figure 5. With this VMT growth, electrification provides an efficiency and cost-savings potential that can help meet this increased demand.

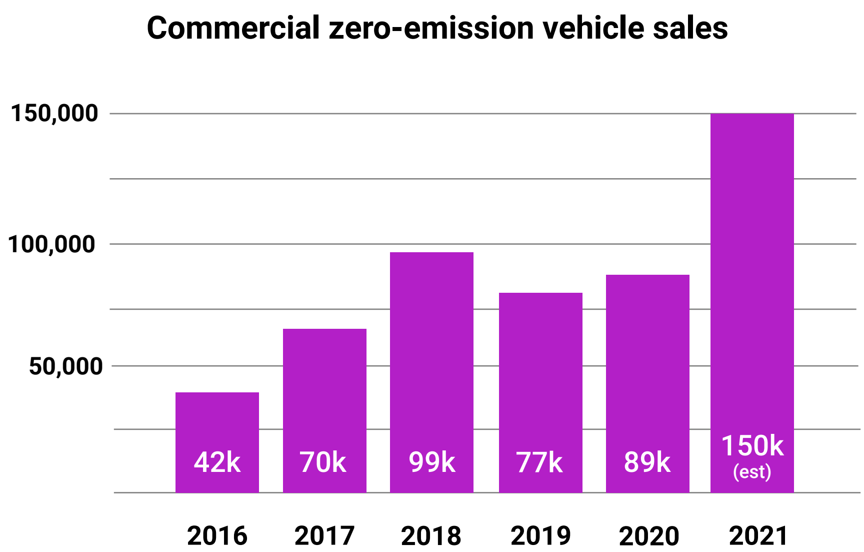


Figure 5: The number of medium- and heavy-duty vehicles on the road has grown significantly in the last decade, and with the e-commerce boom can be expected to increase further. [35] (Source: BloombergNEF)

Despite this uplift in demand, the transportation industry is experiencing considerable shortages of available truck drivers. The trucking industry is an estimated 80,000 drivers short, with many long-term employees citing stress as a reason for quitting.[36] This trend is expected to worsen by 2030 as the industry struggles to meet the growth in freight demand.[37] Electrification offers the potential to entice a younger generation of drivers to get behind the wheel. **Consumer reports consistently demonstrate higher satisfaction with EV over ICEV driving experience, and trucking is expected to benefit from the same trend.** EVs provide a smoother ride with minimal vibrations, less noise pollution, and a high-tech driving experience free from the fumes of diesel exhaust.[38] As a result, the health benefits associated with eliminating diesel fume inhalation and improved experience from a quieter drivetrain may reduce healthcare costs and increase driver retention.[39]

1.2.6 Economies of Scale and Lowered Costs

Among trucks, the shorter-haul vehicle segment is currently more cost-competitive to electrify than long-haul trucking—although technological improvements are accelerating the timeline for the latter. **At present, transit buses and delivery vans are well suited to electrification: they travel shorter distances, regular routes, and benefit from return-to-base operations ideal for charging. Increasing the proportion of EVs in this vehicle segment will demonstrate the viability of this technology, increasing consumer confidence and paving the road for larger scale electrification.** This shift will cause a demand for production of component parts, chargers, and battery packs. The increased demand will create economies of scale to drive down the cost of EVSE necessary for long-haul electrification, will boost EV growth in other vehicle segments, and will inform electrification strategies for other vehicle classes.

1.3 Barriers

While offering a series of long-term benefits, MHDV electrification presents unique challenges: higher upfront cost of EVs, limited charging infrastructure access, potential higher electricity demands, and reduced model availability. Fortunately, there are ways to address each of these challenges, and many fleets are already well on their way toward successful MHDEV operations.

1.3.1 Higher Upfront Costs

Though fuel and maintenance savings are well-documented, the high capital requirement of MHDEV acquisition presents a central challenge for fleet purchasers. The upfront cost of an MHDEV can be 100% higher than the cost for a comparable ICE heavy-duty truck, with the difference driven largely by the sizable battery packs required for electric trucks. On average, an electric bus costs $750,000—73% more than a standard diesel bus.[40] Additionally, most heavy-duty trucks also face a 12% federal excise tax (FET), which, on average, adds $21,000 to the cost of all new trucks and trailers. The higher upfront cost of electric trucks also translates to a higher FET.[41] Fortunately, battery prices have already dropped 89% in real terms from $1,200 per kilowatt-hour in 2010 to $132/kWh in 2021, according to BloombergNEF.[42] **A continued decline in battery costs should help reduce EV purchase costs going forward.**

BloombergNEF projects electric delivery vehicles will reach price parity with diesel trucks close to 2025, and anticipated increases in fossil fuel prices will further boost EVs' cost reductions.[43] Electric trucks with shorter-range trips (fewer than 500 miles for Class 8 and fewer than 120 miles for Class 4 delivery vans) will see the greatest TCO savings, largely as a result of operating in an environment with higher fuel prices and relatively low electricity prices.[44]

Purchase subsidies for MHDEV acquisition offer one way to address these difficulties. While the higher costs of EV acquisition can be offset by incentives, the lower operating expenses for MHDEVs can make them attractive to fleet operators—even without incentives. Ultimately, the TCO reduction is impacted by the cost of electricity. Efforts to reduce MHDEV charging costs via available smart charging software management already underway represent a key component of fleet electrification success and will continue to be a focus area for research and development.

1.3.2 Cost of Charging Infrastructure

In addition to spending more for the truck itself, the cost of installing charging infrastructure is another financial concern. Among fleet owners surveyed, 75% cite installing EV infrastructure for MHDEVs as one of the greatest barriers to adoption.[45] An ultra-fast charger capable of 350kW can cost up to $140,000.[46] However, this amount of power is not required for all vehicles, and smart charging software can optimize power distribution among vehicles according to their charging capabilities and needs. To ensure upfront capital is spent on the right equipment, installation projects will benefit from a customized analysis of a fleet's charging needs based on fleet size and type, average VMT, duty cycles, and time of charging. While the investment in charging infrastructure will be returned via lower lifetime operating costs associated with EV ownership, the upfront investment presents a real but surmountable barrier.

1.3.3 Lack of EV Model Availability

Another commonly-cited barrier to MHDEV adoption is the lack of available EV models with the necessary capabilities. However, medium-duty vehicle offerings are expanding: more than 300 commercial EV models are currently available, and this number is expected to double by 2023.[47] Heavy-duty vehicles, on the other hand, are the most difficult segment to electrify. They travel longer distances and demand a large battery capacity. **As of 2021, there are 67 zero-emission medium-duty truck models with a range of more than 150 miles available.[48]** Overall, the number of available models for both medium- and heavy-duty electric vehicles is expected to grow in the next decade (seen in Figure 6).

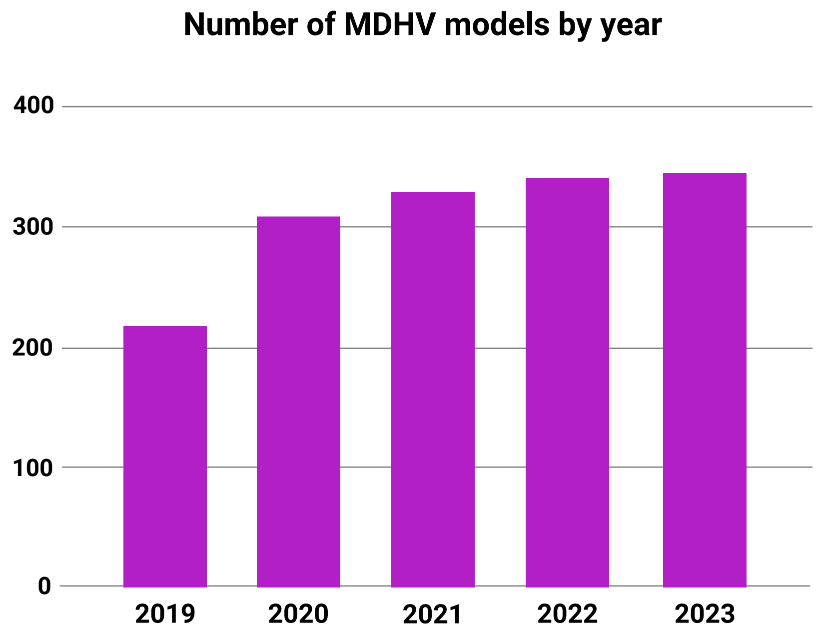


Figure 6: Currently available and projected models of medium and heavy-duty EVs through 2023.[49]

Range anxiety is a common perceived barrier to EV adoption and applies across all vehicle classes, but this concern is particularly relevant for medium- and heavy-duty vehicles. The average MHDV travels 100.85 miles per day.[50] Trucks with the longest routes drive a maximum of 600 miles, but average closer to 300 miles per day. Figure 7 provides the average range of various vehicle classes. **Considering that many EVs available today have a similar range, the electric models currently available can meet up to 60% of operational needs.[51]** Trucks capable of traveling longer distances (370 miles) are expected by the end of 2022, and those with ranges greater than 620 miles are expected after 2023.[52]

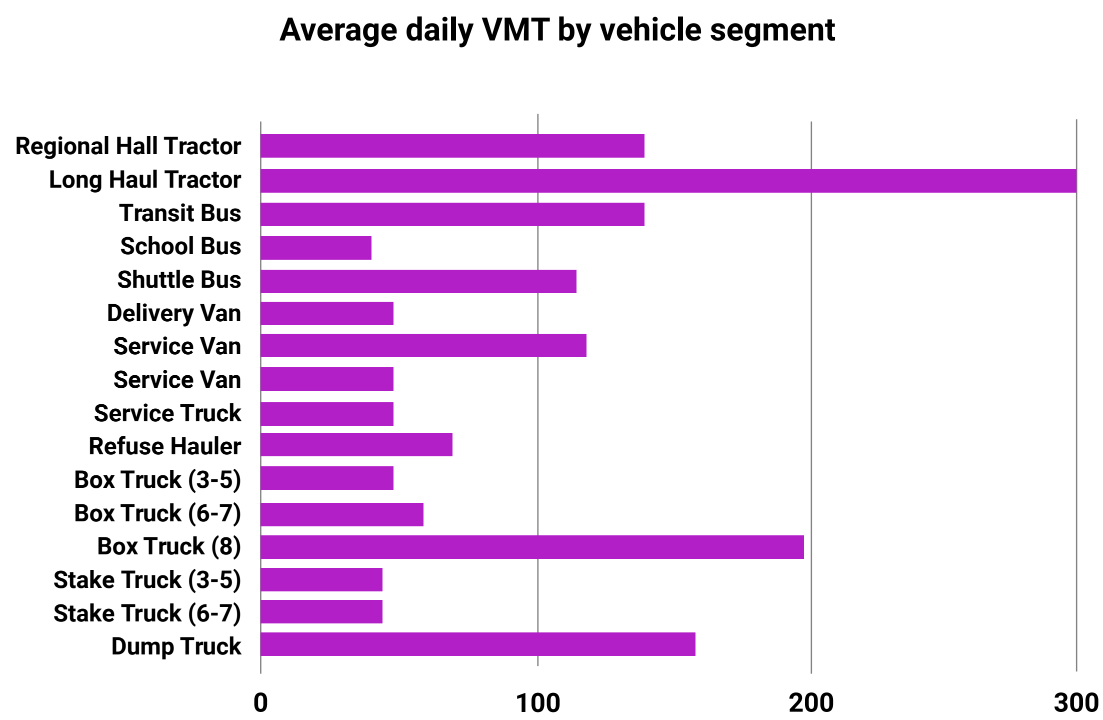


Figure 7: The average miles traveled per day for each vehicle class. The ranges of EV models available today are capable of meeting most vehicle distances needed.[53]

1.3.4 Vehicle Payload Capacity

Aside from traveling longer distances than passenger vehicles, MHDVs also carry a considerably heavier load. Increased battery-pack weight creates payload crowd-out concerns, since the payload capacity of a truck generates revenue for trucking companies. A standard semi-truck with a full load is generally allowed to weigh up to 80,000 pounds.[54] Fortunately, 90% of conventional semi-trucks weigh less than 73,000 pounds when loaded, which means that heavier electric trucks still have space to compete.[55] Soon, electric semi-trucks will be capable of hauling at least as much as a diesel truck due to regulations permitting higher weights for EVs in the European Union (up to 4,400 pounds more) and the United States (up to 2,000 pounds more).[56] Technological improvements in battery energy density will further increase range and the percentage of ICEVs that can be replaced by EVs.

1.3.5 The Impact on the Electrical Grid

As the transportation sector electrifies, the increased electrical demand from charging MHDEVs will require coordination among utility companies and other grid operators, local governments, and fleet operators. One heavy-duty truck alone can demand up to 350 kW of electricity per fast-charging session, depending on its energy needs.[57] Fortunately, with appropriate investments and managed-charging techniques, the grid is well-positioned to support fleet electrification.

2. Electrifying Federal Fleets

At the national level, President Biden has set ambitious goals for transportation electrification, and agencies have a large role to play in this transition. **MHDEVs have the potential to significantly improve federal fleet efficiency, reduce maintenance costs, and offer agencies a simple solution to satisfy statutory requirements for alternative fuel vehicle acquisition.[58]** Congress is currently considering several legislative proposals to authorize funding to procure federal electric fleets and supporting infrastructure. The United States Postal Service (USPS), the General Services Administration (GSA), and the Department of Defense (DOD) offer three opportunities for the federal government to explore fleet electrification.

Electrifying federal fleets will remove hundreds of thousands of ICEVs from U.S. roads, bolster the EV manufacturing industry, and send a clear market signal that EVs are here to stay. Though the majority of EVs manufactured today are passenger automobiles, these cars account for only 13% of the federal fleet. On the other hand, trucks and tractor trailers make up 86% of federal vehicles, while buses account for 1%.[59] Because of lower operating costs, an electrified federal fleet will also save taxpayer dollars, reduce pollution, and boost public health outcomes.

2.1 United States Postal Service

Electrifying the USPS delivery vehicle fleet is a premier opportunity for federal fleet electrification. The USPS fleet numbers more than 200,000 vehicles and constitutes 30% of the U.S. federal fleet.[60] Moreover, 163,000 currently-operating vehicles owned by the Postal Service are classed as Long Life Vehicles (LLVs) and are 27 years old, on average.[61] With the legacy costs of operation and repair increasing each year, exploring electric delivery vehicle acquisition is an opportunity for USPS fleet managers to realize cost savings.

The 10-year cost comparison between USPS EVs and its current fleet

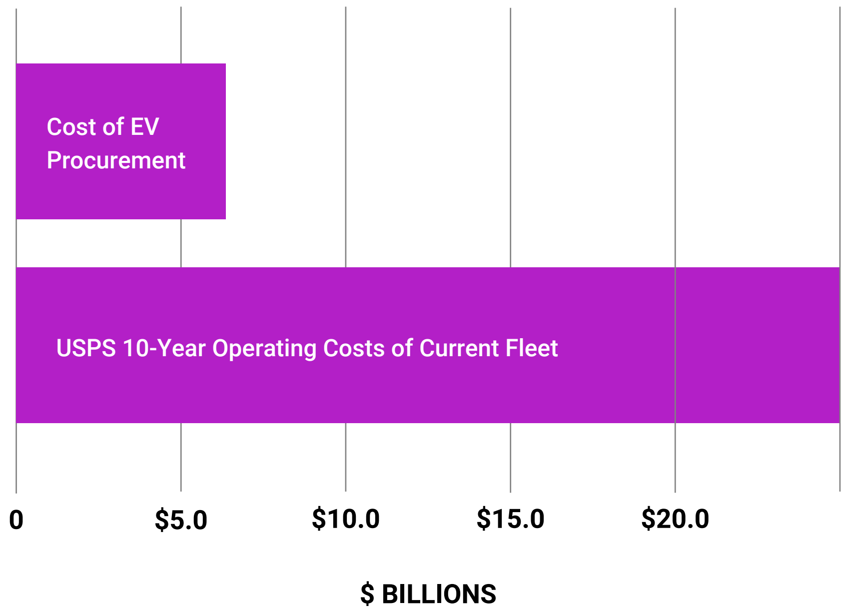


Figure 8: The 10-year total cost of ownership in maintenance and fuel costs of the current USPS LLV fleet far exceed the purchase cost of an all-EV fleet. Savings in maintenance due to fewer moving parts and relatively inexpensive electricity would further benefit operating costs.

The lifetime operating costs for EV charging and maintenance are as low as one-third of comparable costs associated with ICEVs. The savings potential for USPS delivery vehicles is even greater than that for other federal fleet vehicles because of their frequent stops, idling, fixed routes, short driving range, and convenient parking hubs, as seen in Figure 8. **According to a study conducted by Atlas Public Policy, by 2025, EVs can replace 40% of all non-USPS federal fleet vehicles, and 97% of USPS vehicles, at a lower TCO than comparable ICEVs. By 2030, electrifying the USPS fleet could gain $4.3 billion in savings for the federal government.**[62]

2.2 General Services Administration

The GSA provides safe, reliable transportation for federal agencies and their employees. With more than 400,000 trucks in their vehicle inventory, this presents a large sector to electrify. As part of its duties, GSA leads vehicle procurement for the government; these vehicles are then made available to government employees for purchase, lease, or short-term rentals. When the vehicles are retired, they are sold to the public at auction. Ensuring that the GSA acquires EVs during future procurement will substantially grow the secondary EV market. In turn, access to used EVs will make this technology available to a broader range of consumers, further encouraging adoption.[63] Each month, GSA offers a variety of trucks for sale to the public and conducts hundreds of school, shuttle, and inter-city transit bus sales each year.[64] Contractors can also use the GSA eLibrary to search for commercial short- and long-term leases of utility vans. Accessibility through GSA outlets may lead more to more widespread EV procurement for fleet operators and other federal agencies.

2.3 Department of Defense

Electrifying non-combat vehicles presents another opportunity to transition federal fleets. The military operates more than 174,000 non-tactical vehicles—including buses that transport personnel or trucks that provide services on bases—in their fleets.[65] The recently passed National Defense Authorization Act (NDAA) encompasses multiple facets of the military's funding. It also includes a provision directing the Department of Defense to carry out a pilot program to expand defense-critical electric infrastructure. The bill also includes language mandating that military buildings, including military bases and parking structures, must include EVSE. As the military transitions to civilian and combat EVs, EVSE deployment will be necessary both on- and off- base.

3. Electrifying Public Transportation

Outside of government vehicles, public transit and delivery vans are particularly well-suited to electrification: they travel regular, fixed-routes and have 'return-to-base' operating schedules.

Like other MHDVs, most public and school buses run primarily on diesel. As a result, jurisdictions across the country have taken proactive steps toward electrifying their public transit systems. California's Innovative Clean Transit regulation, for example, mandates the purchase of zero-emission buses by 2029: as conventional vehicles are retired, this policy will enable a fully-electrified fleet by 2040.[66] Policies like this serve as a good indicator for future market trends.

Diesel school buses present a particular concern to public health. Each day, approximately 25 million children spend between one-half to two hours traveling on school buses.[67] Inside buses, children's higher exposure to diesel fumes—linked to cancer, respiratory, and cognitive impairment—can exceed ambient levels of exposure by twelve times.[68] As they develop, children are particularly susceptible to the adverse effects of exposure to pollution,[69] and requiring them to travel via diesel-powered school buses further exposes them to needless risk. Notably, students from less affluent households ride school buses more frequently—60% of students from low-income families ride the bus to school.[70]

Likewise, the degree of exposure to public transportation-sector pollution is not distributed evenly across American communities. People of color, in particular, bear an outsized degree of harm.[71] Buses are disproportionately used by low- and middle-income Americans, with 55% of riders coming from households making less than $50,000 a year.[72] Black Americans are also more likely to use transit, representing 30% of bus riders despite constituting 12% of the U.S. population.[73]

Along with health benefits, creating accessible, efficient, and attractive public transportation systems increases communities' access to educational and employment opportunities in rural, urban, and suburban environments. Students who can commute to school easily are more likely to attend.[74] Parents who utilize the public transportation system can use time that would normally be spent ferrying their children to school to get to work or other activities. Similarly, access to public transportation gives adults an opportunity to travel to and from work with minimal delay and at a minimized personal expense.[75] Developing reliable public transportation extends beyond public health to communities' economic and social well-being.

Across the U.S., a growing number of municipalities have plans to electrify their public transit buses. School districts are following suit with plans to switch school buses to electric models, but the shift has been slow. At present, the transition to electric public transit is dependent heavily on the community governance boards' advocacy and the community's wealth, meaning that these transitions are concentrated in higher-income, majority-white neighborhoods and school districts. Without targeted state and federal programs to incentivize electric public transportation in low- and middle-income communities and in communities of color, inequities related to public transportation pollution will continue to grow wider.

4. Electrifying Commercial Medium- and Heavy-Duty Fleets

In addition to federal fleets and the public transportation sector, private commercial fleets are another opportunity for electrification. While most commercial electric fleets are still in the preliminary or planning phases, many companies—including UPS, FedEx, Frito-Lay, and Amazon—have announced their transition to MHDEVs (see Appendix 2A for applied case studies).

Some of the initial barriers companies might face during electrification transitions similarly include having insufficient upfront capital, inadequate charging infrastructure, range anxiety, or limited product availability. Still, a study completed by ICF Climate Center found that, as a whole, truck electrification provides greater benefits to the economy than other alternative fleet models evaluated (such as ICEV fleets). Furthermore, the study found that investment in BEVs and BEV infrastructure results in greater net employment, gross regional product, and industrial activity per dollar spent compared to natural gas vehicles and infrastructure.[76]

Even though medium-duty vehicles make up a larger portion of commercial fleets, Class 7 and 8 fleets such as freight vehicles (garbage trucks, street sweepers, cement trucks, and 18-wheeler trucks) can be found on highways and local neighborhoods alike. Logistics surrounding long-haul freight practices are suited to electrification: under federal regulation, authorities restrict the number of hours drivers can travel per day, mandating that drivers take a 30-minute break within an eight-hour driving period and restricting drivers to a limit of 11 hours of driving per day, after which they are required a 10-hour rest break.[77] During these mandatory rest times, drivers may be able to charge at individual stations or charging depots.

For most MHDV classes, EVs' TCO will likely meet or fall below the cost of ICEVs in the next five to ten years, but incentives may expire. For example, by 2030, an electric walk-in van is expected to have a 22% lower TCO than its diesel counterpart, yielding savings of $47,000 per vehicle.[78] The residual benefits of electrification are expected to be even higher for electric trucks, primarily due to reduced costs of fueling and maintenance for zero-emission MHDVs.[79]

The lack of infrastructure, energy and charging management services, and upfront cost of installation continues to be a challenge when evaluating fleet management. Without proper federal investment in electric charging infrastructure, range anxiety may continue to be an issue for longer-range models: relying solely on public charging will be logistically difficult for most fleets. While many fleet vehicles have shorter, scheduled routes and can rely on primarily depot charging at their origin and destination, some fleets may need private or public on-route charging to supplement depot charging on longer trips. There is an opportunity to continue funding public fast charging "corridors" along major roadways that can be used by passenger and fleet vehicles alike.

Though range anxiety may be an initial challenge, it should not be the final determinant for fleet managers who are considering a transition to zero-emission vehicles. Additionally, there are opportunities to explore fleet electrification without cost through private entities (see Appendix 1A). On average, the majority of single-unit trucks, such as walk-in vans and refuse trucks, travel fewer than 25,000 miles per year, or roughly 100 miles per day.[80] Most MHDEVs available today can achieve this range threshold, and future product launches advertise higher range options. Furthermore, the trucking industry has seen a shift away from longer regional or national hauls to more decentralized hub-and-spoke distribution models, resulting in a 37% decrease in the average length of hauls from 2000 to 2018.[81]

As identified by the NREL, depot charging stations are structures where charging infrastructure is co-located with off-duty bus storage facilities. Under this system, the fleet owns the charging infrastructure and can use it for overnight charging of its vehicles.[82] Deploying this method saves fleet operators money: they install the chargers at a preexisting facility, charge their vehicles during scheduled downtime (which means they do not have to stop during typical hours spent on the road), and pay less for the electricity that they use (per-mile public charging rates are often higher).[83] Depot stations also allow for easier coordination with grid operators to distribute charging activity to off-peak load times and facilitate tracking up-time fleet charging metrics. In an analysis conducted by Atlas Public Policy, more than 98% of cost-competitive scenarios for MHDEV fleets included depot charging.

Companies may also look into bulk charging negotiations through purchase agreements. Fleets that traditionally run short-haul delivery operations may be attuned to applied charging strategies to flatten the load's profile and save money through off-peak charging incentives. Further opportunities for cost-savings may overlap with retail energy designs and align charging with cheaper renewable energy sources.[84]

At the public level, local and state organizations are collaborating with transit planning organizations and utilities to construct "clean freight corridors" that would have charging depots or charging infrastructure reserved for commercial vehicles, but these corridors are not yet fully developed at a national scale.[85]

4.1 Private Industry Fleet Electrification Commitments

Last-mile delivery vehicles are an ideal use-case for electrification: relatively low daily mileage demands and urban drive cycles mean that existing battery ranges are more than sufficient for many delivery routes. Moreover, these MHDVs travel at lower speeds and stop frequently, elements that maximize their potential to use regenerative braking to recharge the battery. These vehicles also often operate out of centralized depots, allowing for convenient and manageable charging. **While most commercial electric fleets are still in the preliminary or planning phases, many companies—including UPS, FedEx, Frito-Lay, and Amazon—have announced their transition to MHDEVs.**

Amazon and Frito-Lay currently have some of the strongest commitments to fleet electrification. As of 2016, Frito-Lay had purchased 269 electric delivery trucks,[86] and in 2010 the company set a public goal to become the country's most fuel-efficient fleet.[87] Likewise, Amazon has ordered 100,000 custom EV delivery vans from Rivian. These vehicles are expected to be on the road beginning in 2022 as part of Amazon's Climate Pledge to achieve carbon neutrality by 2040.[88]

In a study comparing Frito-Lay's diesel and electric delivery trucks, NREL found that the electric models demonstrated more than three times the average fuel economy in MPGe and demanded less than one-third of the energy required by diesel counterparts, despite similar use trends. The study also found that the energy and savings benefits of electric trucks are maximized at greater distances, which bodes well for long-haul trucking and delivery needs.[89]

Several other industry leaders have formalized commitments to electrify their delivery fleets.

Among postal service providers, UPS and FedEx have made progress in this space. UPS has partnered with Arrival to manufacture 10,000 delivery vehicles, though achieving their commitment to carbon-neutrality by 2050 will require converting its entire 125,000-vehicle fleet by 2040.[90] FedEx has made a direct commitment to EV procurement: the company has pledged to fully electrify its fleet by 2040.[91]

4.2 Agricultural Machinery

Finally, agricultural machinery presents another opportunity for commercial medium- and heavy-duty fleet electrification. The agricultural sector accounts for approximately 5% of U.S. energy consumption,[92] and most agricultural machinery—like public transit vehicles—is diesel-fueled. Electric tractors and other farm equipment are currently being developed and implemented in limited-use applications or prototype settings, but concerns about charge length, higher costs, efficiency, and reliability remain barriers to larger-scale agricultural electrification.[93] Despite this, electrifying farm equipment is projected to bring reductions in air and noise pollution, and holds the promise of extensive fuel cost savings for farmers. High-capacity battery packs associated with electric tractors and other equipment also have the potential of bringing grid stabilization benefits and are particularly attractive to farm co-ops because they would likely be charged during off-peak hours.[94]

5. MDHV Deployment and the Electrical Grid

Electrifying vehicle classes throughout the transportation sector will demand a well-equipped, reliable grid: the U.S. Department of Energy found that by 2050, national energy consumption could increase 38% due to economy-wide electrification.[95] Grid preparation is a long-term initiative that will only be achieved by coordination among utilities and other grid operators, federal regulators, and state and local governments to upgrade the system, including targeted investments to increase distribution and transmission capacity where fleets are clustered. This will enhance resiliency as transportation and electricity systems become increasingly interdependent.

While critics of electrification mention grid instability as a reason to oppose an EV transition, studies have widely concluded that planned expansions in power production will meet the increase in demand. In 2019, the U.S. DRIVE Grid Integration Technical Team and Integrated Systems Analysis Technical Team concluded that "based on historical growth rates, sufficient energy generation and generation capacity is expected to be available to support a growing EV fleet as it evolves over time, even with high EV market growth."[96] **Electrifying all medium- and heavy-duty U.S. fleets will increase the demand for electricity by an estimated 168,582 GWh per year.[97]** However, this projected increase in load will occur incrementally as consumers transition to EVs. The increased energy demand will also be distributed geographically: because the rate of EV adoption varies by region across the country, the market will be able to naturally adapt to supply electrical demand as it increases.

5.1 Charging Upgrades

Charging MHDEVs involves higher, more concentrated power loads, and electrifying the medium- and heavy-duty sectors demands an expansion of U.S. charging capacity. As demonstrated in Figure 9, the transmission of electricity from generators to EVSE entails adjustments in distribution and power ramp. Some utilities estimate a new charging project will take nine to thirteen months from initial plans to installation and activation, with the longer periods dependent on the site's grid capability. Maximizing the efficiency of charging hardware requires accompanying software solutions, and lead times for distribution system upgrades associated with heavy-duty electric truck charging are uncertain.[98]

Return-to-base charging operations are the most commercially viable for electrification due to their ability to charge at a central depot. However, depot charging can increase the electricity demand at these locations, though this may require upgrades to the transmission infrastructure. Fortunately, however, some of the energy demand can be met with existing infrastructure. Studies show that 99.26% of federally regulated truck fleets have fewer than 100 vehicles.[99] An NREL study on the implications of heavy-duty electric trucking on charging depots applied heavy-duty charging load to 36 real-world, 100kW substations. **The results demonstrated that an estimated 82% of substations can accommodate 100 battery electric trucks charging at 100 kW without any upgrades, and more than 90% can handle 100 trucks charging at their slowest possible rates with no upgrades.[100]** Innovative rate structures can incentivize fleet operators to use a constant minimum power strategy to charge during off-peak hours (like overnight) and use less expensive Level 2 chargers.

Demonstrating power transmission from high voltage buses to EVSE

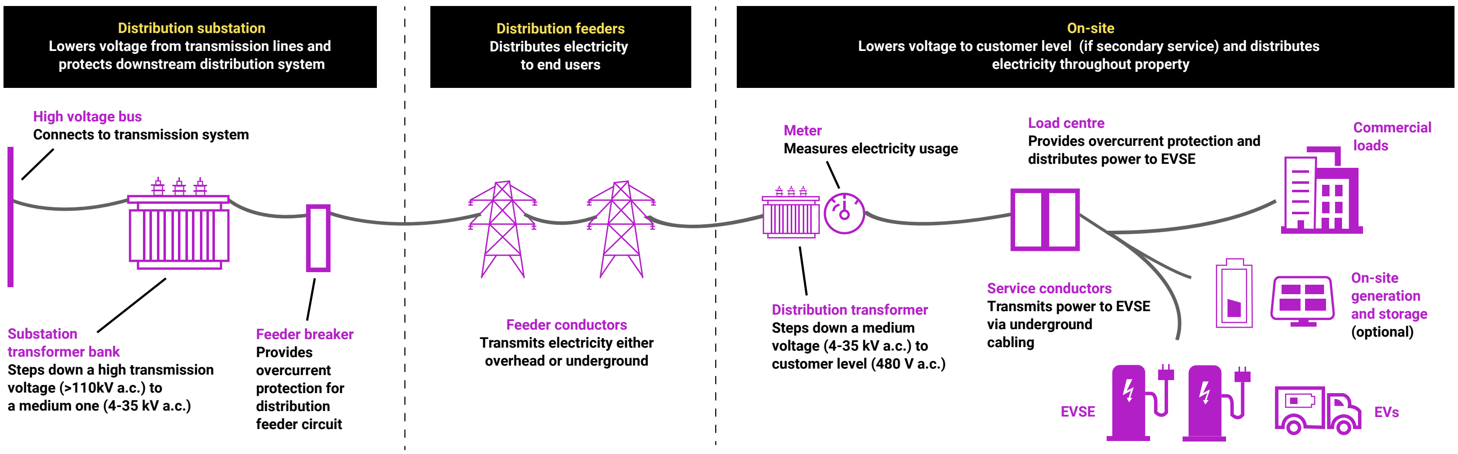


Figure 9: Demonstrating power transmission from high voltage buses to EVSE.[101] (Source: Nature)

5.2 Managed Charging Practices and Vehicle-to-Grid Integration

Utilities and other retail electric suppliers can offer innovative products to incentivize EV adoption and help manage load. Managed charging allows a utility or third-party to remotely control vehicle charging by turning it up, down, or off to better correspond to the needs of the grid, much like traditional demand response programs (see Appendix 4A for applied managed charging programs examples).[102] Also, managed charging is vital to reducing both charging costs and the demand on the grid. Rates for unmanaged electricity are substantially higher than rates under proper management; for example, the dollar-per-gallon-equivalent for electricity in San Diego costs up to $7.44 for unmanaged electricity or just $2.54 for managed charging.[103] As of January 2022, the average gas price in San Diego was $4.63 per gallon.[104] These savings—combined with their grid benefits—make utility management techniques a necessary consideration for MHDEV adoption.

Managed charging practices are a supplemental way that EVs can sustainably serve the grid. Under this process, EVs can act as a flexible grid resource to support the overall reliability of the electrical grid. Managed charging focuses on moving EV charging away from times when electricity is in high demand and toward times when there is less demand, such as overnight, or to when more renewable energy is on the grid, around mid-day. EVs also provide an opportunity to more efficiently use existing generation and prevent renewable idling through managed charging and price signals.

Vehicle-to-grid (V2G) integration may present another opportunity for EVs to give back to the grid. First conceptualized in the 1990s, V2G will eventually allow grid operators to use EVs as power storage assets for maintaining reliability and balancing load.[105] As illustrated in Figure 10, V2G technology allows electricity to flow both into an EV battery and back to the grid. V2G enables a bidirectional EV charger to supply power from an EV's battery to the grid via a direct current to alternating current (DC-to-AC) converter system, usually embedded in the EV charger. While bidirectional EV chargers are emerging products, all EV chargers contain internal converters. While value from managed charging can be obtained without V2G, V2G could eventually provide additional value to customers and the grid. **When paired with managed charging, V2G technology can support grid operators' ability to control frequency, respond to demand, and balance peak load.**[106]

Bidirectional charging

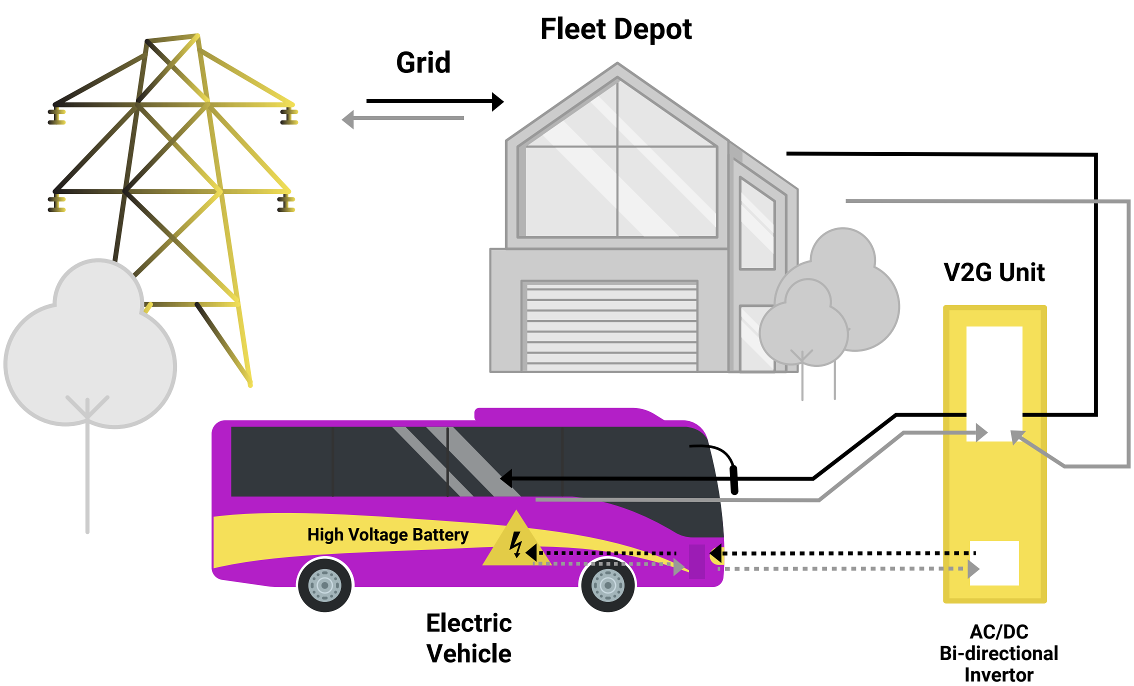


Figure 10: Bidirectional Charging

Long-haul trucks may present a good opportunity for V2G integration. **These vehicles are permitted to travel a maximum of 10 hours a day, meaning they are sitting parked about 58% of the time.**[107] **If connected to a smart grid, electric trucks could behave like a distributed energy resource (DER), offering V2G responses and energy transfers that could improve grid resiliency and facilitate bidirectional and smart charging.**[108] Integrating electric vehicles into the grid may help meet local, regional, or national energy needs. Grid operators could manage their energy demand via range extenders, and energy storage and on-site generation capabilities may mitigate charging costs and enable electric trucks and buses to become grid resources.[109]

V2G is a nascent technology that has yet to see significant applications beyond school and transit buses. Applying V2G nationwide is a complicated endeavor that will require coordination and planning across a host of stakeholders. While capitalizing on V2G is not a catch-all solution, when implemented alongside expanded grid-scale batteries capacity, V2G can become an important tool for balancing load and conserving energy.

5.3 Battery Storage Capacity

Like EV battery capacity, grid-scale battery storage will play a pivotal role in ensuring that the grid can accommodate growth in charging needs (see Appendix 3A). Presently, limited storage capacity relative to demand means that nearly all energy must be generated and distributed instantaneously. As a result, energy loss occurs when hours of high demand are misaligned with those of peak solar generation. However, companies are working to solve this problem. In 2020, the U.S. saw a 35% increase in battery power capacity, and utilities have reported plans to install over 10,000 MW of additional large-scale battery power capacity from 2021 to 2023.[110] **Grid-scale batteries, in particular, have become increasingly important tools for mitigating grid instability and minimizing energy loss.**

Additionally, one of the most promising tools for grid stability currently being applied across the country is strategically placing battery capacity next to charging depots. Pairing battery storage directly with charging stations ensures that existing stations are well-equipped for large-scale commercial fleet electrification. **With high potential for instantaneous utility load response, batteries adjacent to depots allow for vehicles to be charged with minimal impact to the grid.**

The U.S. currently has more than two million solar energy installations across the country, and that number continues to grow.[111] These installations only generate electrons when there is sunshine. Second-life EV battery packs can provide shorter-term solutions for solar farms, especially cloudy or rainy days. A recent study by MIT found that repurposed EV batteries that decline to 80% of their original capacity may be used as backup storage for grid-scale solar photovoltaic installations.[112] Because this concept is still in the exploratory phase, longer-term pilot studies are required to research the limitations of this application of second-life EV batteries. These studies should also consult a variety of stakeholders, including battery manufacturers, solar project developers, and auto manufacturers.

5.4 Time-of-Use Rates & Charging Management

Expanded EV deployment will lead to significant changes to the 24-hour energy demand cycle. Applying innovative rate structures such as **time-of-use (TOU) rates to electricity use will allow EVs to charge during off-peak hours and return energy back to the grid during peak demand hours, thereby lowering the stress on the grid.** TOU rates and charging management also lower operating costs for fleet managers, making medium- and heavy-duty electrification all the more feasible (see Appendix 5A for case study examples).

While EV penetration is still limited, it is growing steadily. As more MHDEVs are introduced to the grid, their charging needs and battery storage capabilities can ensure that clean sources of electricity are not wasted. Vehicles charged during hours of peak renewable generation store clean energy that can be called upon later on during high evening demand, minimizing usage of non-renewables. Nonetheless, innovative solutions in the EV industry are still needed to realize these benefits in full. It is critical that charging infrastructure build-out is shaped in coordination with utility companies and grid operators to ensure that millions of fleet EVs are best situated to use available power and charge at times that support the grid. As fleets electrify, utility rate designs, such as demand charges for peak energy use, should evolve to support the necessary transition to e-mobility.

By expanding MHDEV power storage capabilities and grid-scale battery technology, using smart charging software to optimize charging schedules,capitalizing on TOU rates, and ensuring strategic charging build-out, MHDV fleet electrification can become a feasible mechanism for reinforcing and stabilizing U.S. electricity infrastructure.

6. Recommendations

MHDV electrification requires coordination with utility companies and other grid operators, regulators, federal agencies, state and local governments, the automotive industry, fleet operators, and other stakeholders. For example, utilities must coordinate with fleet operators to ensure the local distribution grid is prepared when fleets electrify. Likewise, fleets will need to balance charging needs between delivery vans with shorter routes, long-haul heavy-duty trucks, and public transit. Fleet managers should also work with their utilities and retail electric suppliers to select the electric plan that makes the most sense for their fleet.

6.1 For the Federal Government

The U.S. government will play a key role in building confidence for MHDV electrification, both for federal fleet partners and commercial operators alike. A federal framework for MHDV electrification must streamline progress throughout the country; the extent of MHDV electrification currently varies substantially by state and municipality. The interstate nature of postal, commercial, and delivery travel demands federal coordination. Notably, the air and climate impacts of emissions from these vehicles are not constrained within any one state or locality and therefore require national coordination as well.

Subsidies, tax credits, and other financial incentives are proven to accelerate electric vehicle adoption throughout vehicle sectors, but are especially important for MHDEVs because of their disproportionate environmental and public health impacts. Financial incentives have the power to lower the upfront cost of EV adoption, thus removing an initial barrier that fleet operators in federal and commercial spaces face.

6.1.1 Expand Tax Credits and Incentives to the MHDV sector

There are a number of opportunities to expand credits to the MHDV sector. The federal government should consider legislative proposals such as amending a section of the U.S. tax code to provide businesses with tax credits for purchasing commercial EVs. This will incentivize private companies to accelerate their EV transition by applying credits to fleet purchases.

Similarly, federal policymakers should consider legislation that would create a 30% tax credit for the purchase of zero-emission commercial vehicles weighing more than 14,000 pounds, with a $100,000 credit-per-vehicle cap. For agricultural and rural communities, the federal government could amend the Rural Energy for America Program to make electric tractors and EVSE eligible for the program's loans, which would facilitate electrification in areas that are typically not afforded the opportunities that come with early EV adoption.

Currently, there is a 12% federal excise tax—a tax levied on the sale of specific goods and services—on the sale of heavy-duty trucks, trailers, and tractors combined with trailers. To further incentivize MDHV electrification, the federal government should suspend the outdated excise fee for zero-emission heavy-duty vehicles.

6.1.2 Provide Regulatory Certainty for Utility Providers and EV Stakeholders

Granting utilities the flexibility to make proactive upgrades to the electrical grid and facilitate transportation electrification will require additional guidance from regulators like the Federal Energy Regulatory Commission (FERC) and EPA. **Regulatory certainty will allow utilities to make the investments necessary to facilitate a smooth EV transition.** In turn, to satisfy such requirements, utilities will need clear insight into multi-year schedules for customer electrification, approval from regulators to recover costs from proactive (rather than in response to firm load) investments in the grid, and/or flexibility to serve loads with non-wire alternatives.

In 2020, FERC issued order number 2222 to address grid modernization needs by removing the barriers of distributed energy resources (DERs) to enable them to compete inside traditional organized markets, which could open domestic wholesale markets to new energy sources and grid services. The final rule does not allow retail regulatory authorities to prohibit DERs from participating in regional markets. It also establishes a small utility opt-in that prohibits grid operators from accepting bids from the aggregation of customers of smaller utilities unless relevant retail regulations allow such participation.[113] This rulemaking has the potential to encourage new technologies such as V2G and managed charging to come online. FERC should continue to explore opportunities for EVSE deployment and its impact on FERC-jurisdictional transmission systems and wholesale electricity markets.

The EPA also has a role to play in ensuring that EV stakeholders have adequate guidance before committing to electrification projects. The EPA is preparing to promulgate rules for the next phase of heavy-duty vehicle GHG standards. Known as the "Phase 3" rules, the next iteration of EPA's heavy-duty GHG regulations will govern Model Year (MY) 2027 and later vehicles. **Given the market's trajectory, the growing list of states seeking to adopt the ACT rule, and the pressing need to decarbonize this vehicle segment, EPA should ensure that its proposed standards are ambitious enough to drive rapid and broad electrification of vehicles in this classification beginning in MY27.**

6.2 For State Governments

At both the local and state level, governments can help accelerate the electrification of the MHD sector through ambitious policymaking that supports the MHDEV industry and directly benefits the environment and public health. These efforts should reflect input from all stakeholders, and doing so will allow states to maximize the environmental and economic benefits of individual state programs. Case studies in states like New York, New Jersey, California, and Colorado show incentives and regulations can successfully encourage manufacturers to provide a higher level of electric trucks and fleets (see Appendix B for successful state case studies).

6.2.1 Adopt the ACT, ACF, and CFS or Develop Similar Policies

Adopting the Advanced Clean Truck (ACT) rule, or similar rules or legislation, will help electrify a growing percentage of state MHDV fleets. The ACT rule requires manufacturers to sell ZEVs as an increasing percentage of their annual sales from 2024 to 2035.[114] The ACT incentivizes manufacturers to electrify by providing larger credits for heavier vehicles. The rule also penalizes auto manufacturers for non-compliance. **Implementing the ACT rule requires manufacturers to shift toward wholesale production and sales of MHDEVs.**

Studies suggest that this rule will bring significant environmental and economic benefits: in California, the Environmental Defense Fund estimates that the ACT will bring cost savings of $7.3 billion through 2040.[115] Similarly, the California Air Resources Board estimates that resulting air quality improvements will deliver $8.9 billion in public health benefits, including 943 premature deaths avoided.[116] Expanding policies like these will allow replication of these benefits to more communities across the country.

In parallel, states should consider adopting companion policies like California's proposed Advanced Clean Fleets (ACF) rule and clean fuels standards (CFS). The ACF rule proposes to set progressively higher purchase requirements on large private fleets, public fleets, and drayage fleets. Doing so will accelerate fleet-switching, especially in targeted applications in the early years of its effectiveness. It will also provide the MHDEV industry with critical demand certainty as the products and markets mature.

CFS policies are similarly important elements of comprehensive MHDV electrification strategies. By setting increasingly more stringent requirements for the average carbon intensity (CI) of transportation fuels, such standards can improve the economics of MHDEVs compared to traditional diesel- or gasoline-fueled alternatives. Specifically, by creating opportunities for MHDEV owners and operators to generate and sell credits under a CFS (typically, when fleets charge their vehicles centrally at a depot or dispatching center and they own the charger, they can capture the credits generated by the relatively low-CI charging events), policies like these create new revenue streams that directly benefit TCO calculations and inherently incentivize and support fleet-switching and charger build-out.

6.3 For Utilities

As the country electrifies, utility providers' role is expanding to ensure that all communities are equipped with the appropriate infrastructure to support EV fleets. Robust charging infrastructure and a reliable electrical grid are essential to a successful MHDEV transition. Utilities play a role in preparing the electrical grid by proactively identifying areas that may need additional upgrades and by using management techniques to anticipate and control the additional energy burden. **Grid management techniques consist of a combination of innovative rate structure, infrastructure replacement, targeted investments in transmission and distribution, automated smart-charging software, demand response, and V2G integration.**

6.3.1 Coordinate Closely With Other EV Stakeholders

Grid management and infrastructure buildout for fleet electrification require a case-by-case approach to synthesizing information from all stakeholders to avoid overloading the grid in a given area. Thus, new grid management techniques must be implemented in coordination with the federal government, local municipalities, the charging industry, and fleet managers. Through competitive federal grants, stakeholders will be able to create the innovative solutions and data mapping that are critical for grid management. Finally, by maintaining open communication in partnerships with local governments, utilities can ensure that rate structure, project mapping, and infrastructure maintenance maximize energy efficiency and community satisfaction.

Coordination will also help utilities play an active role in accessible electrification. Stakeholder engagement is key in identifying future electricity needs and helps utilities make any necessary infrastructure upgrades. In Illinois, for example, a recent bill will require utilities to form stakeholder engagement workshops and track equity metrics such accessibility and affordability.[117] **Together with local governments, utilities can facilitate beneficial electrification by managing charging loads, creating demand profiles, and developing integrated grid solutions.**

6.3.2 Commit to EVSE Investment & Buildout

Investing in the equipment and supporting infrastructure now is key: the greatest cost consideration utilities will make pertains to necessary substation and other grid upgrades. To deploy this infrastructure in a cost-effective way and timely fashion, utilities will need not only any available insights and plans from fleet operators, but also the regulatory support to invest in the grid where fleet loads are expected prior to public announcements and/or contracts.

Together with regulatory policy that allows for investments based on expected future demand, utilities must focus on local charging hubs and grid resiliency for urban delivery, transit, and long-haul applications. Ensuring chargers will be accessible along longer-haul trucking routes is needed to expand EVs to the heavy-duty sector. Until then, electrification of the MHDV segment will largely be constrained to shorter regional travel and last-mile delivery routes. More charging stations and creating chargers capable of higher power demand are required for this transition to occur. Regardless of whether the installation of the chargers will be completed by the utilities, private contractors, or charging companies, the utilities will be ultimately responsible for delivering the electricity.

6.3.3 Educate Utility Customers about the Benefits of Electrification

Finally, utilities must work with municipalities to educate the public and regional transit organizations about current grid preparedness and opportunities to benefit from electrification. Informing communities about grid optimization will alleviate concerns of perceived overload caused by increased EV uptake.

Utilities can play an important role in ensuring that EVs benefit both EV and non-EV drivers by encouraging customers to charge during lower-priced, off-peak hours—and ensuring that they know that this is an option. **Once utility customers are well-aware of these related cost savings, this will also benefit utilities directly.** After initial upgrades are made, the increased demand on the grid will place downward pressure on rates to benefit all electricity users.[118] The reduced rates are due to the fact that EV charging—especially for heavy-duty applications—will in turn bring in more revenue than the associated infrastructure costs. Over the span of eight years, EVs in PG&E and Southern California Edison's service area brought in over $800 million more in revenue than they spent on associated costs.

6.4 For Fleet Managers

Fleet managers are particularly sensitive to cost concerns. Currently, evaluating the upfront, rather than lifecycle, cost of vehicle acquisition is standard practice for both private and public fleet managers. When analyzed this way, gas-powered vehicles often outcompete EVs; however, TCO analyses regularly prove that EVs are significantly cheaper than their ICE counterparts. **Fleet managers can expect to save on fuel, maintenance, and repair costs for EVs; likewise, MHDEVs like transit buses, school buses, and vocational (non-transport) vehicles are cost-competitive with equivalent ICEVs when compared by their lifetime costs.**[119]

6.4.1 Prioritize Fleet Ownership Lifecycle Costs in Decision-Making

EVs have fewer moving parts than their ICE counterparts, a fact that makes them simpler to maintain and reduces the probability of a major malfunction. Reduced maintenance needs save both time and money, particularly for fleet managers facing budget constraints. School districts, in particular, tend to lack the economic and labor resources to make repairs to their existing vehicles, thus making EVs an attractive alternative. **Transitioning from an upfront cost-based decision-making model to one that considers the vehicle's entire lifespan—including purchase cost, depreciation, financing, fuel costs, insurance costs, maintenance costs, taxes, fees, and operational expenses—provides a more accurate picture of the true costs incurred via vehicle ownership.**

6.4.2 Preemptively Adopt Managed Charging

Wherever possible, adopting managed charging practices and preemptively installing chargers at parking sites is essential to maximizing EV cost savings and benefits. By balancing the EV load on the grid, fleet managers can charge more EVs simultaneously for the lowest cost possible: case studies have demonstrated that managed charging practices can decrease peak demand by 500 kW and save $11,500 per month for a 100-truck fleet.[120]

7. Conclusion

Electrifying the MHDV fleet is a prerequisite for meeting essential public health, climate, and national security needs of the United States. Private industry, federal and state governments, and the public have a vested interest in MHDV electrification. In addition, MHDVs transport people and goods billions of miles across the country each year, and these vehicles are disproportionately responsible for some of the country's most toxic fumes. Though light-duty vehicle electrification is achieving increasingly widespread acceptance, those considering MHDV electrification express concerns with high purchase costs and insufficient charging infrastructure. These barriers have deterred significant electrification of the MHDV segment.

Yet, as detailed in this report, these concerns can be readily overcome to generate cost savings, health benefits, and pollution reductions. Already, MHDEVs provide fuel and maintenance cost savings to fleet operators, which will lead to TCO superiority between MHDEVs and diesel-powered MHDVs this decade. As more fleet operators purchase MHDEVs, vehicle and charging infrastructure manufacturers will create economies of scale, further driving down unit costs. Also, job creation in the vehicle manufacturing, charging installation, and trucking industries will continue to surge. These industries can create more jobs per million dollars of investment than other related industries. By creating and retaining manufacturing and transportation jobs, MDHEVs will expand the workforce in ways that will facilitate improvements to our domestic supply chains. Furthermore, MHDEVs will prevent expensive environmental and public health damages that are currently paid by the general public. MHDEVs drastically reduce CO_2, NO_x, and $PM_{2.5}$ pollution, improving public health—especially in the frontline communities located along traffic corridors. Reducing this pollution will also help the United States achieve our commitments under the Paris Climate Agreement and aid in our fight against climate change. Finally, electrifying our MHD fleets will increase our domestic electricity production efficiency and reduce our reliance on foreign-sourced energy supply chains that are subject to price shocks and supply disruptions. Through transportation electrification, the U.S. will boost our energy security and, therefore, our national security.

Federal legislation is required to make the opportunities of MHDEVs outweigh the initial barriers. Amendments to the U.S. tax code so that businesses can receive tax credits for procuring commercial MHDEVs and installing charging infrastructure will expand opportunities for private businesses to invest in fleet electrification. Policymakers should also appropriate funding for federal MHDEV fleet procurements, allocate more grants for charging infrastructure, facilitate enhanced coordination between the charging and utility industries, and incentivize zero-emission public transit and school buses. Finally, Congress should suspend the excise tax on heavy-duty vehicles, which will motivate future heavy-duty EV sales. These policies are all pathways to help electrify the commercial, public, and federal MHDV fleets.

Electrifying the MHDV sector cannot wait. Because of their long lives, gasoline- and diesel-powered MHDVs that roll off the production line in 2030 will still be polluting communities in

2050 and beyond. It is imperative that the federal government works with fleet operators, utilities, charging companies, MHDV drivers, frontline communities, and other stakeholders to overcome the perceived barriers to MHDV electrification and begin delivering the public benefits of MHDV electrification as soon as possible.

Appendices

Appendix A: ZETA Member Case Studies

1A COST ANALYSIS

- While this is often a paid service, **ChargePoint** offers a free introductory analysis of fleet charging needs to help customers begin the process of installing charging infrastructure.

2A COMMERCIAL FLEETS

- **Duke Energy**'s eTransEnergy helps logistics and last-mile delivery businesses, municipalities, transit agencies, school districts, public authorities and other institutions across North America efficiently electrify their vehicle fleet and scale. From pre-planning and construction to deployment and operations, eTransEnergy helps fleet managers minimize their total cost of ownership (TCO), reduce operational risk and accelerate zero-emissions goals.
- Amazon has ordered 100,000 custom EV delivery vans from **Rivian**, which are expected to be on the road beginning in 2022. The announcement comes as part of the company's Climate Pledge to achieve carbon neutrality by 2040.
- UPS has partnered with **Arrival** to manufacture 10,000 delivery vehicles, though achieving their commitment to carbon-neutrality by 2050 will require converting its entire 125,000-vehicle fleet by 2040.

3A BATTERY STORAGE

- In New York, **ConEdison** paired battery systems with the installation of new charging stations.
- Electrify America announced plans to install **Tesla**'s battery systems at 100 charging stations.
- **Vistra** operates the world's largest battery storage facility in Moss Landing, California. The facility holds 400 MW of energy, enough to power 300,000 homes.

4A MANAGED CHARGING

- **Proterra** has developed a charging station capable of supplying large-scale vehicle fleets, and the system can be configured to a broad range of power levels and employs a universal charging technology.
  - Proterra introduced high-powered charging systems that will enable the electrification of large-scale fleets with V2G capabilities.[121] In Chicago, Proterra's Catalyst buses each hold half a megawatt hour of power that can be called upon during instances of peak load to alleviate the grid.[122]
- To further mitigate grid-impact of commercial fleet electrification, attention should be paid

to increased programs like **PG&E**'s Self-Generation Incentives Program (SGIP), which pairs commercially owned solar capacity with battery storage.

- Alameda County has used **ChargePoint** smart charging software to achieve 35-54% savings fueling its EV fleet compared to gas vehicles, depending on the type of vehicle.[123] ChargePoint solutions also offer the ability to balance charging needs with energy prices to keep vehicles charged and ready at a low cost, without compromising vehicle availability.
- **ABB** provides charging solutions for public transit bus fleets in St. Louis, MO,[124] Lake County, OH,[125] and Portland, OR.[126] All ABB charging systems are equipped with connectivity for remote monitoring, diagnostics and upgrades as well as energy management systems via OCPP.
- ABB also provides high power, high voltage 175 kW DC fast chargers for **Southern California Edison** (SCE) in Irwindale, California. In addition to supporting SCE's light-duty vehicles, ABB's chargers also support the company's 550 kWh battery electric Class 8 trucks. ABB also offers additional training, guidance, and maintenance solutions for commercial fleets.[127]

5A RATE STRUCTURE

- A study by **Salt River Project** demonstrated the effectiveness of TOU rates in shifting EV charging loads to off-peak hours: doing so helps utilities use generation capacity that is typically relied on during times when load is lower, increasing their profitability and offsetting the need for building additional generating plants.[128] TOU rates and charging management also lower operating costs for fleet managers, making medium- and heavy-duty electrification all the more feasible.
- **Vistra** has a retail brand in Texas that offers a competitive electric plan to residential EV customers where all energy charges are discounted 50% on weeknights and weekends, encouraging load-shifting to times when there is normally more available generation capacity.[129]

Appendix B: Selected State Case Studies

New York State is home to a MHDV fleet of more than 684,000 vehicles, and the state is considering adopting a program similar to California's Advanced Clean Trucks (ACT) Rule.[130] This is projected to deliver significant environmental and public health benefits. Adopting California's version of the rule, which requires that zero-emission vehicles constitute a growing percentage of new trucks manufactured in the state starting in 2025, would bring New Yorkers $16 billion in public health benefits and savings for fleet owners and utility customers, including:

- Generate annual fuel and maintenance cost savings of $270 million for fleet operators.
- Attract $131 million per year in MHDEV charging infrastructure investments.
- Avoid 355,000 respiratory illnesses, 540 premature deaths, and 523 hospital admissions annually.
- Reduce GHG emissions from trucks and buses by 50 million metric tons (41% reduction), PM by 1,070 metric tons (77% reduction), and NOx by 333,000 tons (91% reduction).[131]

Likewise, the Clean Trucks Program in neighboring New Jersey would bring similar benefits under an umbrella of $11 billion in monetized social benefits, such as:

- Bring annual fuel and maintenance cost savings of $420 million for fleet operators by 2050.
- Attract $68 million per year in investments in charging infrastructure.
- Avoid 136,000 respiratory illnesses, 230 premature deaths, and 250 hospital admissions annually.
- Reduce GHG emissions by 19 million metric tons (41% reduction), PM by 245 metric tons (77% reduction), and smog-forming NOx by 144,000 tons (91% reduction).[132]

In the West, Colorado is similarly well-positioned to benefit from MHDV electrification. In an analysis developed for the Colorado Energy Office, the state is set for significant public benefits and environment improvements if the state is to electrify its MHD fleet by 2050. In all scenarios analyzed by the report (including adoption of California's Advanced Clean Trucks Rule), by 2050 benefits will include:

- Reduce GHG emissions by 3.3 to 4.4 million metric tons, NOx by 7,000 to 12,100 metric tons, and annual PM emissions by 111 to 140 metric tons.[133]
- MHDV fleet electrification will result in a net societal benefit of $20.2 billion to $26.6 billion driven by savings to Colorado MHDV owners, GHG monetized savings and air quality benefits and utility net revenue.

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