# Electric Fleets for Arizona

## SAVING TAXPAYERS MONEY THROUGH MUNICIPAL FLEET ELECTRIFICATION

Arizona PIRG Education Fund

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# Contents

# Executive summary

**CITIES AND TOWNS IN ARIZONA SPEND** millions of dollars each year to purchase, fuel and maintain a wide variety of fleet vehicles – sedans, pickup trucks, emergency vehicles, passenger vans, road maintenance vehicles and many more. Nearly all those vehicles are powered by gasoline or diesel fuel, which are costly and contribute to Arizona's air pollution.

Electric vehicles (EVs) can save money for cities and towns because they are cheaper to fuel and to maintain. A rarity just a decade ago, electric vehicles are becoming increasingly affordable and capable, and with automakers introducing new models every year, EVs are becoming a viable option for many of the tasks municipal vehicles are required to perform.

A survey of fleets in 10 of Arizona's largest municipalities shows large potential for cost savings from vehicle electrification. **Ten of Arizona's largest cities and towns could save a total of nearly $80 million in lifetime vehicle ownership costs by replacing light-duty vehicles in their fleets at the end of their useful lives with EVs.** Recently adopted federal legislation – including the bipartisan Infrastructure Investment and Jobs Act (IIJA) and the Inflation Reduction Act (IRA) – provides valuable new incentives for electric vehicles and infrastructure, making fleet electrification even more attractive to municipalities.

## Municipal governments responding to the survey

Chandler, Gilbert, Goodyear, Mesa, Peoria, Phoenix, Scottsdale, Surprise, Tempe, Tucson

Electrifying a municipal fleet is not as simple as switching out one kind of vehicle for another. It requires planning to provide the necessary charging infrastructure and identify the best opportunities for electrification, as well as workforce training to help fleet managers and drivers get the most benefit from the transition to electric vehicles. **Arizona cities and towns should commit to electrifying their fleets, develop detailed plans to guide the transition, and partner with other municipalities, as well as utilities and state government, to minimize the costs and maximize the benefits of electrification.**

**Replacing retiring light-duty cars and trucks with electric vehicles over the next decade can save 10 Arizona cities and towns a total of nearly $80 million in lifetime ownership expenses.**

**Ten of Arizona's largest municipalities collectively own thousands of vehicles and spend more than $110 million each year to purchase, fuel and maintain their fleets.**

- The 10 large Arizona cities and towns surveyed for this report (see text box, page 1) collectively own and operate more than 10,000 vehicles and pieces of equipment, from passenger sedans to dump trucks to fire engines to all-terrain vehicles. State and local governments in Arizona own a total of 48,000 registered motor vehicles.[1]

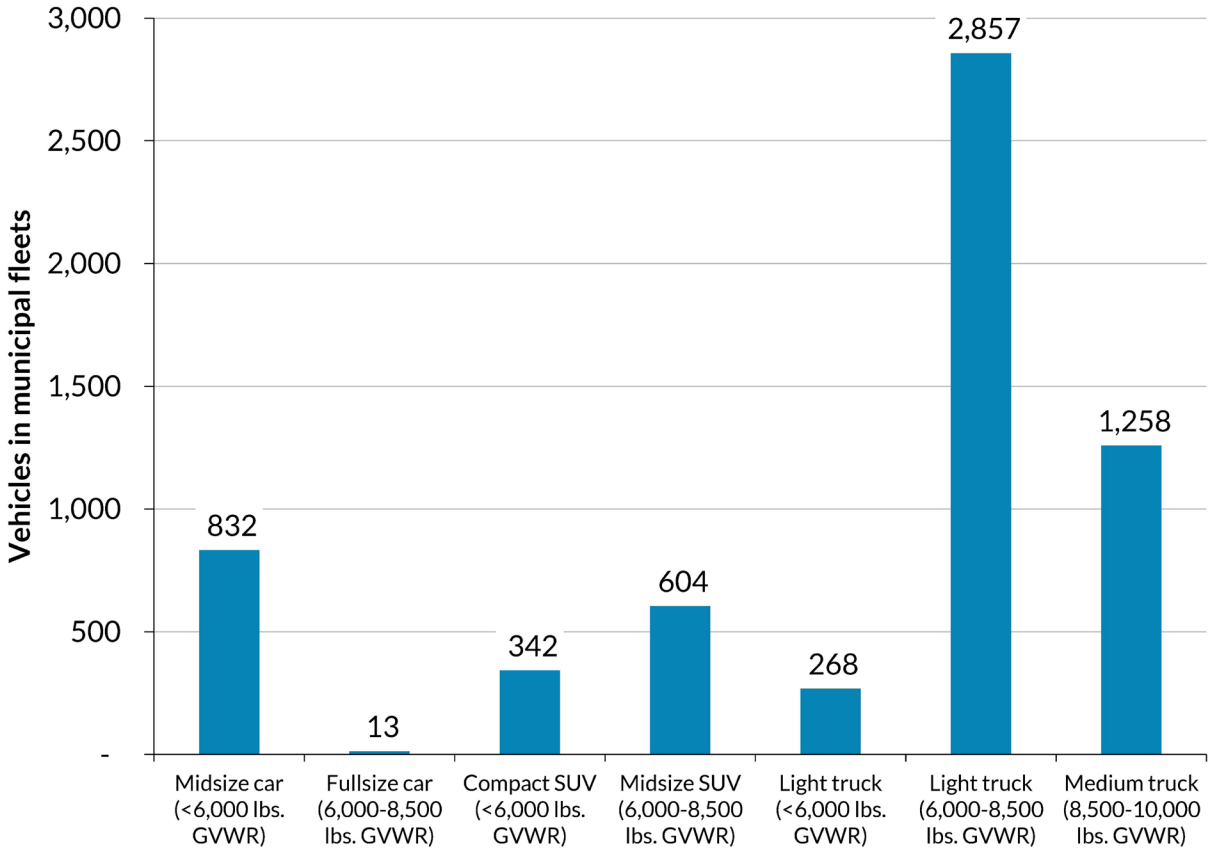
- About 6,100 of the vehicles currently owned by surveyed Arizona cities and towns are light-duty vehicles, which provide the best near-term opportunities for electrification.[2] About 70% of those vehicles are pickup trucks and vans, and roughly 40% of those vehicles are one of two models of half-ton pickups: the Ford F-150 and Chevy/GM Silverado/Sierra/1500 pickup. (See Figure ES-1.)

- There are very few electric vehicles currently in Arizona municipal fleets, with only 31 battery-electric vehicles and five plug-in hybrids in the light-duty fleets of the 10 municipalities studied at the time of the survey (late 2021).

- Cities and towns spend millions each year on vehicle purchases and on fuel and maintenance for their fleets.

  - Surveyed municipalities spent a total of $35.1 million to buy the model year 2020 and 2021 vehicles in their light-

**FIGURE ES-1. LIGHT-DUTY (<10,000 LBS. GROSS VEHICLE WEIGHT RATING) VEHICLES IN FLEETS BY TYPE, 10 OF ARIZONA'S LARGEST MUNICIPALITIES**



and medium-duty fleets, for an average of $34,511 per vehicle. Assuming these represent two years of vehicle purchases, the municipalities surveyed spend upwards of **$17.5 million on light-duty vehicle purchases per year**.[3]

- Total fleet maintenance costs exceeded **$65 million** in the most recent year of data available.[4]

- Fuel expenditures for the cities and towns totaled **$33.5 million** in the most recent year for which data were available.

**Electric vehicles are an emerging alternative to gasoline and diesel vehicles.**

- Electric vehicle technology is improving by leaps and bounds. Today's electric vehicles are more capable and cost less than the vehicles on the market just a few years ago, and there are many models to choose from.

  - The median driving range of new EVs tripled between 2011 and 2020, to over 250 miles per charge.[5]

  - Analysts now project the upfront costs of EVs will achieve parity with gasoline-powered vehicles by the mid-2020s.[6] Incentives available to municipalities under the IRA are expected to reduce or eliminate the difference in upfront costs between electric and gasoline- or diesel-powered vehicles.

  - Automakers are increasingly committing to electrifying their fleets. The Chrysler brand will offer a fully electric lineup by 2028, Volvo will sell only electric cars by 2030 and General Motors plans to sell only zero-emission vehicles by 2035.[7]

- There are viable electric alternatives for many of the vehicles in Arizona municipal fleets. Roughly 30 models of battery-electric vehicles, in approximately 80 configurations, were available in model year 2022, according to the U.S. EPA, with more arriving in model year 2023.[8] These vehicles include the Ford F-150 Lightning pickup, the electric version of one of the most popular vehicles in Arizona municipal fleets, which debuted in 2022. Plug-in hybrid vehicles provide another electric alternative for vehicle types for which fully electric alternatives do not currently exist.

**Arizona cities and towns can save tens of millions of dollars over the lifetime of their fleets – while helping to clean up Arizona's air – by switching to electric vehicles.**

- Over the next decade, the Arizona municipalities surveyed for this report are likely to need to replace over 4,000 light-duty vehicles.

- Replacing the light-duty vehicles in categories where cost-effective electric vehicles are available now or will be soon would save the Arizona cities and towns surveyed nearly $80 million in lifetime ownership costs, according to a model developed by the Argonne National Laboratory, reducing the total cost of ownership of those vehicles by 26% (not including one-time costs for the build-out of charging infrastructure). (See Table ES-1, next page.)

  The bulk of the savings result from reduced expenditures on fuel, maintenance and repair.

- Electrifying vehicles will also reduce air pollution, especially emissions of nitrogen oxides ($NO_x$) and volatile organic compounds (VOCs) that contribute to Arizona's problems with ozone smog. In the 10 large Arizona municipalities

**TABLE ES-1. COST SAVINGS FROM REPLACING RETIRING LIGHT-DUTY MUNICIPAL FLEET VEHICLES WITH EVS OVER NEXT 10 YEARS, 10 LARGE ARIZONA MUNICIPALITIES**

| Expense category | Lifetime savings (parentheses indicate increased expenses) |
|---|---|
| Vehicle cost (depreciation) | $(2,738,151) |
| Fuel | $52,607,048 |
| Diesel exhaust fluid | $258,897 |
| Maintenance and repair | $30,567,898 |
| Insurance | $(718,447) |
| **Total cost of ownership savings** | **$79,977,245** |

surveyed, the economic value of these air pollution reductions are estimated to approach $14 million over the lifetime of the vehicles.[9] While electrification would result in a small increase in emissions of large particulates ($PM_{10}$) from power plants in the short run, Arizona's electric grid is forecast to become much cleaner in the years ahead, leading to the additional air pollution reductions in the years to come.[10] (See Table ES-2.)

All 10 municipalities surveyed would save money over the lifetime of these light-duty vehicles by "going electric," with Phoenix alone saving more than $25 million. (See Table ES-3.)

- Medium- and heavy-duty vehicles – from large pickups to cargo vans to heavy equipment – will be increasingly attractive candidates for electrification as new vehicle models come on the

**TABLE ES-2. AIR QUALITY AND ENERGY BENEFITS FROM REPLACING RETIRING LIGHT-DUTY MUNICIPAL FLEET VEHICLES WITH EVS OVER NEXT 10 YEARS, 10 LARGE ARIZONA MUNICIPALITIES**

| Air quality and energy benefits | Total (parentheses indicate increased emissions) |
|---|---|
| Petroleum use (barrels) | 367,888 |
| Greenhouse gases (short tons) | 144,464 |
| CO (lbs.) | 1,341,488 |
| $NO_x$ (lbs.) | 65,855 |
| $PM_{10}$ (lbs.) | (874) |
| $PM_{2.5}$ (lbs.) | 4,001 |
| VOC (lbs.) | 198,919 |
| $SO_x$ (lbs.) | (289,472) |

**TABLE ES-3. TOTAL COST OF OWNERSHIP SAVINGS FROM REPLACING RETIRING LIGHT-DUTY MUNICIPAL FLEET VEHICLES WITH EVS OVER NEXT 10 YEARS, 10 LARGE ARIZONA MUNICIPALITIES**

| City or town | Total cost of ownership savings |
|---|---|
| Chandler | **$4,993,319** |
| Gilbert | **$3,539,318** |
| Goodyear | **$2,087,907** |
| Mesa | **$9,665,629** |
| Peoria | **$3,791,741** |
| Phoenix | **$25,110,149** |
| Scottsdale | **$11,420,301** |
| Surprise | **$2,042,132** |
| Tempe | **$2,582,594** |
| Tucson | **$14,744,155** |

market and costs decline. Commercial vehicle incentives under the IRA will make electrifying these vehicles even more attractive, defraying up to 30%, or $40,000 of the purchase cost of medium- and heavy-duty trucks and mobile equipment.[11]

- The financial benefits of electrification depend on how electric vehicles are used. Electric vehicles currently in Arizona municipal fleets are driven fewer miles on average than gasoline- and diesel-powered vehicles. Municipalities seeking to reap the full benefits of electrification must carefully integrate EVs into their fleets, aligning charging and use schedules to ensure that EVs are able to replace as much gasoline- and diesel-fueled travel as possible.

**Arizona cities and towns should move swiftly and boldly to take advantage of the potential for electrifying their fleets. Municipalities should:**

- **Make bold commitments and stick to them.** Setting a goal of phasing out gasoline and diesel vehicles as electric versions of those vehicles become available can focus all departments of municipal government (including those with important roles such as facilities managers) on the task of transitioning to EVs and create economies of scale in vehicle purchasing and charging.

- **Develop a municipal electrification plan.** Electrifying a municipal fleet requires more than just a commitment from fleet managers or policy makers. It requires planning by every part of municipal

government as well as the electric utilities serving the municipality. An electrification plan can help municipalities identify the best near-term targets for electrification and ensure that EVs and charging infrastructure are deployed in ways that are best suited to helping cities serve the needs of their communities. Cities and towns should reach out to utilities, many of which already provide technical assistance to entities electrifying their fleets, early in the process to involve them in developing and implementing the plan.

- **Collaborate with other municipalities in Arizona and beyond, as well as state government,** to share information and ideas, negotiate discounts for EVs and equipment, pursue opportunities for financial incentives, and advocate for additional incentives and support for fleet electrification.

- **Work with utilities to accelerate deployment of electric vehicle infrastructure and implement EV-friendly rate structures.** Utilities have an indispensable role in facilitating municipal vehicle electrification. Utility incentives for the installation of EV charging infrastructure (of the kind currently offered by several Arizona utilities) could significantly ease the path toward fleet electrification. The Arizona Corporation Commission, which regulates investor-owned utilities, and public power providers such as Salt River Project should ensure that utility rate structures incentivize EVs and expedite the installation of infrastructure to support municipal EV charging wherever possible.

- **Take full advantage of government and utility incentives.** There are many potential sources of grants, loans and other incentives for municipal fleet electrification. Opportunities for funding exist from federal and state governments, as well as Arizona's electric utilities, which often offer discounts on the installation of EV charging infrastructure.

- **Take full advantage of incentives in recent federal legislation.** The IIJA and IRA contain numerous incentives for electric vehicles and EV infrastructure. Municipalities should work together to identify and pursue federal incentives that further reduce the cost of new vehicles and charging infrastructure, such as the commercial vehicle credit in the IRA and incentives and funding for charging infrastructure in the IIJA and IRA.

# Introduction

**CITIY AND TOWN GOVERNMENTS IN ARIZONA** deliver essential services to their residents – from street repairs to fire protection, trash removal to the maintenance of local parks.

The delivery of many of those services depends on fleets of thousands of vehicles of virtually every description across Arizona – from golf carts to dump trucks and everything in between.

Municipal leaders and fleet managers face the important job of choosing economical, reliable vehicles capable of performing the required tasks – and ensuring that those vehicles are kept fueled up and in good working order. The transportation decisions made by municipal leaders and fleet managers also impact air quality, climate change and our dependence on oil. By transitioning to electric vehicles (EVs), Arizona municipalities can deliver significant taxpayer savings over time while helping to clean the air their residents breathe. While EVs can cost more up front, they cost less to operate and to maintain and with new incentives available under the federal Inflation Reduction Act (IRA) that reduce the upfront cost of EVs, the financial picture for cities and towns is even more advantageous.

This report, based on a detailed survey of 10 of the largest municipal fleets in Arizona, demonstrates the great potential of EVs to save money for cities and towns, and discusses some of the challenges municipalities face in making the transition to EVs. With the market for EVs changing rapidly, and new EV models coming on the marketplace seemingly every day, now is the time for Arizona's cities and towns to work with one another – and with electric utilities, state officials, businesses and non-profit organizations – to develop and implement plans for electrifying their vehicle fleets.

# Arizona municipalities own thousands of vehicles and spend millions each year on their fleets

**ARIZONA'S CITIES AND TOWNS OWN AND OPERATE** a wide array of vehicles – from police and fire vehicles to pickup trucks to passenger sedans. Buying, fueling and maintaining those vehicles comes at a heavy cost to municipalities and, by extension, taxpayers.

Arizona PIRG Education Fund and Frontier Group surveyed 10 of Arizona's largest municipalities, home to more than half of all Arizonans, to learn more about their current vehicle fleets and prospects for the transition to electric vehicles. Those 10 Arizona municipalities collectively spend more than $110 million each year on vehicle purchases, fuel and maintenance of their fleets. Getting the most value out of those purchases should be an important priority for local governments.

## Cities and towns own a wide variety of vehicles

The 10 municipalities surveyed for this report are currently home to more than half of all Arizona residents.[12]

These 10 municipalities – Chandler, Gilbert, Goodyear, Mesa, Peoria, Phoenix, Scottsdale, Surprise, Tempe and Tucson – own and operate more than 10,000 vehicles and pieces of equipment, from dump trucks to fire engines to all-terrain vehicles. This is a significant share of the roughly 48,000 registered motor vehicles owned by all state and local governments in Arizona.[13]

Of those vehicles, more than 6,100 are light-duty vehicles, which represent the most promising opportunity for near-term electrification.[14]

### About the survey

In October 2021, Arizona PIRG Education Fund and Frontier Group sent a survey to 12 of the largest municipalities in Arizona by population, requesting detailed data about the composition and use of their fleets, expenditures on fuel and maintenance, experiences to date with electric vehicles, and perceived challenges and hurdles to vehicle electrification. Of the 12 municipalities, 10 responded with data (Chandler, Gilbert, Goodyear, Mesa, Peoria, Phoenix, Scottsdale, Surprise, Tempe, Tucson) while two declined to participate (Glendale and Yuma).

Not all municipalities provided all the data requested, and the data supplied by the municipalities varied in its coverage and level of detail. In some cases, data for individual municipalities are estimates based on other reporting by that city or town or averages of values from other cities and towns. See methodology for more details.

A range of heavier-duty vehicles are also becoming available in electric versions but are not included in this analysis; see page 17. The vehicles evaluated here include those under 10,000 pounds gross vehicle weight rating (GVWR) that are not used for emergency response (e.g., police patrol vehicles).

## Pickup trucks make up a large share of municipal fleets

Pickup trucks are the workhorses of many municipal fleets, along with passenger and cargo vans. Of the over 6,100 light-duty vehicles in municipal fleets, more than 70% are trucks or vans. (See Figure 1.)

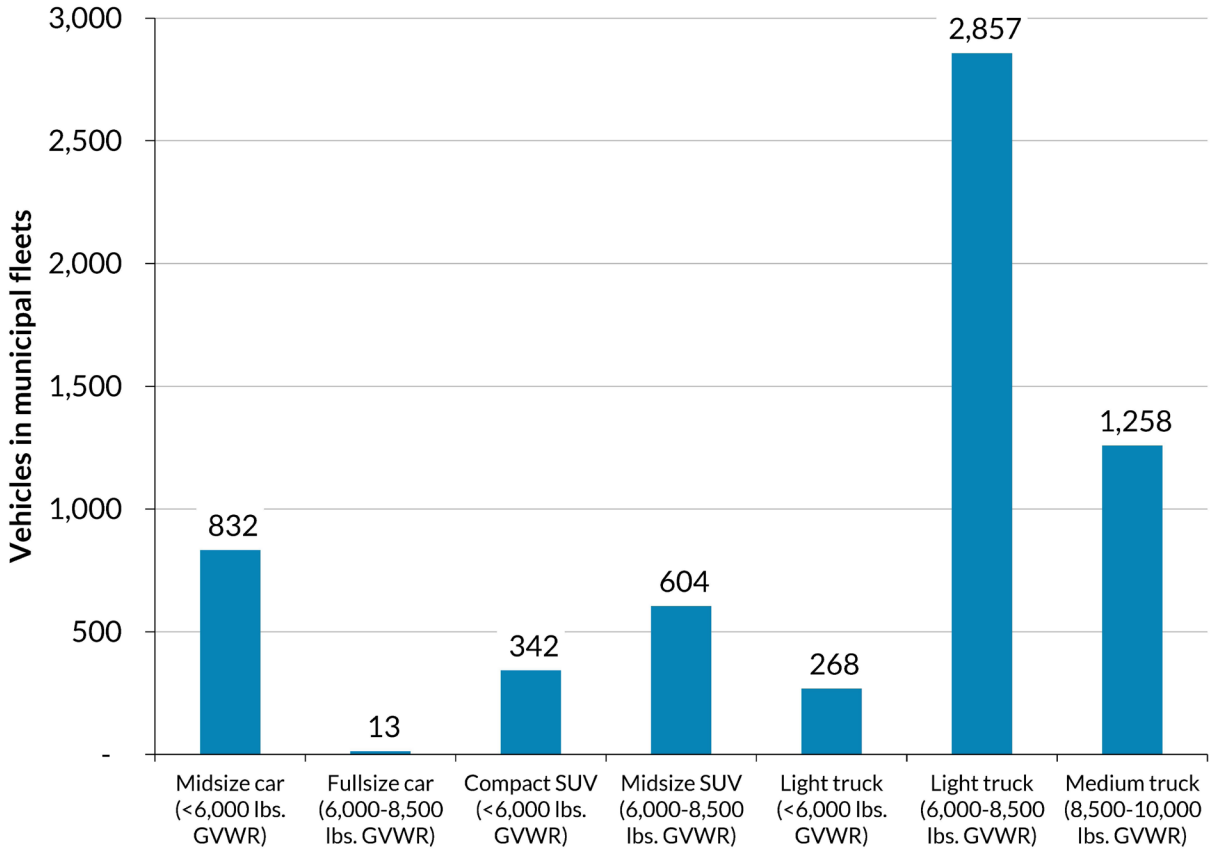
Within the light-duty truck categories, a few models are particularly common. The 10 Arizona municipalities surveyed for this report own 1,232 Ford F-150 pickups and 1,259 Chevy Silverado, 1500 or GMC Sierra pickups, which are used for a variety of municipal purposes.[16] These two models of half-ton pickups account for about 40% of the light-duty vehicles that are the focus of this report.

**Four out of every 10 light-duty vehicles in the fleets of the surveyed municipalities are General Motors or Ford half-ton pickup trucks.**

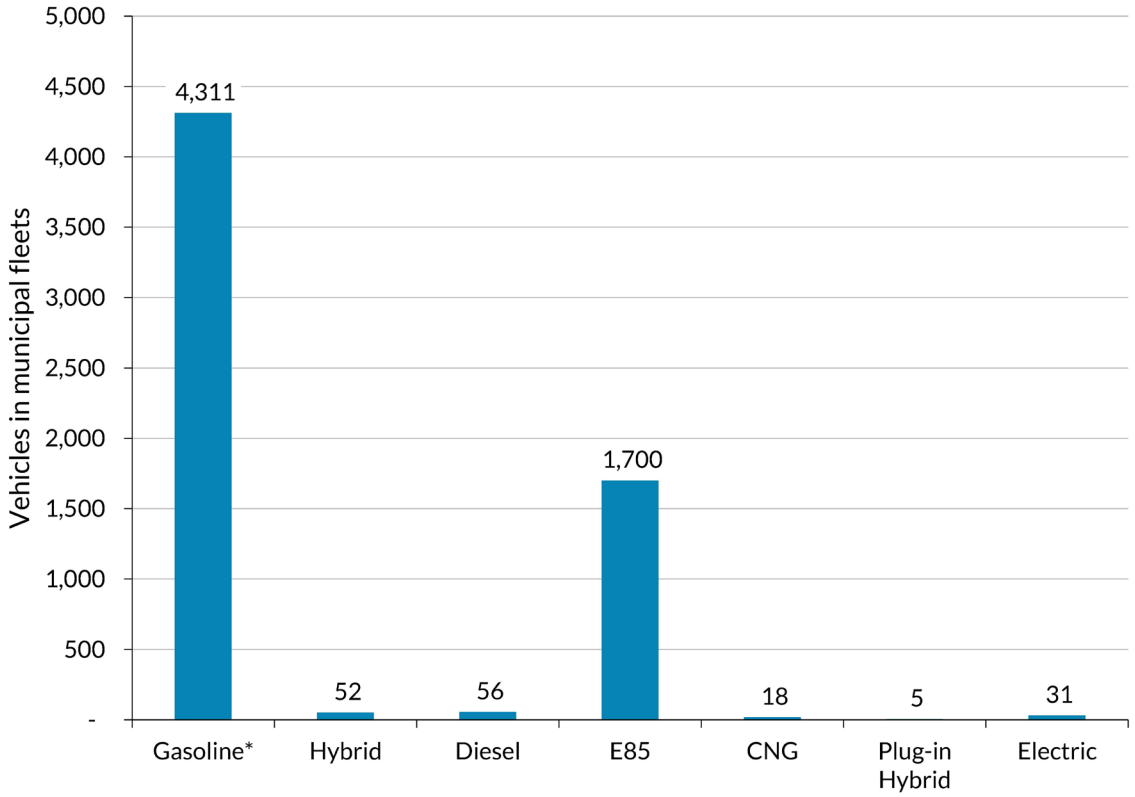
## Nearly all municipal vehicles operate on gasoline or diesel

Nearly all vehicles in the fleets of the 10 large municipalities surveyed are fueled by gasoline or are "flex-fuel" vehicles that can operate on ethanol (E85) or gasoline. About 70% of the light-duty vehicles surveyed can only operate on gasoline, while 28% are E85 flex-fuel vehicles. Another 1% of vehicles – mostly pickup trucks – operate on diesel fuel. (See Figure 2, next page.)

**FIGURE 1. TYPES OF LIGHT-DUTY VEHICLES IN MUNICIPAL FLEETS (10 OF ARIZONA'S LARGEST MUNICIPALITIES)[15]**



## FIGURE 2. LIGHT-DUTY MUNICIPAL FLEET VEHICLES BY FUEL, 10 OF ARIZONA'S LARGEST MUNICIPALITIES[17]




** Fuel type unavailable for vehicles in Surprise. All were assumed to be gasoline vehicles.*

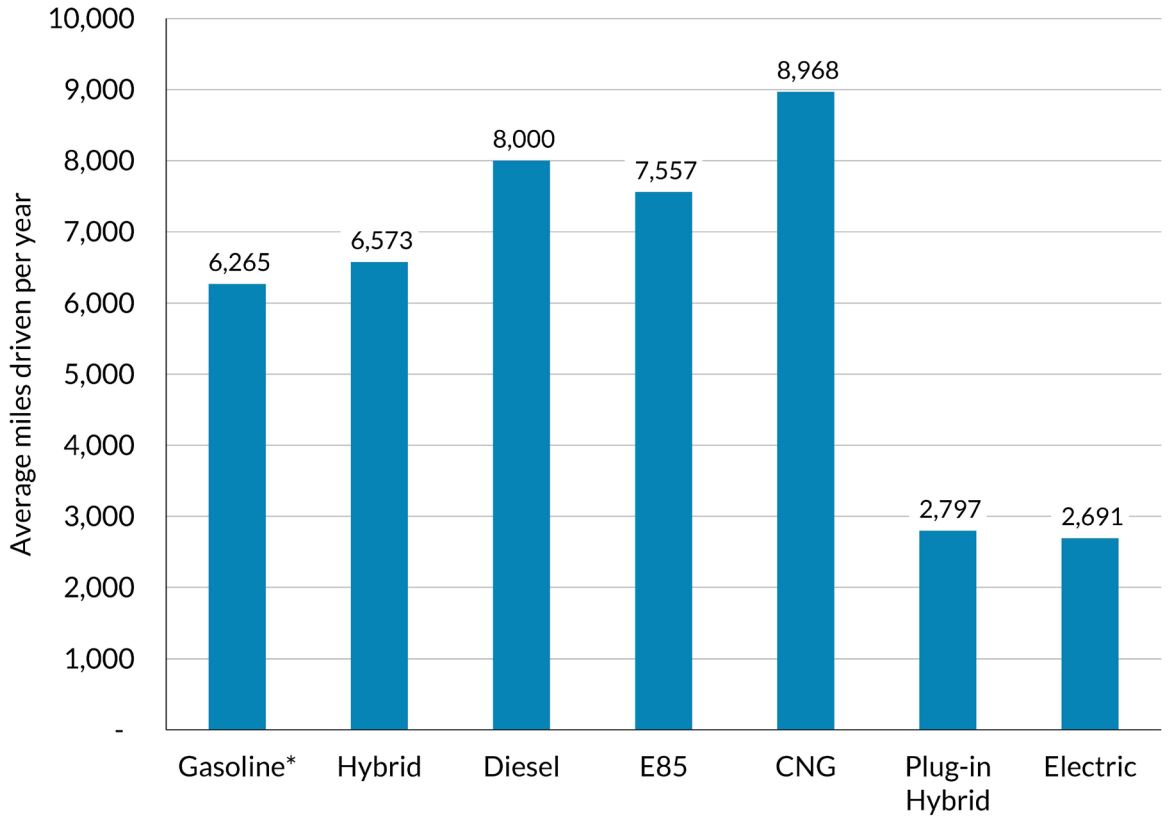
Arizona municipalities have thus far purchased few electric vehicles. As of the time of this survey (late 2021), the 10 municipalities surveyed had just 31 battery-electric vehicles in the light- and medium-duty categories surveyed here, plus another 5 plug-in hybrid vehicles that can operate on grid power or gasoline. The municipalities owned another 52 non-plug-in hybrid vehicles as well.[18]

The vehicles included in this survey are driven approximately 41 million miles each year, an average of 6,659 miles per vehicle per year.[19] The number of miles driven annually in vehicles varies by fuel, with vehicles powered by liquid fuels (gasoline, diesel or ethanol fuel) being driven more than twice as many miles on average as the small number of electric and plug-in hybrids in Arizona's municipal fleets. (See Figure 3.)

While some older vehicles remain in Arizona municipal fleets, the majority of the fleet – and the vast majority of the miles traveled – are accounted for by vehicles purchased in approximately the last decade. (See Figure 4, page 12.)

Vehicles in model years 2011 through 2020 accounted for three-quarters of all miles driven in the eight municipal fleets that reported vehicle usage data.[21] Generally, newer vehicles tend to be driven more than older vehicles in fleets.

**FIGURE 3.** AVERAGE MILES DRIVEN PER YEAR, LIGHT-DUTY VEHICLE FLEET, 10 LARGE ARIZONA MUNICIPALITIES




** Fuel type unavailable for vehicles in Surprise. All were assumed to be gasoline vehicles. CNG=compressed natural gas*

## Vehicle fleets are a major expense for cities and towns

Municipalities responding to the survey provided data about the purchase prices of their vehicles as well as the amount of money spent on maintaining and fueling their fleets.

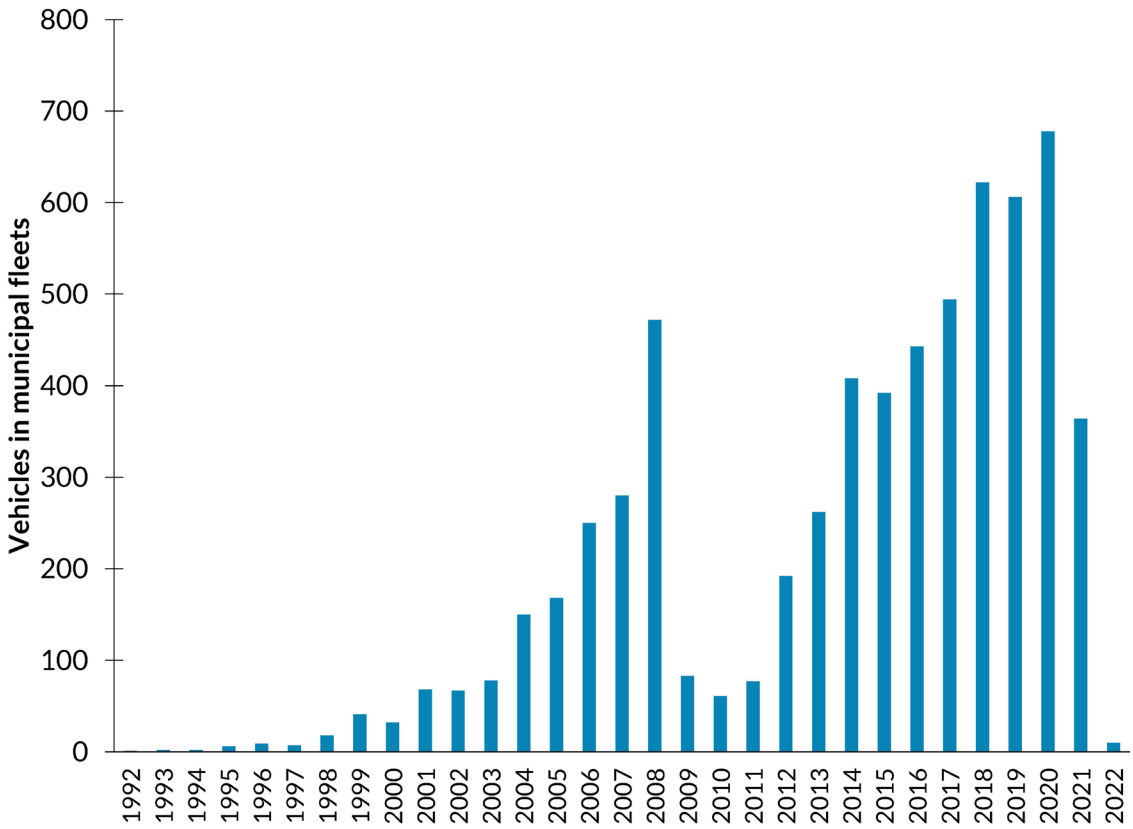
The nine cities that reported the model years of their vehicles had 1,042 model year 2020 and 2021 light-duty vehicles. This can be taken as a conservative estimate of two years' worth of vehicle purchases for these cities.[22] Those vehicles cost a total of an estimated $35.1 million, for an average of $34,511 per vehicle, or annual vehicle expenditures of upwards of **$17.5 million**.[23]

A different set of eight municipalities submitted estimates of the cost of maintaining their fleets each year.[24] Among these eight municipalities, total maintenance costs exceeded **$65 million** in the most recent year of data available.

All 10 municipalities surveyed submitted information on fuel expenditures, which totaled **$33.5 million** in the most recent year for which data were submitted.

While there are many inconsistencies across the municipalities in terms of the types of vehicles included in these cost figures, the years covered and other factors, it is

**FIGURE 4.** NUMBER OF LIGHT-DUTY VEHICLES IN SELECTED ARIZONA MUNICIPAL FLEETS BY MODEL YEAR[20]




possible to estimate that the 10 Arizona municipalities surveyed spend well over $110 million per year to buy, maintain and fuel their vehicle fleets – a significant expense for many localities.

Saving money on vehicle operations – especially at a time of high fuel prices – can make a real difference for municipal governments and taxpayers. Transitioning to electric vehicles brings with it tremendous potential for local governments to save money on their fleets, while cleaning up Arizona's air.

**Saving money on vehicle operations – especially at a time of high fuel prices – can make a real difference for municipal governments and taxpayers.**

# Electric vehicles can meet an increasing share of municipalities' needs

**A DECADE AGO, ELECTRIC VEHICLES WERE** expensive curiosities. Today, thanks to rapid improvements in battery technology, declining costs, and deepening commitment to an all-electric future by elected officials and leading automakers, electric vehicles are coming to be commonplace on Arizona's roads. As of December 2021, over 40,000 fully electric vehicles were on the road in Arizona, the seventh-most of any state.[25] Electric vehicles are now on the market that can meet a large share of the day-to-day needs of Arizona municipalities, with many new varieties of vehicles coming online soon.

## Electric vehicles are advancing rapidly and falling in price

Electric vehicle technology is improving by leaps and bounds. Today's electric vehicles are more capable and cost less than the vehicles on the market just a few years ago, and there are many models to choose from.

Rapid improvements in batteries have led to EVs that travel farther on a single charge. The median travel range for an EV on a single charge grew to over 250 miles between 2011 and 2020 – well over triple the range of 2011.[26]

Those improvements have come even as the cost of EVs has declined. A 2020 report by *Consumer Reports* found that the lifetime ownership costs of the most popular EV models are thousands of dollars lower than those of comparable gasoline-powered vehicles, with typical savings of between $6,000 and $10,000.[27] Further reductions in battery costs could bring the upfront costs of EVs down to the level of gasoline-powered vehicles by the mid-2020s.[28]

Declining costs and improving technology – along with growing concerns about the impacts of fossil fuels on air quality and public health – have led several major automakers to commit to a complete shift to electric vehicles. The Chrysler brand will offer a fully electric lineup by 2028, Volvo will sell only electric cars by 2030, and GM plans to sell only zero-emission light-duty vehicles by 2035.[29]

## Thousands of electric vehicles in Arizona fleets could be electrified

Viable electric alternatives currently exist for many vehicles in Arizona municipal fleets. Roughly 30 models of electric vehicles, in more than 80 configurations, were available in model year 2022, according to the U.S. EPA, with more arriving in model year 2023.[30] (See Table 1, next page.)

Of the categories of vehicles described above as present in Arizona municipal fleets, the following have ready electric alternatives.

**Cars** (845 vehicles in surveyed municipal fleets) – The Chevrolet Malibu is among the vehicle models most frequently found in municipal fleets. The Nissan LEAF is a mid-size hatchback that travels between 149 and 226 miles on a charge and gets between 104 and 111 miles per gallon gasoline equivalent (mpgge) fuel economy. The Chevrolet Bolt is a

## TABLE 1. ELECTRIC VEHICLE MODELS AVAILABLE IN MODEL YEAR 2022[31]

| Make/model | Vehicle class | Fuel economy, combined city/highway, range for all configurations (miles per gasoline gallon equivalent) | Travel range (miles) |
|---|---|---|---|
| BMW i4 | Subcompact Cars | 80-109 | 227-301 |
| Mini Cooper | Subcompact Cars | 110 | 114 |
| Porsche Taycan | Compact/Midsize Cars | 45-79 | 199-227 |
| Audi e-tron GT | Midsize Cars | 81-82 | 232-238 |
| Mazda MX-30 | Midsize Cars | 92 | 100 |
| Nissan LEAF | Midsize Cars | 104-111 | 149-226 |
| Polestar 2 | Midsize Cars | 89-107 | 249-270 |
| Tesla Model 3 | Midsize Cars | 113-132 | 273-358 |
| Hyundai Ioniq 5 | Large Cars | 98-114 | 220-303 |
| Lucid Air Dream | Large Cars | 111-125 | 451-520 |
| Lucid Air G | Large Cars | 121-131 | 469-516 |
| Mercedes-Benz EQS | Large Cars | 95-97 | 340-350 |
| Tesla Motors Model S | Large Cars | 101-120 | 348-405 |
| Chevrolet Bolt EUV | Small Station Wagons | 115 | 247 |
| Chevrolet Bolt EV | Small Station Wagons | 120 | 259 |
| Kia EV6 | Small Station Wagons | 105-117 | 232-310 |
| Kia Niro Electric | Small Station Wagons | 112 | 239 |
| Ford Mustang Mach-E 2WD | Small SUV 2WD | 97-103 | 247-314 |
| Hyundai Kona Electric | Small SUV 2WD | 120 | 258 |
| Ford Mustang Mach-E 4WD | Small SUV 4WD | 82-98 | 224-312 |
| Tesla Model Y | Small SUV 4WD | 111-129 | 244-330 |
| Volkswagen ID.4 | Small SUV 4WD | 95-112 | 245-280 |
| Volvo XC40 Recharge | Small SUV 4WD | 85 | 223 |
| Volvo C40 Recharge | Small SUV 4WD | 87 | 226 |
| Audi e-tron | Standard SUV 4WD | 63-95 | 181-241 |
| BMW iX | Standard SUV 4WD | 83-86 | 305-324 |
| Rivian R1S | Standard SUV 4WD | 69 | 316 |
| Tesla Model X | Standard SUV 4WD | 91-102 | 311-348 |
| Ford F-150 Lightning | Standard Pick-up Truck 4WD | 66-70 | 230-320 |
| Rivian R1T | Standard Pick-up Truck 4WD | 70 | 314 |

small station wagon that gets 259 miles to a charge and gets 120 mpgge in fuel economy.[32] The manufacturer's standard retail price (MSRP) for the vehicles ranges from $27,000 to $37,000 (not counting the commercial electric vehicle incentive enacted in the Inflation Reduction Act (IRA), which offsets up to 30% or $7,500 of the cost of an EV purchase; see page 20).[33]

Other mid-sized electric cars currently available include the Tesla Model 3 and Mazda MX-30. The Hyundai Ioniq5 provides a full-size electric car option.

**Small SUVs/station wagons** (342 vehicles) – The Chevrolet Trailblazer, Ford Escape and Jeep Wrangler are among the gasoline-powered small SUVs currently in use in municipal fleets in Arizona. The Chevrolet Bolt EUV and Volkswagen ID.4 are among a wide and growing variety of vehicles in the small SUV and station wagon space. The Kia Niro station wagon, for example, travels 239 miles on a charge and gets 112 mpgge fuel economy, for an MSRP of under $44,650.[34] The Ford Mustang Mach-E is offered in six configurations, ranging from 82 to 103 mpgge and 224 to 314 miles of range.[35]

**Mid-size SUVs** (604 vehicles) – The Chevy Tahoe and Ford Explorer are mainstays of many municipal fleets. Tesla and Audi are among the manufacturers beginning to market mid-sized electric SUVs, with more options on the way soon.

**Light pickups** (3,125 vehicles) – The Ford F-150 is not only America's top-selling vehicle, but it is also one of the vehicles most often owned and operated by Arizona municipalities, accounting for one out of every five light-duty vehicles in the fleets studied in this report. The 2022 release of the Ford F-150 Lightning was a watershed moment in the history of electric vehicles, promising not just clean electric travel but also onboard energy storage capacity and the ability to provide offsite power to worksites, with an MSRP under $40,000 for a base model.[36]

## Plug-in hybrids are an attractive near-term electric option

Plug-in hybrids (PHEVs) combine the range flexibility of gasoline engines with the fuel-savings potential of electric motors. Only a few plug-in hybrids are currently in Arizona municipal fleets, but a wide variety of PHEVs are currently on the market, including some in vehicle classes for which pure electric options are currently few.

For example, there are currently no battery-electric minivans on the market, but Chrysler's Pacifica PHEV minivan allows drivers to travel 30 miles on electric power on a single charge, with an MSRP of under $50,000.[37]

Among SUVs, the Toyota RAV4 Prime, a plug-in hybrid, has fuel economy of 94 mpgge (when running on electricity) and 38 mpg (when running on gas), and an electric range of 42 miles.[38] Jeep's PHEV version of its Grand Cherokee sports fuel economy of 56 mpgge (electric) and 23 mpg (gasoline) and an electric range of 26 miles.[39]


*The number of electric vehicle models on the market is expanding rapidly – including Ford E-Transit electric vans, which debuted in model year 2022. Credit: Diego Lopez/Northern Colorado Clean Cities, via National Renewable Energy Laboratory/U.S. Department of Energy.*

## Electric pickups and vans represent a big opportunity for Arizona cities and towns

The first generation of battery-electric vehicles were small cars. As battery technology has improved and costs have fallen, automakers have offered a greater variety of vehicles – including larger vehicles – in electric versions. As technology continues to improve, this dynamic will likely continue, resulting in more medium- and heavy-duty options for Arizona municipalities.

The 10 Arizona municipalities surveyed for this report have 1,258 trucks between 8,500 and 10,000 pounds GVWR in their fleets. This category includes several mainstays of municipal fleets such as the Ford F-250 and Chevy Silverado 2500 pickups and the Ford Transit 250 and 350 vans.

At present, there are few electric options available for these larger vehicles, but that is beginning to change. The 2022 Ford E-Transit, the electric version of the best-selling commercial van in America, is currently in production, the first shipments having gone out in February 2022.[40] Three models will be offered – the cutaway, chassis cab and cargo van – as well as three roof heights and three body lengths, with a maximum payload of 4,390 pounds depending on model and configuration.[41] The 2023 model year versions of the vehicles boast a projected range of 108 to 126 miles; no estimates have been released yet about fuel

economy.[42] While the 2023 Ford E-Transit Custom, with an upgraded 236-mile range, will only debut in the European market, the popularity of this vehicle points to further development, and a passenger version is expected in the future.[43]

Volkswagen's ID.Buzz[44] is scheduled for production in 2022 for a possible 2024 release. (The commercial cargo version is not currently planned for release in the North American market.[45])

An array of new pickup options are also on the way. In addition to the Ford F-150 Lightning EV, Chevrolet is planning to release an electric version of its Silverado pickup[46] (the most-popular vehicle among the municipal fleets included in this survey).[47] It is scheduled for a 2024 release with six configurations ranging in price from $42,000 to $107,000; all versions are estimated to have an electric range of 400 miles. Towing capacity varies by model, from 8,000 pounds to 10,000 pounds; Chevrolet intends to eventually produce a vehicle with 20,000-pound towing capacity to the lineup. GMC's offerings will be split between the 2023 Sierra EV[48] and the Hummer EV,[49] the latter of which is expected to see new releases in 2023 and 2024. The Toyota Tacoma EV is scheduled for a 2024 release.[50]

## Heavier-duty electric vehicles are on the way

Electric options also exist for many medium- and heavy-duty vehicles in municipal fleets, with more on the way. The U.S. Department of Energy lists dozens of battery-electric medium- and heavy-duty vehicles available to buyers.[51] In addition to the rapidly increasing array of transit and school buses (see page 18), there are now electric versions of freight trucks, cargo vans, garbage trucks, tractors and other heavy-duty vehicles and equipment available to municipalities.

Even first responders, with their demand for reliable, high-performance vehicles, have access to an increasing number of options, from patrol vehicles to fire engines.[52] Mesa was one of the first cities in the country to purchase an all-electric fire truck, while Goodyear was one of the first municipalities in the state to obtain an electric police motorcycle.[53]

**Mesa was one of the first cities in the country to purchase an all-electric fire truck, while Goodyear was one of the first municipalities in the state to obtain an electric police motorcycle.**

Other Arizona municipalities are also bringing heavy-duty electric vehicles into their fleets. Phoenix, for example, is planning to purchase two electric refuse trucks, which will be delivered in 2024.[54]

Battery-electric vehicles are not the only zero-emission option for heavy-duty vehicles. Fuel cells powered with renewably generated "green" hydrogen hold promise for heavy-duty trucks traveling long distances. The price of hydrogen fuel cell vehicles is expected to fall rapidly in the years to come.[55]

Heavy-duty electric and fuel cell vehicles are even more attractive due to the generous incentives provided in the federal Inflation Reduction Act. The law provides incentives of up to 30% of the cost of Class 4 and larger trucks (vehicles over 14,000 pounds, GVWR) or $40,000, or the difference in cost between an electric and conventional vehicle, whichever is less.[56] The incentives are also available for the purchase of electric "mobile machinery" – enabling municipalities to replace fossil fuel-powered equipment with clean electric versions.

## Opportunities for electric buses

Across the country and in Arizona, electric school buses and transit buses are moving people safely and reliably. Although electric buses cost more upfront, the reduced operating and maintenance expenditures result in overall lifetime vehicle cost savings.[57] Bus electrification is not within the scope of this report, but local governments such as school districts and transit agencies have many opportunities to pursue electrification.

School buses are the largest form of public transportation in the United States, moving approximately 26 million school children.[58] Most conventional school buses run on diesel, exposing children to air pollutants such as particulates.[59] For students who may spend 30 minutes to two hours every day on a bus, these emissions can pose a significant health risk.[60]

Electric school buses are also quieter, leading to calmer passengers.[61] And despite higher upfront costs, electric school buses are often cheaper to fuel and easier and more cost-effective to maintain, resulting in lower lifetime cost of ownership.[62] In addition, buses equipped with vehicle-to-grid (V2G) technology can supply electricity to buildings or the grid – enabling their batteries to be used as a source of mobile energy storage that enhances local resilience and can, in some cases, enable school districts to earn revenue from utilities for helping to stabilize the grid.[63]

Numerous models of electric school buses now exist that can meet the needs of school districts. Blue Bird's electric bus models can travel up to 120 miles on a single charge and have a charging time of eight hours (three hours using its fast charging option).[64] Lion, another electric bus manufacturer, offers several models of school buses, the largest of which, Lion C, can carry 77 passengers and get up to 155 miles per charge.[65] For municipalities that struggle to meet the initial transition costs, companies such as Highland Electric Fleets and Thomas Built Buses have partnered to offer subscription-based models that allow school districts to receive electric buses and charging equipment at rates lower than the cost of owning and operating diesel vehicles.[66]

Incentives available under the Infrastructure Investment and Jobs Act make the economic case for electric school buses even better. The law provided $5 billion in funding nationwide for clean school buses, including $2.5 billion specifically for electric school buses.[67]

Arizona school districts are beginning to explore a transition to electric buses. The Phoenix Union High School district paved the way with the first electric school bus in Arizona, and based on its success now intends to electrify its entire fleet.[68]

Transit buses present another opportunity for electrification. In 2021, Sun Tran, the transit agency serving Tucson, introduced the state's first electric transit buses, and the agency announced in August 2022 that it would add 19 more electric vehicles to its fleet.[69] The city intends to have eliminated all of its diesel buses by 2028.[70] In August 2022, Phoenix received a $16.2 million grant aimed at replacing aging buses with electric and fuel-cell vehicles.[71]


*Sun Tran, the transit agency in Tucson, has been a leader in incorporating electric buses into its fleet. The agency intends to eliminate its diesel buses by 2028. Credit: Diane E. Brown*

# Arizona's largest municipalities could save tens of millions of dollars by going electric

**TRANSITIONING TO EVS WOULD BRING** many benefits to Arizona municipalities, including savings for taxpayers. By shifting entirely to EV purchases for light-duty vehicles over a 10-year span, the 10 Arizona municipalities surveyed could save nearly $80 million in lifetime vehicle ownership costs while reducing air pollution and helping Arizona to meet its clean air goals.

## New federal incentives, plus reduced fuel and maintenance costs, drive electric vehicle savings

Electric vehicles cost more to purchase upfront, but the combination of lower fuel and maintenance costs, along with new federal incentives that reduce or eliminate the price differential between EVs and conventional vehicles, make EVs an economic winner.

While in 2021, the estimated average sticker price of a new electric car was $10,000 above the average for all vehicles, the cost of EVs has fallen in recent years and is expected to continue to do so, with cleantech market analyst BloombergNEF forecasting that "automakers should be able to produce and sell mass-market EVs at the same price (and with the same margin) as comparable internal combustion vehicles in some markets" by 2024.[72]

Additionally, in August 2022, the federal Inflation Reduction Act was signed into law. Included in the Act are provisions that will make it easier for municipalities to adopt electric vehicles – the most important of which is the incentive for commercial electric vehicles.

The commercial electric vehicle incentive is available to municipalities purchasing light-duty or heavy-duty electric vehicles and equipment. For vehicles under 14,000 pounds GVWR – that is, light-duty and some medium-duty cars and trucks – the incentive is:

- 30% of the purchase price of the vehicle,
- $7,500, or
- the difference between the cost of an electric vehicle and a comparable gas or diesel vehicle, whichever is less.

For heavier-duty trucks and equipment, the same incentives apply, except that the cap on the incentive is raised to $40,000.[73]

These incentives are already sufficient to eliminate the cost gap between EVs and gasoline-powered vehicles in some vehicle categories (e.g., small and mid-size cars) and to dramatically reduce the gap for larger vehicles.

The IRA also includes incentives available to municipalities for the installation of electric vehicle charging equipment, though those incentives come with conditions that may limit municipal governments' ability to use them.[74]

### Fuel savings

Electric vehicles cost less to fuel than gasoline- and diesel-powered vehicles, in large part because they use energy much more efficiently.

In internal combustion engines, only about 12%-30% of the energy in gasoline or diesel

fuel is actually used to propel the vehicle down the road – most of the rest is wasted as heat.[75] Electric vehicles, by contrast, are far more efficient, with many getting the fuel economy equivalent of 100 miles per gallon of gasoline or more.[76]

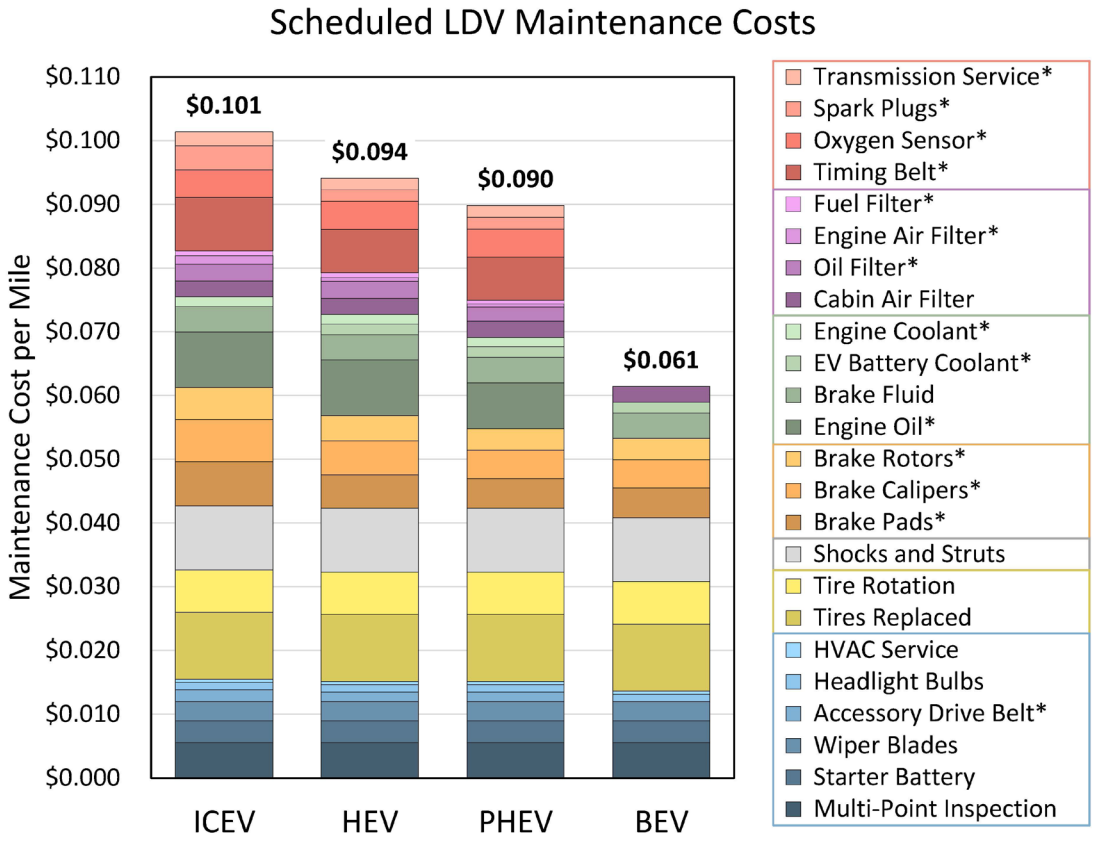
Higher efficiency translates directly to lower fuel costs. A small electric SUV, such as the 2022 Chevy Bolt EUV, costs $550 to fuel for a year, while the 2022 Chevy Trailblazer, a comparable small SUV, burns through $2,000 worth of gasoline – roughly four times as much.[77] The gasoline version of the all-electric Volvo XC40 costs nearly three times as much to fuel per year as the electric version of the same SUV.[78]

## Maintenance cost savings

Electric vehicles have fewer moving parts than internal combustion engine vehicles and require less routine maintenance (such as oil changes). Electric vehicles do not have timing belts, spark plugs or oxygen sensors or require engine oil – all of which can impose costs and maintenance burdens on vehicle owners.[79] Electric vehicles typically come with 100,000-mile warranties on batteries, reducing the risk of a costly battery replacement.[80]

A recent analysis by researchers at Argonne National Laboratory compared the per-mile maintenance costs of various types of vehicles, finding that light-duty electric vehicles cost approximately 40% less per mile to maintain than internal combustion engine vehicles.[81]

**FIGURE 5. MAINTENANCE COSTS FOR VEHICLES BY FUEL TYPE (ARGONNE NATIONAL LABORATORY, USED WITH PERMISSION)[82]**




*(LDV = light-duty vehicle; ICEV = internal combustion engine vehicle; HEV = hybrid electric vehicle; PHEV = plug-in hybrid electric vehicle; BEV = battery electric vehicle)*

## Savings for 10 of the largest Arizona cities and towns could total nearly $80 million

To estimate the potential benefits of municipal fleet electrification in Arizona, we identified those vehicles in municipal fleets that are most likely to be replaced in the next 10 years and used the Argonne National Laboratory's Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) model to compare what would happen under two scenarios: replacement of those vehicles with vehicles of the same or similar fuel type (generally, powered by gasoline or diesel), or replacement with electric vehicles.[83]

We assumed that vehicles reaching 100,000 miles (in municipalities that provided data on miles traveled by vehicle) or 20 years of age by 2032 would be replaced.[84] Roughly 4,100 vehicles across the 10 municipalities – nearly two-thirds of the fleet in the categories of vehicles included in this analysis – would be replaced under this scenario. The replacement vehicles in both scenarios were evaluated based on an expected lifespan of 15 years, with total mileage accumulated over that time varying by vehicle type and municipality based on the average annual travel of vehicles currently in the fleet. (See methodology for complete details of vehicle turnover model.)

As described in greater detail in the methodology, these vehicles were sorted by body style and weight into vehicle "classes" and their total cost of ownership and emissions performance was compared using the AFLEET tool. In an effort to make the results as true to the experience of Arizona municipalities as possible, the AFLEET tool was run using city- or town-specific data on the makeup of the fleet, actual number of miles driven, and current prices for vehicles comparable to those in the existing fleet wherever available. We also assumed that municipalities would be able to take advantage of the commercial EV credit under the IRA, passed by Congress in August 2022.

By replacing vehicles expected to retire in the next 10 years in categories where electrification is currently cost-effective, the 10 Arizona municipalities surveyed could save nearly $80 million in lifetime vehicle ownership costs. (See Table 2.)

The greatest additional expense for electric vehicles as compared to conventional vehicles is the upfront cost (expressed in the AFLEET model as "depreciation," or the amount of its initial value that a vehicle loses during the period of ownership). The higher upfront cost of EVs, however, is overwhelmed by savings

**TABLE 2. COST SAVINGS FROM REPLACING RETIRING LIGHT-DUTY MUNICIPAL FLEET VEHICLES WITH EVS OVER NEXT 10 YEARS, 10 LARGE ARIZONA MUNICIPALITIES**

| Expense category | Lifetime savings (parentheses indicate increased expenses) |
|---|---|
| Vehicle cost (depreciation) | $(2,738,151) |
| Fuel | $52,607,048 |
| Diesel exhaust fluid | $258,897 |
| Maintenance and repair | $30,567,898 |
| Insurance | $(718,447) |
| **Total cost of ownership savings** | **$79,977,245** |

**TABLE 3. TOTAL COST OF OWNERSHIP SAVINGS FROM REPLACING RETIRING LIGHT-DUTY MUNICIPAL FLEET VEHICLES WITH EVS OVER NEXT 10 YEARS, 10 LARGE ARIZONA MUNICIPALITIES**

| City or town | Total cost of ownership savings |
|---|---|
| Chandler | $4,993,319 |
| Gilbert | $3,539,318 |
| Goodyear | $2,087,907 |
| Mesa | $9,665,629 |
| Peoria | $3,791,741 |
| Phoenix | $25,110,149 |
| Scottsdale | $11,420,301 |
| Surprise | $2,042,132 |
| Tempe | $2,582,594 |
| Tucson | $14,744,155 |

on fuel, maintenance and repair, with fuel being the biggest source of cost savings. Fuel costs in this analysis were based on average fuel prices in 2021 in the West Coast region (excluding California) of $3.42 per gallon for gasoline and $3.48 per gallon for diesel fuel.[85] Fuel savings from electrification would be significantly greater if fuel prices over the next 15 years were similar to the prices of $5 per gallon and up paid by Arizona consumers in the summer of 2022.[86]

Lifetime cost savings are possible in every Arizona municipality studied. Phoenix alone could amass savings of more than $25 million in vehicle ownership costs over the lifetime of vehicles purchased over the next 10 years by implementing a comprehensive approach to vehicle electrification. (See Table 3.)

Because of their prominence in municipal fleets, the greatest potential cost savings come from electrifying light pickup trucks, with the potential to save nearly $54 million out of the $80 million in total savings across all classes of vehicles.

The figures above exclude one very important cost for municipalities seeking to electrify their fleets: the charging infrastructure to support those vehicles. These costs can be significant (see page 26), but incentives from utilities, automakers or charging companies, along with new incentives available under the IIJA and IRA, can reduce the cost.[87] Further, charging infrastructure is a one-time cost for infrastructure that can be shared by many vehicles. The potential cost of EV charging infrastructure is an important consideration for municipalities but is beyond the scope of this analysis.

Falling costs and the incentives available under the IRA will also improve the economics of larger electric trucks. The savings estimates above exclude municipal medium trucks between 8,500 and 10,000 pounds, which were found to have a higher

total cost of ownership than conventional vehicles in this analysis. Electrification may make economic sense for specific vehicles within this category, and municipalities should continue to explore options to electrify all types of vehicles and equipment, including heavy-duty vehicles. (See page 17.)

## Air pollution reductions improve public health and deliver economic benefits

Cost savings, while significant, are not the only reason for Arizona cities and towns to move toward electrifying their vehicles. Electric vehicles also reduce pollution and clean the air – a key consideration for Arizona given the state's persistent air pollution problems and challenges related to nonattainment of national ambient air quality standards. The Phoenix-Mesa area is in nonattainment for ozone pollution.[88] Much of Maricopa County, as well as part or all of Cochise, Gila, Pinal, Pima, Santa Cruz and Yuma counties, are currently in nonattainment for $PM_{10}$, a measure of particle pollution.[89]

Air pollution can have serious consequences for human health. Exposure to pollutants such as ozone and particulate pollution has been linked to premature death; damage to the respiratory and cardiovascular systems; worsened mental health and neural functioning; problems with fertility, conception, pregnancy and birth; and increased risk of many types of cancer.[90]

Arizonans suffer an unacceptably high amount of air pollution, and pollution from vehicles is a primary contributor. In 2020, residents of the Phoenix-Mesa-Chandler area spent 149 days breathing elevated levels of ozone and/or particulate pollution, with residents of the Tucson area breathing polluted air 77 days out of the year.[91]

The American Lung Association's *State of the Air 2022* report ranked the Phoenix metropolitan area the fifth most polluted in the country for ozone and the eighth most polluted for annual exposure to particle pollution. In the same report, Phoenix and Tucson areas both received an "F" for ozone pollution, and Maricopa County received an "F" for particle pollution.[92]

Under the Clean Air Act, the EPA must determine whether areas of the country are meeting National Ambient Air Quality Standards (NAAQS) for certain pollutants. Areas that don't meet those standards are considered to be in nonattainment and must develop plans for how they will reduce air pollutant emissions to reach and maintain air quality standards.

**Electric vehicles also reduce pollution and clean the air – a key consideration for Arizona given the state's persistent air pollution problems and challenges related to nonattainment of national ambient air quality standards.**

The AFLEET model produces "well-to-wheels" estimates of air pollution produced by vehicles powered by various fuels. For the 10 Arizona municipalities studied, vehicle electrification would lead to significant reductions in emissions of nitrogen oxides ($NO_X$) and volatile organic compounds (VOCs), the two chemical components of ozone smog. (See Table 4, next page.) Electrification would lead to a small – and likely temporary – increase in $PM_{10}$ and sulfur oxide ($SO_X$) emissions, as the electricity supplied to charge vehicles is assumed to come from today's coal-heavy electric grid.

**TABLE 4. AIR QUALITY BENEFITS FROM REPLACING RETIRING LIGHT-DUTY MUNICIPAL FLEET VEHICLES WITH EVS OVER NEXT 10 YEARS, 10 LARGE ARIZONA MUNICIPALITIES**

| Air quality and energy benefits | Total (parentheses indicate increased emissions) |
|---|---|
| Petroleum use (barrels) | 367,888 |
| Greenhouse gases (short tons) | 144,464 |
| CO (lbs.) | 1,341,488 |
| $NO_x$ (lbs.) | 65,855 |
| $PM_{10}$ (lbs.) | (874) |
| $PM_{2.5}$ (lbs.) | 4,001 |
| VOC (lbs.) | 198,919 |
| $SO_x$ (lbs.) | (289,472) |

However, electric vehicles purchased today are likely to deliver even greater emission reductions as dirty power plants in the Southwest are replaced with cleaner sources of electricity such as renewable power. The U.S. Energy Information Administration (EIA) forecasts dramatic reductions in emissions from power generation in the Southwest in the years to come. By 2035, according to the EIA, $NO_x$ emissions per unit of electricity generation are forecast to decline by nearly 80% in the region that includes Arizona, while emissions of $SO_x$ per unit of generation are expected to fall by more than two-thirds, and emissions of carbon dioxide by more than 50%.[93] Should those reductions materialize, electric vehicles will likely produce across-the-board reductions in air emissions, helping Arizona cities and towns to meet their air quality goals.

In addition to enabling Arizona residents to live longer, healthier lives, air pollution emission reductions also translate into dollars-and-cents benefits. The AFLEET tool estimates that the emission reductions achieved by electrifying municipal vehicles in the 10 surveyed cities and towns would produce economic benefits of nearly $14 million. As Arizona's grid becomes cleaner, these economic benefits can be expected to increase.

Electrifying municipal fleets can also help to reduce Arizona's dependence on oil, cutting oil consumption by approximately 368,000 barrels over the lifetime of EVs purchased over the next 10 years, while also delivering lifetime greenhouse gas emission reductions of more than 144,000 tons. Again, these greenhouse gas emission benefits can be expected to increase over time as Arizona's electric grid becomes cleaner.

## The benefits of EVs depend on how they are used

To maximize the lifetime benefits of EVs, municipalities must use them as much as possible to substitute for travel in gasoline- and diesel-powered vehicles and manage their use effectively to extend the lifetime of the vehicles, especially their batteries.

As described above (see Figure 3, page 11), the small number of electric vehicles

currently in Arizona municipal fleets tend to be driven fewer miles on average than conventional vehicles. Increasing EV utilization is essential to reap the full economic benefits of electrification. Argonne National Laboratory research found that quadrupling the number of miles driven in a battery EV resulted in only a 50% increase in the total cost of ownership. Or, put another way, the per-mile total cost of ownership of the electric vehicle fell by a factor of three.[94]

Fully utilizing the electric vehicles in their fleets is not the only way for cities and towns to maximize their value. Managing the vehicles' battery life is also important. Manufacturers currently warranty electric vehicle batteries for at least eight years or 100,000 miles, but many vehicles in Arizona's municipal fleets are older or have accumulated more mileage than those benchmarks.[95] EV batteries can last much longer than 100,000 miles, particularly with careful battery management. Avoiding charging practices that accelerate battery degradation and reducing exposure to extreme temperatures (where possible) can ensure that electric vehicles can serve the needs of cities and towns for a long time.[96]

## Overcoming infrastructure challenges

Installing EV charging infrastructure is an additional challenge (and expense) municipalities will have to face in transitioning from internal combustion engine vehicles to EVs.

According to the U.S. Department of Energy, equipment and installation costs for EV chargers can range from a few hundred dollars to tens of thousands of dollars or

*(continued on p. 28)*


*Providing charging infrastructure for electric vehicles can be a challenge. Fortunately, assistance from utilities, as well as recently adopted federal incentives, can help municipalities build out the charging infrastructure needed to support their fleets. Credit: Pixabay/CC0 public domain*

## Depreciation, fuel prices also shape lifetime EV costs and benefits

Cities and towns purchasing electric vehicles can maximize their value by using them frequently and wisely. However, there are two factors that are beyond the control of local governments that also play a big role in determining the savings potential of EVs: depreciation and fuel costs.

**Depreciation:** Early EVs did not hold their value as well as conventional vehicles, leaving the initial owners of EVs receiving less money on resale than owners of similar conventional vehicles, and increasing their lifetime total cost of ownership. In part, this was due to the rapid technological progress of EVs – as EVs available in the new car market became cheaper and more capable, older EVs became less desirable and, therefore, worth less. Concerns about battery life and range also hurt resale values for EVs, particularly early ones.[97]

However, the gap in resale values between electric vehicles and conventional vehicles has been narrowing over time.[98] That is expected to continue as the initial cost of EVs declines, the pace of technological change moderates, and resale markets for EVs develop and improve. Incentives for the purchase of used electric vehicles included in the 2022 Inflation Reduction Act are also likely to create a more robust market for used EVs and to boost resale values.[99]

In addition, some theorize that – especially as EV charging networks improve and EVs become seen as the "wave of the future" – electric vehicles may become preferred to internal combustion engine cars, at which point their residual value may surpass that of gasoline- and diesel-powered vehicles.[100] This possibility is speculative but could affect the resale values of vehicles purchased by Arizona cities and towns over the next decade.

**Fuel costs:** A large part of the lifetime savings from EVs comes from reduced fuel costs – savings that become even greater at times when gasoline and diesel prices are high. As of mid-2022, gasoline and diesel prices were far above levels predicted just a few years ago (as well as those used in calculating the total cost of ownership savings presented in this report).

In May 2022, fuel prices in the region that includes Arizona were $4.96 per gallon of gasoline and $5.62 per gallon of diesel, compared to the $3.42 per gallon for gasoline and $3.48 per gallon for diesel used in estimating the total cost of ownership savings in this report.[101] Should these higher fuel prices continue (and not be matched by even greater increases in electricity prices), Arizona cities and towns would reap millions more dollars in lifetime savings.

even over $100,000 (for high-capacity fast chargers) depending on the type, level and number of chargers and the location.[102] After installation, there are also ongoing operation and maintenance costs.[103]

There are, however, a wide variety of tools and strategies local governments can use to reduce the costs of EV charging infrastructure and ensure that EVs are able to remain on the road. A critical first step is to develop an integrated fleet electrification plan that identifies the vehicles and use cases that are best suited to electrification. Cities and towns can then identify the types of EV charging infrastructure that are required and where they should be located, ensuring that municipalities are able to keep their vehicles on the road while avoiding investment in unnecessary infrastructure.

Utilities are key partners for cities and towns pursuing electrification. Arizona Public Service, Tucson Electric Power and Salt River Project already offer EV and/or EV charging infrastructure incentive programs.[104] Utilities also frequently offer technical assistance to fleet operators seeking to shift to EVs.[105] To obtain further potential cost savings from adopting EVs, municipalities could consider partnering with utilities to obtain bidirectional chargers that allow for power to be drawn from vehicles' batteries when not in use and sent to buildings or the wider grid. Such "V2X" capabilities would allow electrified fleets to serve as backup energy sources for buildings – helping power critical infrastructure during emergencies – or to provide grid services, which can sometimes allow such fleets to earn revenue from utilities.[106]

Finally, federal incentives under the IIJA and IRA can also help to reduce the cost of EV infrastructure. The IIJA provided $5 billion to fund the National Electric Vehicle Infrastructure program, which will create a national network of publicly available EV charging infrastructure along major roads, as well as $2.5 billion in discretionary grants for additional public EV charging, with an emphasis on expanding charging opportunities in rural and low- and moderate-income communities.[107] While these provisions do not provide direct support for infrastructure intended to serve municipal fleets, city and town-owned vehicles may have the opportunity to take advantage of these publicly accessible charging networks.

Municipalities can also take action now to reduce future infrastructure burdens by requiring the installation of chargers – or the electrical infrastructure needed to add chargers later on – in every newly built or renovated municipal building.[108]

## Reuse, recycling of used batteries can extend the benefits of EVs

As EVs become more common on Arizona's roads, concern has been raised about whether used EV batteries will become a new source of waste. In fact, used EV batteries are a valuable resource, both as a potential source of energy storage capacity and for the valuable minerals they contain, which, when batteries are recycled, can be used to produce the next generation of EV batteries.

Lithium-ion batteries that are no longer capable of powering an EV still retain significant energy storage capacity – as much as 80% of their originally rated capacity.[109] "Second life" EV batteries can be used for stationary electricity storage, helping to stabilize the electric grid and integrate more renewable energy into Arizona's electricity system – significantly reducing batteries' lifetime environmental impact.[110] While the number of retired EV batteries is currently small, energy storage companies, utilities and automakers are already beginning to use second-life batteries to store electricity.[111]

Recycling EV batteries can also help to address surging demand for materials like lithium and cobalt, which are currently in high demand globally. A 2021 study found that, under optimal circumstances, recycled EV batteries could supply more than half of global demand for lithium, cobalt and nickel.[112]

EV battery recycling is not without challenges – particularly the cost and difficulty of transporting batteries to centralized recycling facilities.[113] Profit margins in battery recycling can be thin, though as the number of used EV batteries increases, economies of scale may help to bring the cost of recycling down and make it more affordable and convenient.

The batteries in electric vehicles purchased today will likely not need to be recycled until after a decade or more of normal use – and potentially not for years after that if they are repurposed for second-life energy storage. Governments at all levels should adopt policies to encourage and facilitate the recycling and second use of electric vehicle batteries. With proper planning and the development of robust markets, used EV batteries can be an asset to the environment, rather than a burden.

# Arizona cities and towns are taking steps toward electrification, but concerns remain

**AS PART OF OUR SURVEY, ARIZONA PIRG EDUCATION FUND** and Frontier Group asked municipal officials to describe their experiences with electric vehicles to date as well as their aspirations for the future. While some Arizona cities and towns have begun to adopt electric vehicles – and many are planning to expand their commitment to fleet electrification – a great deal of work remains to be done.

## Charging infrastructure

The 10 cities and towns surveyed reported owning a total of 56 chargers for municipal vehicles, though the true number may be greater as some cities and towns may have only reported those chargers owned solely for use of municipal vehicles. Cities and towns are planning to add to their charging networks. The city of Scottsdale, for example, reported that it is installing two dual-port charging stations for use of its fleets in 2022 at no cost to the city through Arizona Public Service's "Take Charge AZ" program. The cost of adding enough charging infrastructure to support fleet electrification was a concern to many of the cities and towns responding to the survey, as was the cost of planning. As noted above, Arizona utilities provide assistance in overcoming these hurdles, and by sharing information and experiences, Arizona cities and towns can learn from one another as they electrify their fleets.

## Matching the right vehicle to the job

Even as the number and types of electric vehicles on the market continue to increase, municipal officials responding to the survey questioned whether current EV offerings are suited to the tasks municipal vehicles must perform. As noted above, pickup trucks represent a large share of many municipal fleets, and with electric pickups like the Ford F-150 Lightning just now hitting the market, and similar offerings from General Motors a year or two away, it will take some time to fill that gap. As these vehicles begin to make their way onto the market, it will be critical for municipal fleet managers to assess their performance and share experiences.

Another issue raised by one respondent is that current vehicle contracts may limit the variety of vehicles that municipalities may purchase (e.g., to just Ford and General Motors vehicles). Municipalities, as well as the Arizona State Procurement Office, which makes contract pricing available to municipalities through its cooperative contract program, should consider widening the variety of vehicles eligible to be purchased under contract to include electric vehicles made by other manufacturers that meet the needs of the state's fleets.

## Buy-in and support

Several respondents to the survey noted the importance of having buy-in and support from the municipality's political leadership and the employees using the vehicles, as well as adequate staff resources to manage the transition to EVs.

It can seem as though electrification adds yet one more task to the difficult job of fleet management. But the benefits of electric vehicles to municipal budgets and air quality – coupled with the likelihood that electric vehicles will make up an increasing share of the vehicle fleet in years to come – mean that it is well worth it for municipalities to make a commitment to EVs now and to devote the staff resources to making it happen. Collaborating with other municipalities – and taking advantage of resources and expertise provided by utilities, the non-profit sector, and the state and federal government – can lighten the load on municipal staff and help to ensure a smooth transition.[114]

# Policy recommendations

**ELECTRIFYING MUNICIPAL FLEETS PRESENTS** a golden opportunity for cities and towns in Arizona to save money, clear the air, and help make the state a leader in the transition to electric vehicles.

The analysis in this report points to several lessons for Arizona municipalities seeking to "go electric."

**Make bold commitments and stick to them.** Arizona municipalities should commit to replacing every retiring vehicle that has an electric equivalent with an EV, starting now. Municipalities in Arizona, including the state's three largest – Phoenix, Tucson and Mesa – have adopted EV Roadmaps and/or Climate Action Plans to reduce carbon emissions.[115] However, by moving farther and faster – and by committing the resources to ensure that meaningful goals are actually met – municipalities can realize greater economic and air quality benefits for their residents.

Setting a bold target for electrification can achieve multiple goals. First, it sends a signal to departments throughout local government – including those that manage facilities, budgets and interactions with utilities – that the municipality intends to transition to EVs, driving every department to adjust its practices to accommodate that commitment. Second, a bold commitment to electrification can enable the municipality to achieve economies of scale in its investments in vehicles and charging infrastructure. Rather than purchasing a couple of electric vehicles that inefficiently share a small number of chargers, municipalities can build a sufficient electric fleet to take full advantage of the infrastructure. Third, larger orders for electric vehicles could enable cities and towns to negotiate better deals with dealers and send a message to manufacturers that a market for their vehicles will be available in Arizona. Vehicle availability is a major challenge for fleets seeking to electrify – the Ford F-150 Lightning, for example, is sold out for the 2022 model year. A strong commitment to municipal electrification could help persuade automakers to make their vehicles available in Arizona.

Local governments should update their vehicle purchasing policies to require the purchase of EVs unless no suitable model is available. At the federal level, for example, an executive order directs agencies to achieve "100 percent zero-emission light duty vehicle acquisitions by 2027" and 100% for other vehicle classes by 2035.[116] Local governments should at least match that requirement.

**Develop a detailed municipal electrification plan.** Electrifying a municipal fleet requires more than just a commitment from fleet managers or policy makers. It requires planning by every part of municipal government as well as the electric utility serving the municipality. After setting an electrification goal, municipalities should develop a comprehensive plan for electric vehicle purchasing, charging and deployment. For example, municipalities could analyze use patterns and routes of all the vehicles in their fleets to figure out how many chargers are required, where chargers would be most useful, and the best charging schedule to ensure the health and proper functioning of their vehicles. Electric utilities frequently provide technical assistance and funding to help local governments plan and execute electrification projects, and municipalities should take full advantage of their help and expertise.


*Electric school buses reduce school children's exposure to diesel emissions, and many are now equipped with technology to allow their batteries to supply stored energy back to buildings or the grid, which can help stabilize the grid during disruptions, provide emergency power during outages, and support the addition of more solar and wind power to the electricity system. Credit: Virginia Clean Cities via National Renewable Energy Laboratory/U.S. Department of Energy*

**Collaborate with other municipalities in Arizona and beyond, as well as school districts and state government,** to share information and ideas, negotiate discounts for EVs and equipment, and advocate for additional incentives and supports for municipal electrification. The transition to electric vehicles is complex, and Arizona cities and towns that embark on the journey should establish forums to learn from each other's successes and mistakes, as well as the experience of municipalities nationwide.

One concrete way that municipalities can work together is to engage in bulk purchasing of vehicles and equipment, negotiating discounts with auto dealers.

Municipalities already have the ability to gain the benefits of bulk purchasing by purchasing vehicles through the state of Arizona's vehicle purchasing contracts. The Arizona State Procurement Office offers a Cooperative Program through which municipalities can purchase vehicles, as well as other goods and services, under contracts negotiated with vendors by the state.[117] All 10 of the municipalities surveyed for this report are members of the program.[118] Cooperative contracts provide significant discounts – up to several thousand dollars – for new electric vehicles compared to the manufacturer's suggested retail price. Reducing upfront purchase costs through bulk purchasing and the use of state contracts can enable

municipalities to enjoy the benefits of reduced fuel and maintenance costs sooner and pass along greater savings to their residents.[119]

Government agencies including the Maricopa Association of Governments and the Pima Association of Governments and entities such as the League of Arizona Cities and Towns can serve as valuable facilitators in this process. Municipalities can also take advantage of existing networks of cities and towns, such as the nationwide Climate Mayors Electric Vehicle Purchasing Collaborative, which can help provide planning guidance and support, models for electrification, and discounts or other tools to reduce costs and streamline the process of procuring charging infrastructure.[120] Five Arizona cities are already part of the Climate Mayors coalition.[121]

**Work with utilities to accelerate deployment of electric vehicle infrastructure and assure EV-friendly rate structures.** Utilities have an indispensable role in facilitating municipal vehicle electrification. Utility cooperation is often needed to install sufficient electric distribution capacity to support the large electric load that can be imposed by charging many municipal EVs at once. In addition, utility rate structures are an important part of the financial equation for EVs. The Arizona Corporation Commission, which regulates the state's investor-owned utilities, and public utilities such as the Salt River Project are already working to create EV-friendly electricity rate options, and municipalities should work with their local utilities to ensure that they are getting the best available deal, and to eliminate any bottlenecks or delays in the installation of infrastructure needed to support EVs.[122]

**Take full advantage of government and utility incentives.** There are multiple potential sources of grants, loans and other incentives for municipal fleet electrification. At the federal level, sources include U.S. Department of Transportation loans and grants; U.S. Department of Energy grants; and U.S. Environmental Protection Agency grants and rebates. Arizona cities like Tucson and Phoenix have used some of these federal funding sources for past fleet electrification efforts.[123] As described above, the commercial electric vehicle incentive in the IRA, passed in August 2022, is a powerful economic incentive that will significantly reduce the upfront cost of electric vehicles for municipalities.

Through policies enacted by the Arizona Corporation Commission, Arizona Public Service (APS) and Tucson Electric Power (TEP) also provide useful incentives. APS has a pilot program, Take Charge AZ, that provides selected organizations with chargers for four vehicles, for free.[124] TEP offers funding opportunities to support fleet electrification through its smart EV charging program. Pima County plans to have 160 EVs in its fleet by the end of 2022, and TEP is helping this fleet electrification effort by offering rebates of up to 75% of the cost of purchasing and installing Level 2 or DC Fast Charging stations.[125] The utility also offers time-of-use pricing, with lower rates for EV owners and fleet managers who charge their vehicles during off-peak hours when demand is lower.

Salt River Project (SRP) is offering rebates of $4,000 per Level 2 charging port for governments, municipalities, schools and non-profits to help with the installation of networked EV charging infrastructure. SRP is also offering up to $20,000 for fleets to conduct electrification studies to determine which EVs make the most sense for their fleets. Half of the money is provided to pay for the study by a qualified electrification service provider, and half can be used to pay for EVs themselves.

The bipartisan Infrastructure Investment and Jobs Act (IIJA), passed by Congress in 2021,

also creates and funds programs that can be of help to municipalities in building out electric vehicle charging infrastructure. Funding under the law for the U.S. Department of Energy's State Energy Program, new requirements for states to consider EV-friendly utility policies, discretionary grant programs and other opportunities created by the law could provide municipalities with additional resources to expand EV charging or improve the cost-benefit picture of electrification.[126] Municipal leaders should continue to coordinate with the state of Arizona as it implements its federally approved Electric Vehicle Infrastructure Deployment Plan, which will shape the installation of charging infrastructure funded by the IIJA.[127]

**Invest in staffing to support the transition to electric vehicles.** Municipalities committing to bold electric vehicle goals should also allocate funding for staff to help manage the electrification program. Smaller towns without the resources to add staffing could benefit from taking part in collaborations with other municipalities, or by encouraging the state of Arizona to provide technical and policy assistance to municipalities intending to electrify.

**Create financing tools to ease the upfront cost of EVs and infrastructure.** The upfront investments needed to buy EVs and install EV infrastructure can be a significant barrier to EV adoption by cash-strapped municipal governments. Unfortunately, these hurdles can deter municipalities from electrification opportunities that are financially beneficial for taxpayers in the long run. Cities, towns and utilities should work together to explore or develop financing tools to cover the upfront cost of EVs and infrastructure with the fuel and maintenance cost savings achieved over time.

# Methodology

**IN OCTOBER 2021, ARIZONA PIRG EDUCATION FUND** and Frontier Group sent a survey to 12 of the largest municipalities in Arizona by population, requesting detailed data about the composition and use of their fleets, expenditures on fuel and maintenance, experiences to date with electric vehicles, and perceived challenges and hurdles to vehicle electrification. Of the 12 municipalities, 10 responded with data (Chandler, Gilbert, Goodyear, Mesa, Peoria, Phoenix, Scottsdale, Surprise, Tempe, Tucson) while two declined to participate (Glendale and Yuma).

The data supplied by municipalities varied in its completeness, level of detail and coverage.

## Fleet characterization

From the raw data supplied by municipalities, we identified light-duty vehicles, which are the best candidates for near-term electrification. This is *not* a complete list of vehicles that can be electrified – electric options currently exist for a wide range of vehicles including garbage trucks, large vans, fire trucks and police vehicles, all of which were excluded from this analysis. However, many of these heavier-duty or more specialized vehicles are in the earlier stages of deployment and are used by cities and towns in smaller numbers than those that are the focus of this analysis.

Vehicles were limited to those with a Gross Vehicle Weight Rating (GVWR) of 10,000 pounds or less, corresponding with the Federal Highway Administration's definition of "light-duty vehicles."[128] The largest valid vehicles were class 2b trucks, described by the EPA as medium-duty passenger vehicles. For example, that includes the Ford F-250 but not the Ford F-350. Public safety vehicles, including police cruisers and ambulances, were excluded unless clearly labeled as administrative vehicles. Police vehicles make up a considerable fraction of many municipal fleets, and we heard from fleet managers that these vehicles have unique reliability needs that would need to be addressed during the electrification process. However, with modifications, EVs can be capable patrol vehicles, and several are in service in police departments nationwide.

For the city of Phoenix, we also excluded vehicles listed with a status code of "T," signifying "retained salvage." In addition, the cities of Chandler, Phoenix and Tucson included in their fleet data significant numbers of vehicles with zero reported miles traveled in the previous year or blanks in the column for previous year usage. These vehicles were excluded from the analysis. In cities that reported the purchase price of vehicles, vehicles with blank or zero values for prices were excluded from the calculation of the average purchase price of model year 2020 and 2021 vehicles.

Vehicles and vehicle use patterns were further characterized as follows:

### Vehicle categories

Vehicles included in the analysis were assigned to seven categories based on their body style and weight. (See Table M-1.)

Classification of individual vehicles was done based on information available from the U.S. Environmental Protection Agency's *fueleconomy.gov* website, manufacturer websites, trade publications and other publicly available sources. All vehicles of a particular model were assigned the same classification, even in cases where certain

**TABLE M-1. VEHICLE CLASSIFICATIONS IN THIS ANALYSIS**

| Vehicle class code | Name | Max GVWR | Example |
|---|---|---|---|
| 1 | Midsize car (<6,000 lbs. GVWR) | 6,000 | Chevy Malibu, Toyota Camry |
| 2 | Fullsize car (6,000-8,500 lbs. GVWR) | 8,500 | Chrysler Voyager |
| 3 | Compact SUV (<6,000 lbs. GVWR) | 6,000 | Jeep Wrangler |
| 4 | Midsize SUV (6,000-8,500 lbs. GVWR) | 8,500 | Chevy Tahoe |
| 6 | Light truck (<6,000 lbs. GVWR) | 6,000 | Chevy Colorado |
| 7 | Light truck (6,000-8,500 lbs. GVWR) | 8,500 | Silverado 1500, Ford F-150 |
| 8 | Medium duty pickup (8,500-10,000 lbs. GVWR) | 10,000 | Chevy Cargo Van 1500, Ford F-250 |

** Code 5 was reserved for SUVs between 8,500 and 10,000 lbs. GVWR, of which there were none in the municipal fleets surveyed.*

engine configurations or body packages might lead to a particular configuration of the vehicle being assigned to a different class.

## Vehicle age, fuel type and mileage

All 10 municipalities supplied the model years for all vehicles in their data sets. Nine of the 10 cities (all except Surprise) supplied the fuel type (e.g., gasoline, diesel, E85, electric) for their fleets. In Surprise, all vehicles were assumed to be powered by gasoline. In some cities, vehicles were identified as gasoline powered hybrid electric vehicles, but it is unknown whether all cities identified hybrid vehicles specifically.

All cities except Peoria supplied odometer readings or tallies of annual miles traveled for the vehicles in their fleets. In Surprise, the format in which the mileage data were supplied made it difficult to integrate with the fleet data; as a result, mileage data for Surprise were not used. Three cities – Phoenix, Scottsdale and Tucson – supplied vehicle usage data for the most recent year. In the other six cities (Chandler, Gilbert, Goodyear, Mesa, Peoria and Tempe), the number of miles traveled in the most recent year was assumed to be the average mileage traveled over the vehicle's lifetime (total odometer reading divided by years since the model year of the vehicle), and in Peoria and Surprise, miles driven in the most recent year was assumed to be the same as the average for the other eight municipalities for vehicles of that classification.

## Fleet turnover expectations

To assess the economic and public health benefits of replacing existing municipal vehicles with EVs, we first selected those vehicles anticipated to be replaced by the surveyed Arizona municipalities over the next decade. Vehicles included in the fleet turnover group were:

- For cities and towns in which odometer readings were available, those vehicles expected to exceed 100,000 miles by 2032 (calculated by multiplying average or most-recent-year mileage by 10 and adding it to the current odometer reading) or those that would be 20 years old or older in 2032.

- For those cities without odometer readings, vehicles that would be 15 years of age or older by 2032.

Total cost of ownership is evaluated assuming a vehicle lifetime of 15 years. Given average mileage accumulation rates of vehicles in the fleets of the Arizona municipalities surveyed, this would translate into approximately 100,000 miles of travel over the vehicle's lifetime.

## Total cost of ownership and public health benefits

To estimate the total cost of ownership and "well-to-wheels" public health benefits of electrification, we used the 2020 version of the Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) tool. This spreadsheet model, developed by the Argonne National Laboratory, allows users to estimate petroleum use, emissions and costs of ownership for light-duty vehicles (LDVs) and heavy-duty vehicles (HDVs).

Separate estimates of benefits were calculated for each vehicle classification within each municipality based on the current mix of fuels in each city or town and the number of miles driven in vehicles of each type in a given year, obtained/calculated as described above. For each model run, total cost of ownership and vehicle emissions were calculated for two scenarios: a "replace-like-with-like" scenario that assumed that vehicles currently in municipal fleets would be replaced with those of a similar fuel type, and a scenario that assumed their replacement with electric vehicles.

Arizona municipalities have numerous "flex-fuel" vehicles in their fleets that can run on ethanol (E85) as well as vehicles powered by compressed natural gas (CNG). In the "replace-like-with-like" analysis, we assume that these vehicles will be replaced with gasoline vehicles for the following reasons: 1) manufacturers have been reducing their number of flex-fuel vehicle offerings and CNG vehicle availability remains limited; 2) many flex-fuel vehicles are largely fueled with gasoline, rather than ethanol, and so are often used in ways similar to gasoline-only vehicles; and 3) data on flex-fuel and CNG vehicle characteristics and price are difficult to obtain.

### Vehicle characteristics

Arizona municipalities have a wide variety of vehicles in their fleets. To simplify the analysis, each class of vehicles in Arizona fleets was represented in the AFLEET model runs by a synthetic vehicle representing a hybrid of some of the most popular vehicles of their type in municipal fleets, and either current or emerging potential electric substitutes.

For those vehicles for which electric substitutes currently exist or are about to come to market (our classes 1, 3, 6 and 7), an initial cost (MSRP) and fuel economy rating was determined based on data from the U.S. EPA's *fueleconomy.gov* web site, manufacturer websites, trade publications or other public sources. A full list of the vehicles used in the analysis, and their characteristics can be found in Appendix A.

For vehicles in our classes 2, 4 and 8, fewer electric options currently exist, making it more difficult to use current market data to estimate the cost or fuel economy of these vehicle types. For these classes of vehicles, AFLEET defaults for cost and fuel economy for electric vehicles were used. For classes 2 and 4, these default assumptions tracked reasonably well with current electric vehicle offerings, but for class 8, the AFLEET model's assumed high vehicle costs and low fuel economy for those led to a negative total cost of ownership estimate. Vehicles in our class 8 were therefore excluded from the rest of the analysis.

The effects of the commercial electric vehicle incentive in the Inflation Reduction Act were modeled as follows: For vehicle types where the difference in cost between an electric and

gasoline-powered vehicle was greater than $7,500, the upfront cost of the electric vehicle was reduced by $7,500. For vehicle types where the difference was less than $7,500, the price of the electric vehicle was reduced to match that of the gasoline-powered vehicle. In all cases, the size of the incentive was less than 30% of the cost of the electric vehicle.

Other assumptions used in the AFLEET modeling were based on 2021 data on energy pricing from the U.S. Energy Information Administration, with the following price levels used:

Gasoline ..... $3.417/gallon
Diesel..... $3.484/gallon
Electricity (commercial).....$0.103/kWh

Vehicles in the model were assumed to be purchased directly and not financed. No incentives beyond the commercial vehicle incentive included in the Inflation Reduction Act were assumed to be available. In all other cases, AFLEET default assumptions were used.

No attempt was made to forecast changes in electric vehicle, conventional vehicle or fuel prices over the 10-year period studied. Instead, estimates of total cost of ownership are calculated as though the entire set of vehicles in the "fleet turnover" group were to be replaced today. To the degree that further reductions in electric vehicle prices would make EVs more financially beneficial – or further improvements in conventional vehicle fuel economy would make them relatively less beneficial – these effects are not captured in the analysis. All costs and savings are expressed in nominal dollars and are not adjusted for inflation nor discounted.

All estimates of public health benefits of electrification were based on a "well-to-wheels" basis – that is, including all emissions resulting both from vehicle use and the production of fuel used to power vehicles. This is important for ascertaining the full impact of electric vehicles as the air pollution associated with their use is created "upstream" at power plants. The grid power mix for the Western Electricity Coordinating Council (WECC) was selected in AFLEET for the estimate of power plant emissions associated with electric vehicle use. Note that emissions rates for power plants in the West are falling as coal-fired power plants in the region are retired and renewable energy sources such as solar and wind power expand.[129] The emission reductions and economic benefits from air pollution reductions estimated in this report should be considered a lower bound of what is achievable as municipalities replace their fleet vehicles with electric vehicles over the next decade.

# Appendix A: Total cost of ownership savings from electrification by vehicle type

(values in parentheses=increased expense compared with "replace-like-with-like" scenario)

| Vehicle class code | 1 | 2 | 3 | 4 | 6 | 7 | Total (class 1-7) |
|---|---|---|---|---|---|---|---|
| Name | Midsize car | Fullsize car | Compact SUV | Midsize SUV | Light truck 1&2 | Light truck 3&4 | |
| Max GVWR | 6,000 | 8,500 | 6,000 | 8,500 | 6,000 | 8,500 | |
| Gas vehicle examples | Chevy Malibu, Toyota Camry | Chrysler Voyager | Jeep Wrangler | Chevy Tahoe | Chevy Colorado | Silverado 1500, F-150 | |
| Depreciation | $24,795 | $- | $(760,539) | $- | $(1,299,533) | $(702,874) | $(2,738,151) |
| Fuel | $6,277,842 | $131,318 | $1,938,970 | $9,111,310 | $2,286,776 | $32,860,832 | $52,607,048 |
| Diesel Exhaust Fluid | $- | $- | $- | $- | $- | $258,897 | $258,897 |
| Maintenance and Repair | $4,109,898 | $61,095 | $1,160,950 | $4,358,085 | $1,439,080 | $19,438,790 | $30,567,898 |
| Insurance | $6,506 | $- | $(199,553) | $- | $(340,977) | $(184,423) | $(718,447) |
| License and Registration | $- | $- | $- | $- | $- | $- | $- |
| **Total Cost of Ownership Savings** | **$10,419,041** | **$192,413** | **$2,139,827** | **$13,469,394** | **$2,085,346** | **$51,671,223** | **$79,977,245** |

*Note: Results for our "class 8" (medium trucks, 8,500-10,000 GVWR) excluded as these vehicles did not yield total cost of ownership savings using the assumptions in this analysis. Certain class 8 vehicles may yield economic benefits for municipalities, and the number of vehicles in this class that are cost-effective to electrify will increase over time as the cost of electric vehicles continues to fall.*

# Appendix B: Sample vehicles used in AFLEET analysis and default vehicle price and mileage assumptions

| Vehicle class code | Name | Max GVWR | Gas vehicle example | Gas vehicle price | Gas vehicle mileage (mpg) | Hybrid vehicle price | Hybrid vehicle mileage (mpg) | Diesel vehicle price | Diesel vehicle mileage (mpg) | Electric vehicle price (before IRA incentive) | Electric vehicle price (after IRA incentive) | Electric vehicle mileage (mpgge) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Midsize car | 6,000 | Chevy Malibu, Toyota Camry | $24,398 | 29.0 | $25,735 | 52 | NA | NA | $29,200 | $24,398 | 115.5 |
| 2 | Fullsize car | 8,500 | Chrysler Voyager | $32,115 | 22.0 | NA | NA | NA | NA | $37,000 | $32,115 | 106.2 |
| 3 | Compact SUV | 6,000 | Jeep Wrangler | $25,663 | 26.5 | $28,030 | 41 | NA | NA | $38,472 | $30,972 | 113.0 |
| 4 | Midsize SUV | 8,500 | Chevy Tahoe | $41,400 | 20.0 | NA | NA | $49,700 | 24.0 | $46,000 | $41,400 | 69.5 |
| 6 | Light truck 1&2 | 6,000 | Chevy Colorado | $25,188 | 22.0 | NA | NA | $25,200 | 23.0 | $39,937 | $32,437 | 69.0 |
| 7 | Light truck 3&4 | 8,500 | Silverado 1500, F-150 | $31,968 | 21.0 | NA | NA | $48,140 | 26.0 | $39,937 | $32,437 | 69.0 |
| 8 | Medium truck 2b | 10,000 | Cargo Van 1500, Ford F-250, E-350 | $40,443 | 14.5 | NA | NA | $48,390 | 15.5 | $93,000 | $85,500 | 37.8 |

*Trucks in class 7 were assumed to be potential substitutes for lighter trucks in category 6. "NA" = vehicle type was not found in existing municipal fleets.*

# Appendix C. Municipal fleet survey

### 1. Inventory

List all the light- and medium-duty motor vehicles in your municipal fleet. Feel free to send your own files or spreadsheets if that is more convenient for you. For each vehicle, please include:

Make

Model

Model year

Vehicle type (car, passenger truck, light truck)

Fuel type

Year obtained

Mileage for the most recent year

Cost of vehicle (if leased, please include up-front cost, monthly payment and lease term)

### 2. Fleet management

How much did your municipality spend last year on vehicle maintenance? Please separate spending by fuel type and vehicle type if possible.

How much did your municipality spend last year on gasoline for your fleet?

How many gallons of gasoline did you purchase for your fleet last year?

How much did your municipality spend last year on diesel fuel for your fleet?

How many gallons of diesel did you purchase for your fleet last year?

### 3. Battery Electric Vehicles

Does your municipality track electricity consumption for EVs separate from general electricity consumption? If so, how much did your municipality spend on electricity for EV charging last year?

How many charging stations/plugs has your municipality installed for the use of fleet vehicles? If possible, please provide an estimate of the cost of installing charging facilities for municipal vehicles.

(optional) What have been some benefits to having electric vehicles in your fleet?

(optional) What have been some challenges regarding electric vehicles in your fleet?

(optional) What one change (e.g., better technology, infrastructure improvements, financial incentives or group purchasing policies) would make the most difference in supporting your municipality in the transition to electric vehicles?

# Notes

1 U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics 2020*, Table MV-7, December 2021, archived at https://web.archive.org/web/20220614212207/https://www.fhwa.dot.gov/policyinformation/statistics/2020/mv7.cfm.

2 Excludes vehicles in Chandler, Phoenix and Tucson without odometer readings for the previous year; see methodology. The definition of "light-duty vehicles" used here is that used by the Federal Highway Administration. Vehicles between 8,500 and 10,000 pounds GVWR are classified as light-duty vehicles by FHWA but as "medium-duty passenger vehicles" by the Environmental Protection Agency. Source: U.S. Department of Energy, Alternative Fuels Data Center, Vehicle Weight Classes & Categories, accessed at https://afdc.energy.gov/data/10380#:~:text=These%20classes%2C%201%2D8%2C,(Class%207%2D8), 27 September 2022.

3 Based on reported expenditures on vehicles by eight municipalities. Average cost reflects average for the eight municipalities; total reflects inclusion of estimated expenditures for Phoenix calculated based on the average expenditure per vehicle for the other municipalities. It is likely that this is a very conservative estimate of annual vehicle expenditures. It excludes vehicles of previous model years that were purchased in 2020 or 2021 (for example, model year 2019 vehicles purchased in 2020). In addition, the data for some cities may not include all model year 2021 vehicle purchases. Finally, the disruption caused by the COVID-19 pandemic may have affected vehicle purchasing patterns in these years.

4 Gilbert and Scottsdale did not supply estimates of maintenance costs.

5 U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, "FOTW# 1167, January 4, 2021: Median Driving Range of All-Electric Vehicles Tops 250 Miles for Model Year 2020," *Fact of the Week*, 4 January 2021, archived at http://web.archive.org/web/20210630005037/https://www.energy.gov/eere/vehicles/articles/fotw-1167-january-4-2021-median-driving-range-all-electric-vehicles-tops-250.

6 Consumer Reports, *Consumer Reports Comments on EPA's "Revised 2023 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions Standards" (Docket No. EPA-HQ-OAR-2021-02087)*, 27 September 2021, 16, accessed at https://advocacy.consumerreports.org/wp-content/uploads/2021/09/EPA-SAFE2-Comment.pdf.

7 Chrysler: Ben Klayman, "Stellantis' Chrysler brand to go all electric by 2028 -executive," *Reuters*, 5 January 2022, available at https://www.reuters.com/technology/stellantis-chrysler-brand-go-all-electric-by-2028-executive-2022-01-05/; GM: General Motors, *General Motors, the Largest U.S. Automaker, Plans to be Carbon Neutral by 2040* (press release), 28 January 2021, archived at http://web.archive.org/web/20210201212205/https://media.gm.com/media/us/en/gm/home.detail.html/content/Pages/news/us/en/2021/jan/0128-carbon.html; Volvo: Nick Carey and Helena Soderpalm, "Betting on death of petrol cars, Volvo to go all electric by 2030," *Reuters*, 2 March 2021, available at https://www.reuters.com/article/us-autosvolvo-electric/betting-on-death-of-petrol-cars-volvo-to-go-all-electricby-2030-idUSKBN2AU0AU.

8 U.S. Environmental Protection Agency, *Fuel Economy Guide 2022 Datafile* (Excel files), downloaded from https://www.fueleconomy.gov/feg/download.shtml, 31 May 2022.

9 See methodology.

10 See U.S. Energy Information Administration, *Annual Energy Outlook 2022*, Table 54: Electric Power Projections by Electricity Market Module Region: Western Electricity Coordinating Council/Southwest region, accessed at https://www.eia.gov/outlooks/aeo/data/browser/#/?id=62-AEO2022&region=5-20&cases=ref2022&start=2020&end=2050&f=A&linechart=ref2022-d011222a.5-62-AEO2022.5-20&map=&sourcekey=0, 23 September 2022.

11 For vehicles under 14,000 pounds GVWR, incentives are capped at $7,500 per vehicle. Source: Inflation Reduction Act of 2022, Pub. L. No. 117-169, Section 13403, accessed at https://www.congress.gov/bill/117th-congress/house-bill/5376/text, 23 September 2022.

12 U.S. Census Bureau, *2020 Decennial Census Redistricting Data by Race for Places*, downloaded from data.census.gov, 16 August 2022.

13 See note 1.

14 Excludes vehicles with no reported travel in past year from Chandler, Phoenix and Tucson. See methodology. Note: The definition of "light-duty vehicles" used here is that used by the Federal Highway Administration. Vehicles between 8,500 and 10,000 pounds GVWR are classified as light-duty vehicles by FHWA but as "medium-duty passenger vehicles" by the Environmental Protection Agency. Source: U.S. Department of Energy, Alternative Fuels Data Center, *Vehicle Weight Classes & Categories*, undated, accessed at https://afdc.energy.gov/data/10380#:~:text=These%20classes%2C%201%2D8%2C,(Class%207%2D8), 27 September 2022.

15 Vehicle categories based on emissions classes established by the EPA, with additional distinctions made between SUVs and light trucks within the EPA's "light truck" category. Note that trucks between 8,500 and 10,000 lbs. GWVR are categorized as "light trucks" by the Federal Highway Administration but as "medium-duty passenger vehicles" by the EPA. See U.S. Department of Energy, Alternative Fuels Data Center, *Vehicle Weight Classes and Categories*, undated, accessed at https://afdc.energy.gov/data/10380#:~:text=These%20classes%2C%201%2D8%2C,(Class%207%2D8), 15 June 2022.

16 The Chevrolet Silverado and GMC Sierra are built on the same platform manufactured by General Motors, with "1500" representing the half-ton pickup in both model lines. See George Kennedy, "2021 Chevrolet Silverado vs. 2021 GMC Sierra 1500," *U.S. News and World Report*, 30 June 2021, archived at https://web.archive.org/web/20220615135313/https://cars.usnews.com/cars-trucks/silverado-vs-sierra.

17 Excludes one vehicle listed as "CNG UN" in Mesa.

18 Note: Cities reported additional electric, plug-in hybrid and hybrid vehicles in categories not included in this analysis, including carts, emergency response vehicles and equipment. These figures do not include these additional vehicles.

19 Based on mileage accumulation for the most recent year available (2020 or 2021) where provided by the municipality. Where this was unavailable, vehicle travel estimates were based on average annual mileage of the fleet's vehicles (where odometer readings were available), or, in the cases of Peoria and Surprise, which did not supply usable mileage data, an average of the annual mileage for the other cities surveyed. See methodology.

20 Excludes Surprise.

21 Excepting Peoria and Surprise.

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128 See note 2 for definition of "light-duty vehicles" used in this report.

129 Specifically, according to the U.S. Environmental Protection Agency's eGRID tool, the carbon dioxide emission rate of power plants in the WECC region fell from 770.49 lbs./MWh to 706.53 lbs./MWh, a decline of 8.3%, between 2018 and 2020. Source: U.S. Environmental Protection Agency, *eGRID Data Explorer*, accessed at https://www.epa.gov/egrid/data-explorer, 22 July 2022.