



# FEDERAL FLEET ELECTRIFICATION ASSESSMENT

A total cost of ownership analysis of federal fleet light vehicles  
and buses in 2025 and 2030

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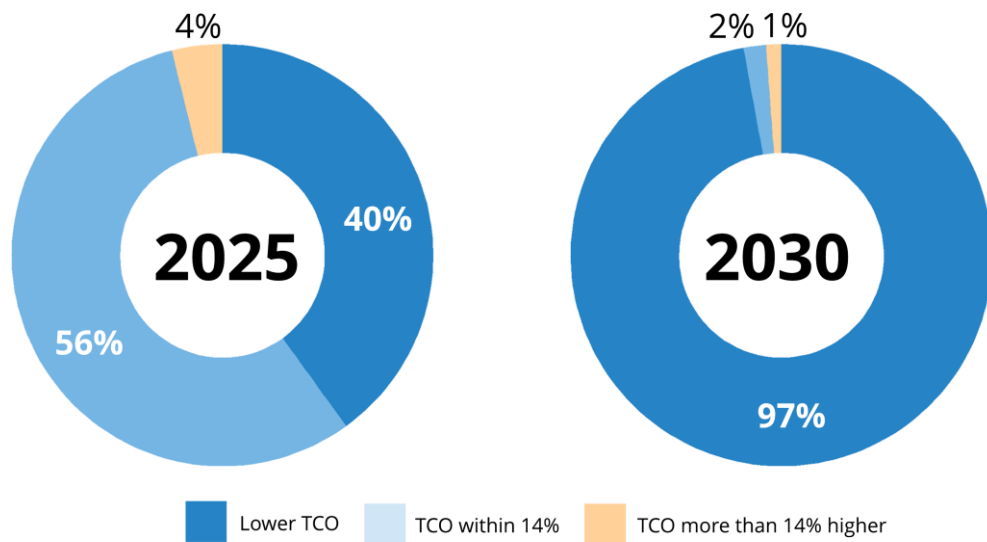
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## Key Findings

By 2025, 40 percent of all non-Postal Service federal fleet vehicles and 97 percent of U.S. Postal Service (USPS) vehicles can be replaced with electric vehicles (EV) at a lower total cost of ownership (TCO) than comparable gas and diesel vehicles. This means that choosing an EV over a conventional vehicle will save money over the life of the vehicle. By 2030, the vast majority of all federal fleet vehicles—USPS and non-USPS—will be cost competitive on TCO basis. Electrification of non-USPS federal fleet vehicles could yield vehicle life-time savings of as much as \$1.18 billion, while USPS electrification could yield as much as \$4.3 billion in savings. Given this opportunity, federal agencies should begin planning for widescale fleet electrification immediately with the expectation that most new or replacement light vehicles and buses acquired within this decade should be electric.

Figure 1: Non-USPS Federal fleet electric vehicle TCO performance compared to conventional vehicles in 2025 and 2030



Source: Atlas analysis of DRVE tool outputs

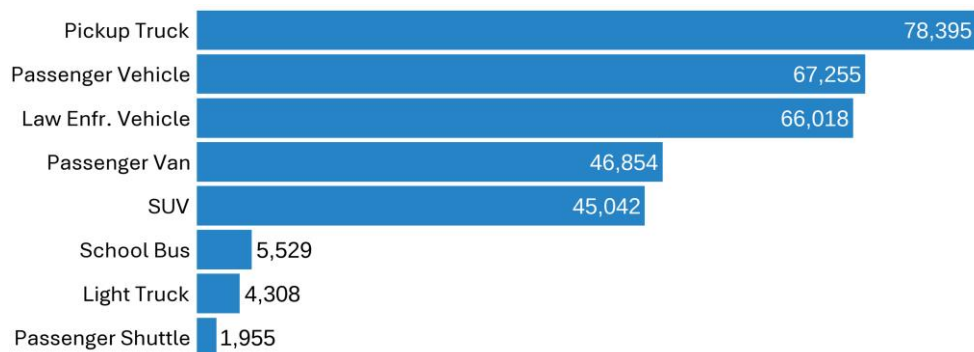
## Opportunity for Rapid Electrification

Federal agencies outside the USPS can electrify their fleets faster if they reinvest savings from electrifying TCO-competitive vehicles into electrifying vehicle classes where EVs are not yet cost competitive. In 2025, using these savings could support the electrification of 96 percent of vehicles in the federal fleet at a net savings of \$8 million. This would more than double the number of vehicles that could be electrified in 2025 at no additional cost.

# Introduction

The federal government is the single largest fleet operator in the United States. Federal agencies—not including the U.S. Postal Service (USPS)—control fleets consisting of 315,000 light-duty vehicles and buses while USPS operates an additional 192,000 light-duty vehicles. Pickup trucks, passenger vehicles and law enforcement vehicles make up the bulk of the federal light-duty and bus fleet with passenger vans and SUVs also comprising a significant portion. School buses, light trucks (work trucks and flatbeds) and passenger shuttles are all small minorities of the fleet (Figure 2). The USPS fleet is dominated by mail trucks—referred to as *Long Life Vehicles*—which make up 87 percent of all USPS light vehicles.<sup>1</sup>

Figure 2: Non-USPS federal fleet inventory as of 2019



Source: General Services Administration (GSA) Federal Fleet Report

With few exceptions, federal fleet vehicles run on gasoline or diesel fuel. However, because fleet vehicles drive predictable distances and regularly return to central depots for long periods of time where they can recharge, EVs are well suited to federal fleet applications. Moreover, switching federal fleets to EVs brings a host of societal benefits including reduced greenhouse gas and harmful air pollutant emissions, and improved energy security due to decreased dependence on oil.

EV use can also bring economic benefits to federal fleet operators by reducing fueling and maintenance costs. However, high upfront purchase prices can make EVs seem like an uneconomic choice when only capital costs are considered. In this study, Atlas conducted a

<sup>1</sup> All assumptions used in the analysis are explained in a companion document called *Methodology and Assumptions for Federal Fleet Analysis*.

high-level total cost of ownership (TCO) analysis to compare the full cost of purchasing *and* operating EVs relative to gas or diesel fueled counterparts when either vehicle is acquired in 2025 or 2030.

The study identifies when and for which vehicle types EVs have a lower TCO than their conventional counterparts and therefore represent the economical choice when choosing between vehicle types. In addition, the study also estimated the total savings (or cost) associated with electrifying all or subsets of the federal fleet in both 2025 and 2030 along with the emissions benefits of those fleet conversions. The analysis is focused on light-duty vehicles and buses which have large and growing selections of commercially available EV alternatives and a relatively long commercialization history.

## Methods

Atlas staff modeled TCO for electric and conventional federal fleet vehicles using our in-house Dashboard for Rapid Vehicle Electrification (DRVE) Excel-based tool [1]. TCO is a metric used to compare two or more capital investment options and accounts for costs across the entire capital equipment lifecycle: from acquisition to operation to decommissioning and residual value. A lower TCO indicates a vehicle that will cost less to operate over the life of the vehicle. TCO models costs as negative cash flow in a discounted cash flow framework which combines costs that occur across time into one present-value<sup>2</sup> figure. TCO modeling is most valuable when comparing alternatives that trade off higher upfront costs with operational cost savings—an important feature when comparing EVs with their conventional counterparts.

We conducted the TCO analysis on a by-vehicle type and by-agency basis using vehicle inventories from the 2019 GSA Federal Fleet Report and the 2020 Office of Inspector General report on the Postal Service fleet. For each agency and vehicle type, the DRVE tool takes input parameters for: vehicle and charger prices, mileage, maintenance, fuel efficiency, fuel price, social cost of carbon, useful life, and residual value to compute a TCO for a conventional vehicle and its EV replacement.<sup>3</sup> By varying these inputs, the DRVE tool

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<sup>2</sup> Present value is an accounting concept that allows income and expenses that occur at different times to be compared against each other. Future dollars are worth less than present dollars and thus must be discounted to present value to be compared. We use a 3 percent real discount rate which is conservative given current trends in federal borrowing costs. This means that we are likely underestimating the savings of switching to EVs.

<sup>3</sup> For each vehicle type, the DRVE tool maps the closest comparable EV vehicle to existing fleet vehicles. For a complete accounting of model inputs and assumptions see Appendix A.



accommodates different scenarios including assumptions about the price trajectory of EVs over the study period and the costs associated with installing EV charging infrastructure.

The TCO analysis results presented in the following section are derived from the default Atlas scenario. In this scenario, we assume that EV costs decline over time due to economies of scale and battery improvements.<sup>4</sup> The scenario also assumes that light-duty federal fleet vehicles will be able to share charging equipment due to relatively low daily driving distances. While these assumptions are realistic, we describe the implications of making these assumptions and how sensitive the analysis findings are to them later in the brief. The Atlas scenario also accounts for the social cost of carbon<sup>5</sup> as recommended by the *Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis* [2].

In addition to the TCO analysis, Atlas also conducted an emissions analysis using the DRVE tool. This analysis compares emissions of greenhouse gas (GHG) and air quality pollutants between EVs and conventionally fueled vehicles. While GHG benefits are monetized into the TCO estimates using the social cost of carbon, the air quality emission analysis only estimates changes in total pollutant emissions. We do not monetize air quality benefits in this analysis.

The analysis accounts for all energy-related emissions—known as a well-to-wheel emissions—to accurately compare emissions between EVs, where emissions occur upstream at electric power plants, and the tailpipe emissions of pollutants from conventional vehicles. Well-to-wheel emissions also include emissions from the extraction refining and transport of fuel used both in power plants and directly in vehicles. Because federal fleet vehicles only stay in the fleet for a portion of their overall lifecycle (retired vehicles are sold on the secondary market) the emissions analysis is limited to energy-related emissions and does not include vehicle manufacturing lifecycle emissions.

## TCO Analysis

We find that federal fleets can realize large cost savings (and emissions benefits) by beginning to adopt EVs early in the 2020s. If in 2025, federal fleet managers (for all agencies other than the USPS) replaced all their vehicles and chose to electrify only those where the

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<sup>4</sup> The default technology scenario is based on the R&D success scenario modeled by Argonne National Labs in *Energy Consumption and Cost Reduction of Future Light-Duty Vehicles through Advanced Vehicle Technologies: A Modeling Simulation Study Through 2050*.

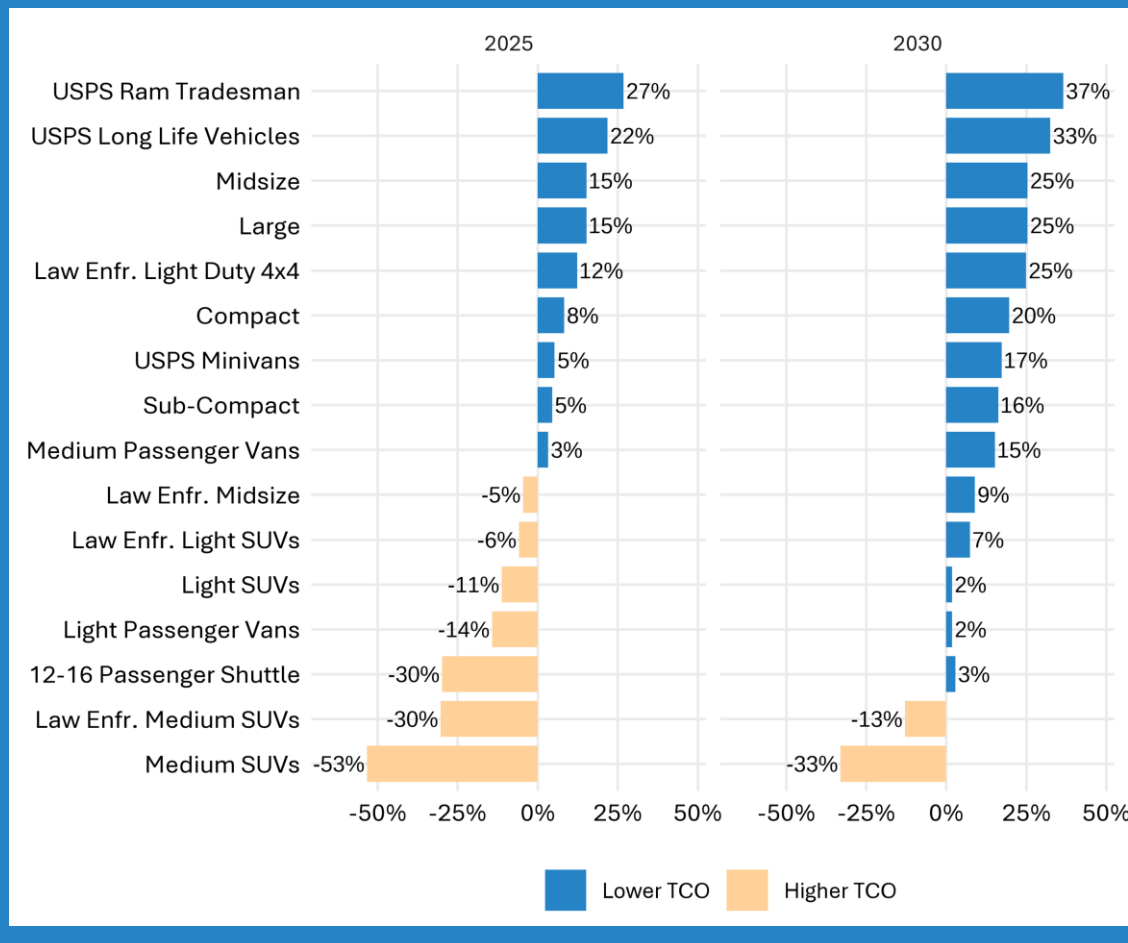
<sup>5</sup> The social cost of carbon is a measure of the future monetized damage one ton of carbon dioxide emissions will inflict on society due to the impacts of climate change.

### Box 1: Special Case—the U.S. Postal Service

The U.S. Postal Service (USPS) is an independent agency of the U.S. Government and controls the largest fleet of vehicles by far of any agency. Its large size and independent nature make it unique among federal agencies, which is why we have separated USPS results from the remainder of the federal fleet analysis.

The USPS offers a uniquely strong case for vehicle electrification. By 2025, it will be cheaper to use an EV over a conventional vehicle for more than 99 percent of the USPS fleet of light vehicles. If USPS was to electrify all those vehicles in 2025, it would save \$2.9 billion dollars over the life of those vehicles. By 2030, that figure increases to nearly 100 percent of vehicles and would see \$4.6 billion in savings. USPS mail trucks (Long Life Vehicles) alone account for \$2.8 billion and \$4.3 billion in savings in 2025 and 2030 respectively.

Figure 3: EV TCO percentage savings compared to conventional vehicles in 2025 and 2030



TCO of the electric vehicle is less than the TCO of the conventional alternative, they would save \$316 million over the life of the replaced vehicles. If in the same year, fleet managers chose to electrify all vehicles within 14 percent of the TCO of a conventional counterpart, they would electrify more than twice the number of vehicles at a savings of about \$8 Million combined across all agencies. In 2030, reductions in EV purchase prices improve the economics considerably, making the same choices deliver \$1.18 billion or \$1.12 billion in savings, respectively, with nearly all light-duty vehicles and buses being electrified in both circumstances.

The above aggregate cost savings estimates are useful for understanding the potential economic benefits of switching to EVs when large portions of the federal fleet are electrified. However, the DRVE tool does not simulate fleet turnover when generating aggregate cost savings estimates, meaning that figures described here are what would occur if all vehicles were replaced in 2025 and again in 2030. In reality, vehicles in the federal fleet are not replaced all at once, but whenever they each reach the end of their useful life.<sup>6</sup> This means that there will be opportunities to electrify vehicles immediately, with more EV replacements becoming viable each year. Most vehicles in the federal fleet have a lifecycle of less than 10 years, meaning that there will be a near complete turnover of federal fleet vehicles between this report's publication in 2021 and the end of the decade.

## Reinvesting Savings into Rapid Electrification

Savings realized from electrifying vehicles with favorable TCOs can be reinvested in electrifying vehicles that do not quite beat the TCO of conventional vehicles. DRVE modeling suggests that by 2025, the savings from cost-competitive EVs could offset all the costs of electrifying vehicle classes within 14 percent of cost parity with conventional vehicles—allowing for the electrification of 176,000 more vehicles before the end of the decade. This can be a budget neutral way of paying for more rapid vehicle electrification than would be possible from only electrifying vehicles where the TCO for EVs is lower than conventional vehicles. This strategy is particularly important in the middle of the decade when there will be significant savings available from the TCO competitive vehicles but also many vehicle types where EV TCOs are close to, but not quite competitive with conventional counterparts. Those vehicles could nonetheless be electrified, delivering earlier and more

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<sup>6</sup> It is likely the case that the return on investment for some EVs is high enough to justify early retirement of some conventional vehicles; however, TCO analysis frameworks are not well suited to identify those opportunities.



emissions benefits than would occur if federal agencies wait an additional vehicle lifespan to electrify.

## Comparative TCOs of Federal Fleet Vehicles in 2025

By 2025, about 40 percent of all light-duty vehicles operated by federal agencies other than the USPS will have a lower total cost of ownership (TCO) compared with conventional vehicles. An additional 56 percent of total fleet vehicles are in categories where their TCOs fall within 14 percent of their conventional counterparts. Because many of these fleet vehicles are replaced as frequently as every five years, this represents a significant opportunity for federal fleets to electrify large portions of their fleet before the end of the decade.

Figure 4: EV TCO percentage savings compared to conventional vehicles in 2025

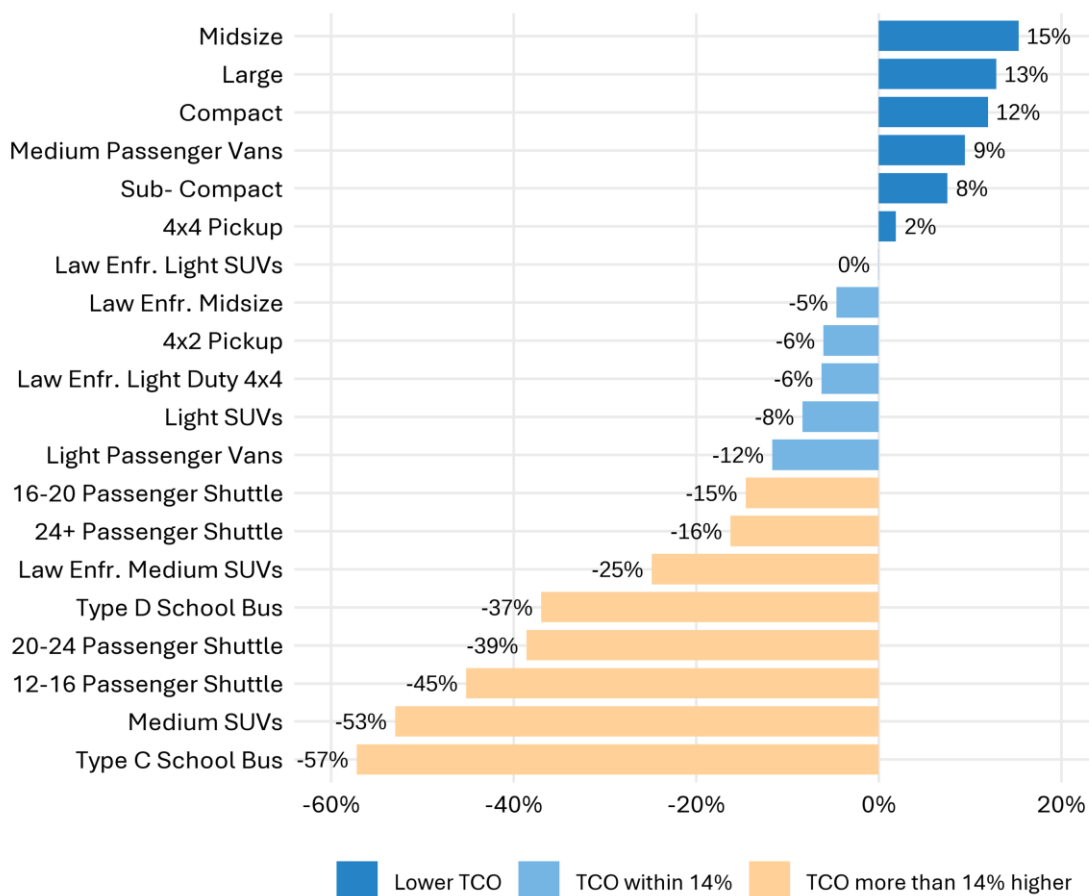


Figure 4 shows relative TCO savings (or costs) associated with each vehicle class in the federal fleet. Vehicle classes with a relative TCO percentages above zero are where EVs are less expensive than their conventional alternative on a TCO basis. The opposite is true for

percentages below zero. Per-vehicle-class TCO comparisons are an average across all vehicles of that type across the fleet.

In the near term, EVs remain more expensive to purchase than conventional vehicles. That means for an EV to have a better TCO than its conventional counterpart it must deliver more operational cost savings than the price premium of the vehicle. Whether EVs have a TCO advantage is driven by four key factors:

- 1) the price premium for the EV
- 2) the number of miles the vehicle is driven
- 3) how fuel-efficient the conventional vehicle is compared to the EV alternative
- 4) fuel costs<sup>7</sup>

### Passenger vehicles

Passenger electric vehicles in all size classes outperform their conventional counterparts by wide margins in 2025. Electric medium passenger vans also outperform their conventional counterparts by 2025; however, electric light passenger vans do not because there are currently no fully-electric light passenger van alternatives available. As a result, the DRVE tool uses the same medium-duty Ford E-Transit passenger van as the comparison vehicle for both medium and light passenger vans. The smaller conventional vans are more fuel efficient than the medium duty vans and drive fewer miles on average making the comparison less favorable. As a result, Ford E-Transits do not outperform conventional light passenger van alternatives in 2025.

### Pickup trucks<sup>8</sup>

Electric light 4x4 pickup trucks moderately beat their conventional counterparts on a TCO basis in 2025 but electric 4x2 pickup trucks underperform conventional alternatives. Similar to the light-duty vans, there is no directly comparable electric 4x2 pickup truck currently available or announced. Therefore, the 4x4 Ford F-150 Lightning is used as the comparison electric vehicle for both 4x2 and 4x4 conventional trucks. Because conventional 4x2 trucks

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<sup>7</sup> In a typical vehicle TCO outcomes will be very sensitive to the difference in price between electricity and liquid fuels. However, in this analysis, the same national average fuel costs are used for all vehicles and agencies.

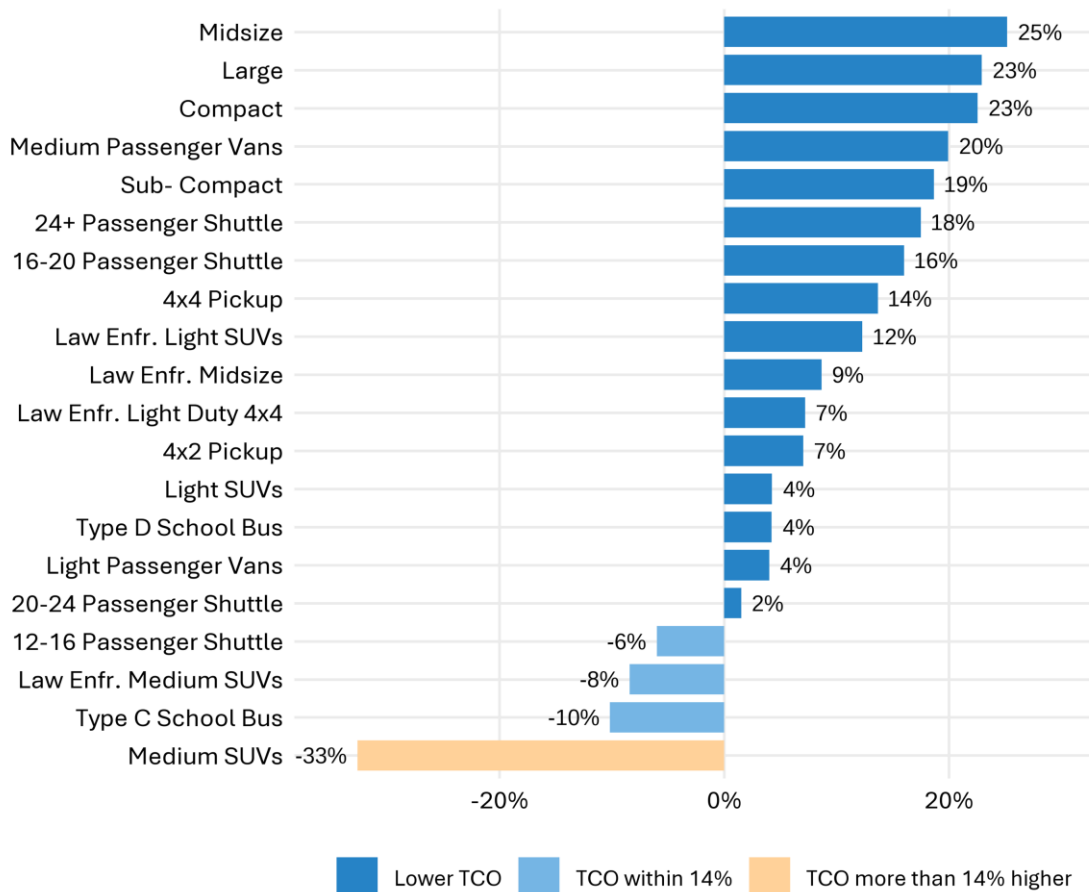
<sup>8</sup> Flatbed and work trucks are not included in Figure 4 or Figure 5. They have the largest modeled TCO advantages over conventional counterparts. However, that is in part because the DRVE tool is comparing Ford F-250 super duty trucks used by federal fleets to Ford F-150 Lightning EVs which are substantially less expensive. Ford has not yet announced an EV version of the F-250 and while the F-150 Lightning outperforms conventional F-150 trucks, it does not perfectly match the capabilities of F-250 trucks. This means that some flatbed and work trucks may not yet be electrifiable. There are only 4,308 of these trucks in the federal fleets.

are much cheaper than 4x4s, drive fewer miles and are slightly more fuel efficient, the F-150 Lightning compares less favorably in the 4x2 pickup application.

## Comparative TCOs of Federal Fleet Vehicles in 2030

Figure 5 shows that by 2030, electric vehicles across most vehicle types have average TCOs that are less than their conventional counterparts. These vehicle categories represent the vast majority of the federal light vehicle and bus fleet. From 2030, as many as 97 percent of the vehicles in the federal fleet—should they be retired—would be cheaper to replace with an EV than a conventional vehicle.

Figure 5: EV TCO percentage savings compared to conventional vehicles in 2030



The expansion of TCO competitive vehicles is driven primarily by cost reductions for electric drivetrains forecasted by the U.S. Department of Energy. This closes the upfront cost gap between EVs and conventional vehicles, making it much more likely that the operational savings realized by EVs will outweigh any remaining price premium.

While EVs hold a comparative advantage in most vehicle categories by 2030, 12-16 passenger shuttles, law enforcement and non-law enforcement medium SUVs, and type-C school buses remain at a disadvantage compared to their conventional counterparts on a TCO basis.

There is currently no direct EV alternative for 12-16 passenger shuttles. The closest alternative in that range is the EV Star 19 passenger shuttle, which is the same alternative vehicle for the 16-20 passenger shuttle class. In the 16-20 passenger shuttle class, the EV Star has a significantly lower TCO than its conventional counterpart. However, because the comparison conventional vehicle for the 12-16 passenger shuttle is less expensive and far more fuel efficient than the conventional model 16-20 passenger shuttle, the comparative TCO for the 12-16 passenger shuttle remains more expensive.

Both the law enforcement and non-law enforcement electric medium SUV options are based on the Rivian R1S, which is about twice as expensive as the conventional vehicles for those use cases. While the DRVE tool simulates vehicle cost reductions over time, the large cost premium of the EV alternative continues to dominate the TCO in 2030 leaving these vehicles uncompetitive. The R1S is a luxury SUV and thus is not well suited for most federal fleet purposes. Depending on the price point of more standard EV SUVs when they become available—such as the recently announced Electric Ford Explorer [3]—the viability of electric medium SUVs in federal fleets by 2030 may increase considerably.

Under the assumptions used in this analysis, Electric type C school buses remain significantly more expensive than conventional counterparts through the remainder of the decade. Because type C school buses in the federal fleet travel relatively few miles, fuel and maintenance savings do not outweigh the upfront price premium. However, due to their large battery sizes and operating patterns, electrified school buses may be able to provide additional value to federal agencies by providing vehicle-to-grid (V2G) services,<sup>9</sup> which might provide significant cost offsets. Multiple utility pilot programs are currently underway to test the viability of school bus V2G applications [4]. However, these additional sources of value were not considered in this analysis.

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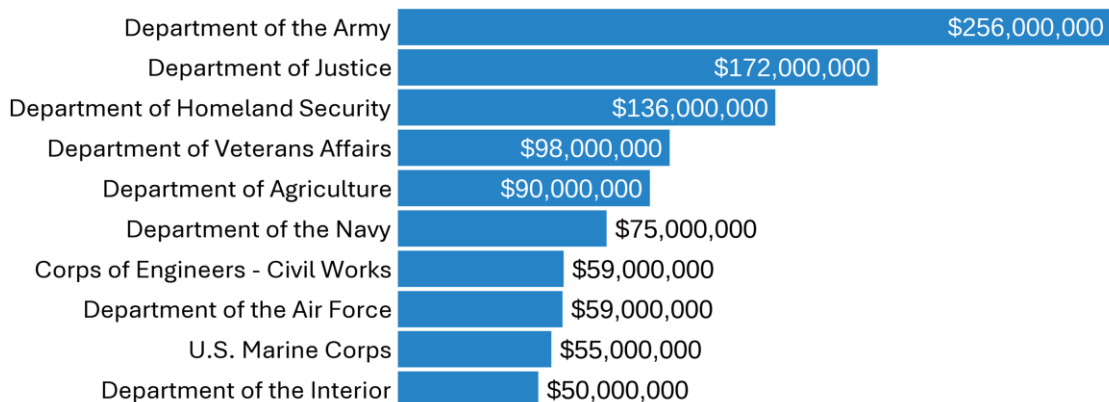
<sup>9</sup> V2G services are where an idle and plugged in EV returns electricity stored in its traction battery back to the electrical grid to provide grid services or respond to peak electrical demand. This in turn generates revenue for the vehicle operator. With their large batteries and long idle times, school buses are potentially well suited to this application.

## EV Cost Savings by Agency

Switching vehicles with lower TCOs can deliver significant cost savings to taxpayers, with as much as a \$1.18 billion dollars in cumulative savings across all vehicles in 2030. While not all vehicles will be up for replacement at once, relatively short vehicle lifecycles in the federal fleet mean that turnover happens frequently, and savings should accrue quickly.

Savings are unevenly distributed across the fleet, with larger agencies with more vehicles to convert making up a large share of the total savings. The top ten agencies by total savings (see Figure 6) account for more than 85 percent of the savings across the entire fleet. While total savings are unquestionably correlated with the number of vehicles each agency maintains, the makeup of vehicles in each agency has large impacts on the savings amounts. For example, the Department of the Army has considerably more potential savings from EVs than either the Department of Justice or Homeland Security, despite having around the same number of vehicles to electrify. This is because the Army has more of the vehicle types with highly favorable TCOs. The same pattern can be observed with the Department of Civil Works, which is ranked seventh despite having far fewer vehicles to electrify than those ranked eighth, ninth, or tenth.

Figure 6: Savings from electrifying all TCO competitive vehicles in 2030, top ten agencies



## DRVE Tool Assumptions and Scenario Analysis

The results presented in this brief are informed by the best available public data and represent the set of conditions we believe is most likely to reflect reality in the near future. Like any forecast, however, a TCO analysis depends on several inputs with varying degrees of certainty, meaning the assumptions we make can have noticeable impact on the outcome.

In addition, the Atlas default scenario includes the social cost of carbon which increases the financial benefits of EV use relative to a private-costs-only analysis. In this section we discuss the impact of our assumptions and scenario choices have on the outcome of the analysis.

### Sensitivity to distance vehicles travel

The relative difference in TCO between an EV and a conventionally fueled vehicle are highly sensitive to the number of miles that the vehicle will drive. Electric powertrains are both more fuel efficient and less complex than conventional fuel powertrains. That increased efficiency means that EVs cost less to fuel and the decrease in complexity means they cost less to maintain. These two factors translate into lower operating costs for electric vehicles. However, the magnitude savings is a function of how much the vehicle will drive because both fuel and maintenance costs are functions of distance traveled. EVs remain more expensive to purchase in the near term (and will initially require charging equipment investments), so for an EV to compete with a conventional vehicle it must provide enough operational savings to offset that price premium.<sup>10</sup>

Federal fleet vehicles are not driven very far on average. Short duty cycles are in one sense a benefit to electrification because it means that daily vehicle mileage is considerably less than the typical ranges of new electric vehicle models, eliminating range as a practical constraint on electrification. However, that attribute also makes the economics of switching to electrics less favorable than if federal fleet vehicles saw more use and thus could accrue more fuel cost savings.

The sensitivity of TCO savings to vehicle use has key implications for the results of this study and for electrification plans made by federal fleet managers. The TCO estimates calculated by the DRVE tool are based on average mileage estimates per vehicle. In real world usage, vehicles will be driven across a wide range of daily mileage that will vary by specific use cases and geography. That means that at an individual level some vehicles will have lower comparative TCOs than others and will therefore be even better candidates for electrification than the DRVE tool suggests. Others will be driven less and therefore compare less favorably to conventional vehicles. Fleet managers have access to ground level

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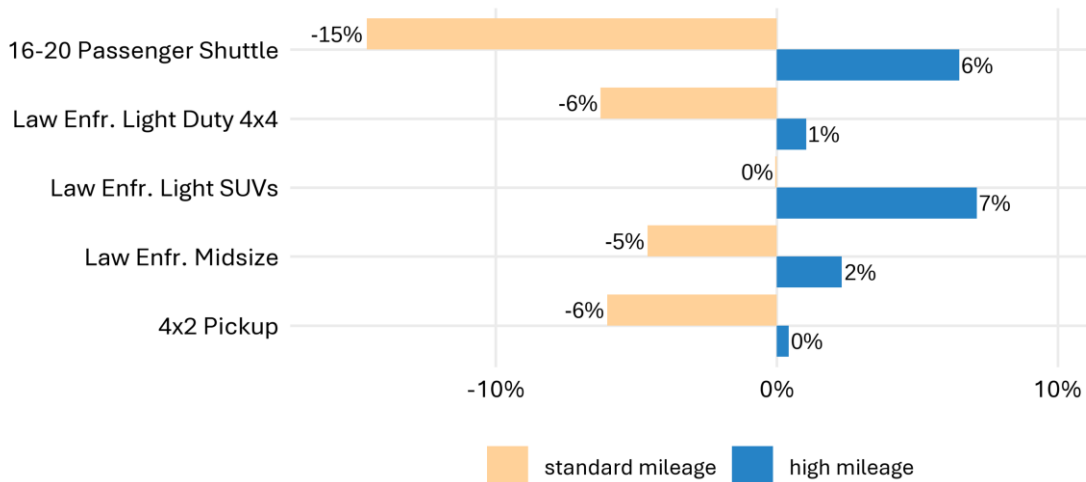
<sup>10</sup> Because TCO analysis uses a discounted cash flow framework to adjust future-value operational costs back to present-value figures, operational savings must exceed the cost premium in nominal terms. The exact amount by which they must exceed the initial difference in costs is determined by the length of time over which operational costs accrue and the chosen discount rate.



information about the operations of their fleets and therefore have the capacity to conduct much more specific TCO analyses when planning to replace vehicles in their fleet.

To simulate potential TCO results for fleet vehicles with longer than average duty cycles, we created a synthetic sub-fleet of vehicles with annual mileage greater than one standard deviation<sup>11</sup> above the mean mileage of federal fleet vehicles and then computed the TCO for those vehicles using DRIVE. These vehicles have substantially better comparative TCO than the average fleet vehicle which is especially notable in 2025 when upfront EV costs are higher than in 2030. Figure 7 shows which vehicle types become TCO competitive under high mileage conditions in 2025.

Figure 7: EV TCO percent savings compared between standard and high mileage scenarios in 2025



## Sensitivity to charging equipment deployment costs

Electric vehicles require a completely new refueling (charging) infrastructure. The deployment of charging infrastructure is an important cost consideration in switching to EVs because it loads additional upfront costs into EV TCOs. Fueling with electricity is much slower than fueling with liquid fuels in general, meaning that more fueling equipment is required per vehicle to supply energy needs. The ratio of charging equipment to vehicles is

<sup>11</sup> Atlas assumes that the standard deviation of Federal fleet vehicles is the same as those of state vehicles in Washington State and that miles traveled is normally distributed across vehicles.

therefore an important cost driver. If each vehicle requires its own charger, costs will be much higher than if vehicles can share two or more chargers.

In the case of charging infrastructure costs, the relatively low usage of federal fleet vehicles works well for electrification. Federal fleet vehicles drive considerably less per day than the range of typical EVs which means that they may be able to go several days without charging. This will allow multiple vehicles to share a single charger simply by alternating days on which they charge.

The assumption of charger sharing is built into Atlas's default DRVE scenario. When we run a DRVE scenario where vehicles all require their own charging infrastructure, it considerably decreases the number of vehicles that exceed TCO parity with conventional vehicles. In 2030, that scenario estimates that only 66,000 vehicles will have TCO advantage over conventional vehicles, compared to 306,000 in the default scenario.

Efficient use of charging is critical to EV TCO savings in the short term. Fleet managers planning to electrify their fleets should think strategically about how effectively the vehicles under their purview can share charging because the better they can right size their charging infrastructure deployment, the more savings they will realize from switching to EVs.

### **Sensitivity to assumptions about EV technology development**

Vehicle purchase price is the largest component of TCO and thus variations in purchase price will drive large changes in TCO. In the last decade, technological progress in EV powertrains has outpaced expectations, causing large improvements in EV capabilities and corresponding decreases in EV price. However, the pace of technological change in the future is uncertain. In the Atlas default scenario, we assume that the cost of EVs will fall over time in accordance with research and development targets set by the U.S. Department of Energy's (DOE) Vehicle Technology Office. The DRVE tool forecasts vehicle price reductions based on DOE's forecasts [5].<sup>12</sup> Given the EV industry's record of innovation, we believe that the DOE's success scenario is the closest model for technological advancement in the coming decade.

However, to accommodate the uncertainty inherent in predicting future trends, the DRVE tool also models a technology scenario in line with DOE's more conservative business-as-usual case. In this scenario, only 214,000 vehicles meet TCO parity in 2030 compared to

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<sup>12</sup> See DRVE User Guide, Appendix B for a detailed description of how Atlas estimates vehicle prices from DOE's technology forecasts.

306,000 in the default scenario. Unlike in the Atlas scenario, there are no TCO-parity EV buses or passenger vans in the federal fleets under the business-as-usual case.

## Impact of internalizing the social cost of carbon

The DRVE tool internalizes the social costs of carbon dioxide emissions into the TCO analysis by including the social cost of carbon in the operating costs of EV and conventional vehicles, treating carbon emissions similarly to operating expenditures like fuel. When we conduct the analysis using only private costs, EVs perform moderately worse on a TCO basis than they do when social costs of carbon are included.

In 2025, 30 percent fewer vehicles<sup>13</sup> are TCO competitive when the social cost of carbon is excluded. In addition, the total savings realized by switching to EVs falls by almost half, from \$316 million to \$185 million. In 2030 the impact of excluding the social cost of carbon on vehicle type viability is much smaller, only removing 20-24 passenger shuttles from TCO competitiveness. However, discounting the cost of carbon in 2030 reduces total savings from \$1.18 billion to \$767 million.

# Emissions Analysis

The DRVE model estimates both greenhouse gas and air quality pollutant emissions from conventional vehicles and their alternative. Switching from conventionally fueled vehicles to electric vehicles eliminates all direct tailpipe pollutant emissions from the vehicle. Electric vehicles consume electricity, which causes emissions upstream at electric power stations. However, because electric power generators are generally cleaner and more efficient than the internal combustion engine in conventional vehicles,<sup>14</sup> total emissions from EVs are lower than from their conventionally fueled counterparts.

## Greenhouse Gases

Greenhouse gases (GHG) trap heat in the atmosphere and contribute to climate change. In this analysis we focus on carbon dioxide, methane, and nitrous oxide—the three primary

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<sup>13</sup> Excluding the social cost of carbon renders 4x2 pickup trucks (a large portion of the federal fleet) non-competitive.

<sup>14</sup> Approximately 38 percent of U.S. electricity in 2020 is generated by non-polluting sources such as hydro-power, nuclear power, and renewables. However, even fossil fueled electricity generation is more efficient than internal combustion engines due to scale and more efficient operations.

GHGs produced by vehicle use [6]. The DRVE model combines all three GHGs into a single 100-year carbon dioxide equivalent unit<sup>15</sup> (CO<sub>2</sub>e-100) for easy comparison.

For the non-USPS federal fleet vehicles, electrifying all TCO competitive vehicles in 2025 will deliver 3.2 megatons<sup>16</sup> of CO<sub>2</sub>e-100 emissions over the life of all electrified vehicles. That is the equivalent of 380,000 household's annual energy use emissions. In 2030 TCO competitive vehicles will deliver 7.6 megatons of CO<sub>2</sub>e-100 reductions—the equivalent of energy use emissions of 915,000 homes. The USPS fleet offers an even stronger GHG reduction case, delivering 12.8 megatons CO<sub>2</sub>e-100 of emissions reductions in 2025 and 11.6 in 2030.

It is somewhat counterintuitive that emissions savings would go down between 2025 and 2030 in the USPS fleet. That reduction is due to improvements in vehicle fuel economy outpacing improvements in electrical grid GHG emissions between 2025 and 2030. It is also caused by the model being unable to forecast reductions in grid emissions that would occur over the life of an electric vehicle acquired in 2030. This is occurring in both the USPS and non-USPS fleet. However, in the non-USPS fleet, enough new vehicles become TCO competitive in 2030 to mask the effect whereas most postal vehicles are TCO competitive in 2025.

## Air Quality Emissions

Burning fuel in vehicles or at a power plant causes emissions of air pollutants that harm human health. In this analysis we focus on three key damaging pollutants: oxides of nitrogen (NO<sub>x</sub>), sulfur dioxide (SO<sub>2</sub>), and primary fine particulate matter (PM<sub>2.5</sub>). NO<sub>x</sub> is formed when oxygen reacts with nitrogen in the air during combustion, and SO<sub>2</sub> is formed from the same reaction with sulfur compounds in the fuel. Both pollutants cause respiratory effects when inhaled and form secondary fine particulate matter in atmospheric reactions. [7] [8] PM<sub>2.5</sub> is soot, comprised of 2.5 micron or smaller sized particles or aerosols that result from incomplete combustion of fuel and non-combustible materials in fuel. PM<sub>2.5</sub> enters deep into the lungs when inhaled and is associated with asthma, cardiovascular and respiratory illness, and premature death [9]. Of the three, primary PM<sub>2.5</sub> is the most dangerous to human health, while the primary damage caused by NO<sub>x</sub> and SO<sub>2</sub> is from the formation of

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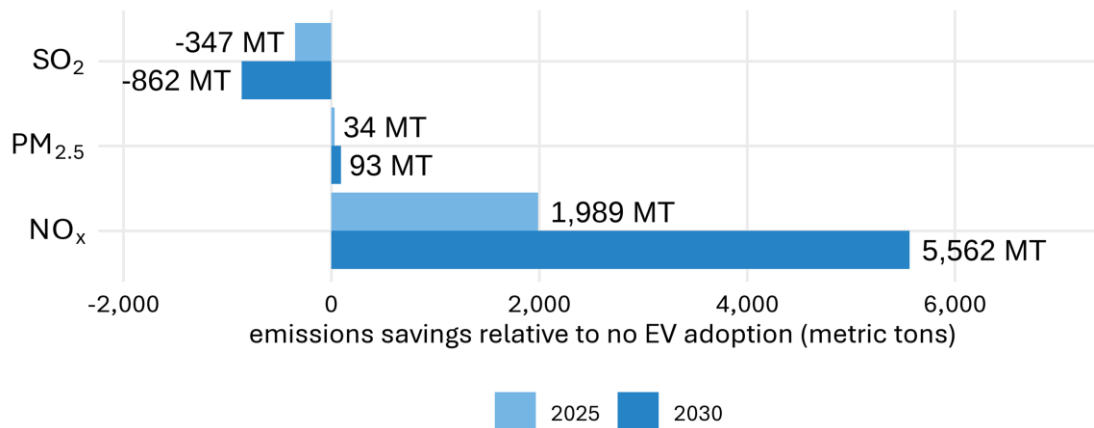
<sup>15</sup> Methane and nitrous oxide contribute more to climate change than carbon dioxide over a 100-year time scale. The CO<sub>2</sub>e unit takes into account those differences and combines the emissions to produce one comparable figure.

<sup>16</sup> One million metric tons

secondary PM<sub>2.5</sub> [9]. However, NO<sub>x</sub> also contributes to ground level ozone and SO<sub>2</sub> can cause acid rain [7] [8].

Figure 8 shows the comparative savings of pollutant emissions for the non-USPS federal fleet when all TCO competitive vehicles are electrified in 2025 and 2030. For both direct PM<sub>2.5</sub> emissions and NO<sub>x</sub> emissions, emissions from electricity generation are substantially lower than tailpipe emissions from conventional vehicles. However, EVs cause more emissions of SO<sub>2</sub> than conventional vehicles. This is because coal contains high quantities of sulfuric compounds and coal power plants (especially older units with fewer emissions controls) emit very high levels of SO<sub>2</sub>. On the other hand, gasoline, and diesel in the United States is de-sulfured during the refining process.

Figure 8: Well-to-wheel air pollutant emissions impacts of electrification: 2025 and 2030



While electric vehicles currently cause an increase in SO<sub>2</sub> emissions, the negative effects of those emissions are swamped by the positive effects of reduced PM<sub>2.5</sub> and NO<sub>x</sub> emissions (as depicted in Figure 8).<sup>17</sup> Moreover, because power plants tend to be located further from

<sup>17</sup> Unlike GHG which is a global pollutant, air pollutant impacts are local and dependent on where the emissions occur, weather patterns, nonlinear atmospheric chemical reactions and transport, and ultimately population exposure. Moreover, some pollutants (such as direct PM<sub>2.5</sub>) cause much more damage to health than others (like SO<sub>2</sub>) on a mass-equivalent basis. Also, on average, emissions from on-road mobile sources are more damaging than those that come power plants. These factors combine to strongly suggest that the net impact of air pollutant emissions changes estimated in this analysis would be positive. To fully estimate the differential in impact would require a spatially explicit inventory of emissions changes and the use of an air quality model to estimate population exposure which is outside the scope of this study.

population centers, and vehicles are driven through population centers, tailpipe emissions cause more damage than emissions from power plants [10].

Results from the air quality emissions analysis of USPS fleet vehicles are complicated by an artifact of the model that makes it appear that electrifying postal service vehicles would lead to increases in  $PM_{2.5}$  and  $NO_x$  in addition to  $SO_2$ . This is due to a mismatch in the model between the conventional mail truck (long life vehicle) and the EV alternative the Work-horse C-650. The C-650 is rated to carry much more cargo than the USPS long life vehicle, and thus consumes more electricity per mile than a closer comparison vehicle would. The mismatch is enough to push the emissions rate for the comparison EV higher than the conventional vehicle. Because the USPS fleet is dominated by long life vehicles, the DRVE model results show an increase in all air quality emissions for all pollutants. It is likely that a more directly comparable vehicle (such as the Oshkosh EV [11]) would not cause the same results had data been available on such a vehicle.

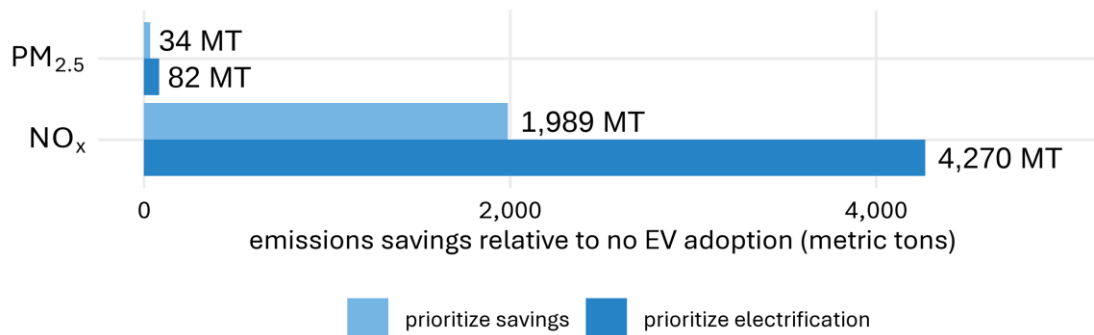
## Benefits of Rapid Electrification

While the DRVE tool takes into account the monetary value of GHG emissions reductions, it does not account for the benefits of reduced air quality pollutant emissions. Air quality emissions cause human harm now and earlier electrification will lead to fewer harms over time. Therefore, faster electrification provides significant public benefits. This is illustrated by comparing the air pollutant emissions benefits of a savings--oriented policy of only electrifying vehicles with competitive TCOs with a rapid electrification strategy that reinvests electrification savings into faster electrification of less competitive vehicle types.

Figure 9 shows that when savings are reinvested in vehicles that are within 14 percent of TCO parity, potential air quality emissions benefits more than double, at no-more cost than federal fleets would have spent with no electrification. If federal fleets reinvested savings into additional electrification for those vehicles that are not quite competitive between 2025 and 2030, they could avoid adding heavier polluting vehicles to the fleet where they would stay, continuing to pollute, until they reach the end of their useful life.



Figure 9: Comparative emissions reductions (in metric tons) between savings oriented and rapid electrification strategies



## Conclusions and Next Steps for Federal Fleets

Atlas's analysis has illustrated that electrifying much of the federal fleet not only produces large environmental benefits, it can also deliver significant cost savings for federal agency budgets. While the economic benefits of switching to electric fleets grows considerably over the next decade, our analysis shows that electrifying as many as 40 percent of all non-USPS federal fleet vehicles could yield a net savings in 2025 and the USPS has the opportunity to electrify most of its fleet early in the coming decade. In addition, due to variation in miles traveled by individual vehicles, there are likely to be vehicle replacements currently in the pipeline where federal fleets would save money if they were electrified prior to 2025. This suggests that federal fleets should already be planning on incorporating EVs into their fleets and recent evidence suggests this process is already underway [12]. Moreover, they should expect that a large majority of vehicles put into service this decade could be electric.

## Plan for Near-future EV Deployment

Fleet managers across agencies should plan now for electrification. Agencies should determine the threshold at which fleets might consider electrifying vehicles which do not meet TCO parity to reinvest savings into faster electrification and more societal benefits in the form of earlier emissions reductions. They should update their procurement strategies to build TCO comparisons with EV alternatives into their normal procurement processes with commitments to electrify vehicles that meet or exceed electrification thresholds.

When planning to electrify their fleets, fleet managers must recognize that adopting EVs will require larger initial capital outlays for more expensive vehicles and charger deployment and budget accordingly. Moreover, because TCO savings rely on reductions in operating budgets paying for higher upfront costs, agencies should make sure that capital budgets and operating budgets are not separated in the decision-making process for acquiring fleet vehicles.

As larger EV charging installs have lower costs on a per-charger basis—particularly the electrical service that supports charging equipment<sup>18</sup>—fleet managers should consider sizing early charging infrastructure builds to serve larger fleets of EVs. This will increase initial costs and impact immediate capital budgets. However, by planning for future electrification, overall capital costs for charging infrastructure can be reduced.

## Future Study on Medium- and Heavy-duty Vehicles

This analysis excludes medium- and heavy-duty fleet vehicles (other than buses) because these vehicles are very early in the commercialization phase and there is sparse public data with which to inform direct TCO analyses. However, there are an additional 142,000 medium- and heavy-duty vehicles in the federal fleet which may benefit from electrification in the near term.

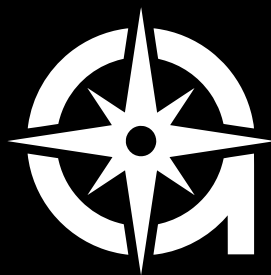
High level TCO analysis of medium- and heavy-duty segments should be revisited in the next 1–2 years when more vehicles in those classes have become commercially available. Moreover, fleet managers should not discount electric medium- and heavy-duty vehicles as they make replacement decisions for those vehicles in the near term. Especially where replacement vehicles will have high mileage, EVs may prove to be the least-cost option even early in the 2020s.

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<sup>18</sup> Installing EV charging equipment often requires significant construction activities such as trenching and running electrical conduit and might require upgrades to building electrical service. It is usually less expensive on a unit basis to build more of the underlying infrastructure at one time rather than to build as needed.

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