GETTING INVOLVED IN FLEET ELECTRIFICATION
OPPORTUNITIES FOR PUBLIC POWER
The American Public Power Association is the voice of not-for-profit, community-owned utilities that power 2,000 towns and cities nationwide. We represent public power before the federal government to protect the interests of the more than 49 million people that public power utilities serve, and the 93,000 people they employ. Our association advocates and advises on electricity policy, technology, trends, training, and operations. Our members strengthen their communities by providing superior service, engaging citizens, and instilling pride in community-owned power.

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Electric vehicles (EVs) are poised to become the vehicle technology of choice in the coming decades. It’s not just personal vehicles that are switching to electric – the passenger vehicle an Uber driver picks riders up in and an urban delivery truck transporting goods are also making the change. Behind these decisions are fleet operators who are increasingly exploring and committing to vehicle electrification, ranging from light to heavy-duty vehicles.¹

As trusted energy advisors, public power utilities can assist other fleet operators as they transition to EVs. This report is intended to guide public power utilities, state/regional associations, and joint action agencies as they consider electrifying their fleet and to help them assist other community entities who wish to electrify their fleets.

When public power providers electrify their fleets, they can lead by example and gain first-hand experience with EVs and associated technology. Utilities can perform fleet assessments, conduct vehicle charging studies, and evaluate options when the vehicles are near the end of their useful life. Some utilities may set goals about the percentage of vehicles they want to be electric by a certain timeframe, which could be tied to local or statewide goals, whether those be specific to EV fleets or broader goals related to climate or sustainability.

As discussed in the American Public Power Association’s Creating an Electric Vehicle Blueprint for Your Community: Public Power Strategies, public power utilities have various options for implementing an EV program.² Since no two utilities are the same, EV programs should be tailored to address community needs, interests, and goals. Key topic areas to consider including in an EV program are: charging infrastructure, education and awareness, fleet electrification, rate design, vehicle-grid integration technologies, incentives, EV adoption, and grid impacts.

This report explains how the elements of a public power EV program connect to, and impact, EV fleet adoption. Through highlighting public power examples alongside trends and case studies from other companies, this report covers considerations for fleet deployments including EVs for local government, public transit, school districts, commercial trucking, transportation network companies, and autonomous vehicles.

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¹ A fleet operator may or may not be the same entity as the fleet owner; however, for simplicity, this report will use the term “fleet operator.”
² Please review the blueprint for additional detail on these topics, and to leverage checklists and explore industry topics.
³ FCEVs are out of scope for this report.
Motivations to electrify a fleet can differ across utilities, public transit agencies, government agencies, school boards, transportation network company operators, or commercial trucking companies. Motivations may include a wide variety of policy pressures, load growth potential, and operational savings.

Policies or Legislation
While an increasing number of municipalities support EV adoption through incentives, policies, or (in a few cases) mandates, there are no state or federal regulations requiring states to fully transition to electric vehicles. There are several related programs and commitments, such as Corporate Average Fuel Economy (CAFE) standards, state Renewable Portfolio Standards (RPS), state and local incentives, and voluntary programs such as the C40 Fossil Fuel Free Streets Declaration.

CAFE Standards
CAFE standards were first enacted by Congress in 1975 with the goal of increasing fuel economy in cars and light-duty trucks. The standards set a specific fuel economy that automakers must ensure all their vehicles meet. Periodically, since 1978, the standards have been raised and automakers have had to increase their fuel efficiency to meet the new standards. CAFE standards are overseen by the Department of Transportation’s (DOT) National Highway Traffic and Safety Administration (NHTSA). In 2010, CAFE standards were expanded to include fuel economy and greenhouse gas emission standards for medium- and heavy-duty trucks. The standards set a specific fuel economy that manufacturers must ensure all their vehicles meet. Periodically, since 1978, the standards have been raised and automakers have had to increase their fuel efficiency to meet the new standards.

ZEV Targets
States and local governments are also enacting policies that may incentivize, or require, fleet operators to electrify. For example, in 2013, the governors of eight states committed to a memorandum of understanding (MOU) to coordinate implementation of their state ZEV programs. A ninth state joined the MOU in 2018. These states — California, Connecticut, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island, and Vermont — have committed to having a combined 3.3 million ZEVs on their roads by 2025.

In 2019, the District of Columbia signed an act that requires “100% of all public buses, passenger and light-duty vehicles associated with privately-owned fleets with a capacity of 50 or more passengers or light-duty vehicles licensed to operate by the District of Columbia, commercial motor carriers, limousine-service vehicles, and taxis certified to operate by the District of Columbia,” be ZEV by 2045. In fall 2019, DOT and the Environmental Protection Agency issued a rule revoking California’s tailpipe waiver under the Clean Air Act to set emissions standards. The rule also “will enable the federal government to provide nationwide uniform fuel economy and greenhouse gas emission standards for automobiles and light-duty trucks.” Twenty-three states and a coalition of environmental groups have filed lawsuits in the U.S. District Court for the District of Columbia asking the court to find the rule revoking California’s waiver unlawful. The outcome of the litigation and the rule are unknown at date of publication of this report.

Renewable Portfolio Standards

RPS goals are developed at the state level and require electric retail suppliers to acquire a specific portion of their load from renewable energy sources. Since RPS standards are enacted at the state level, programs can vary from state to state. Typically, the program has a penalty for non-compliance and allows for facilities and electric suppliers to trade renewable energy credits (REC) to achieve compliance.12 According to a Lawrence Berkeley National Laboratory (LBNL) report, “roughly half of all growth in U.S. renewable energy generation and capacity since 2000 is associated with state RPS requirements.”13 When charged during times of renewable generation, EV adoption can aid in meeting RPS and greenhouse gas (GHG) emission reduction targets since BEVs release no tailpipe emissions and EVs have the potential to be powered by renewable energy depending on the energy generation mix in the service territory.

As RPS program targets increase, states and utilities will look for unique ways to balance reliability and the intermittent nature of many renewable resources. An article in The Electricity Journal found that relying on solar generation during the middle of the day in place of gas plants leads to “the potential for over-generation and steep ramps on days with abundant sun and relatively low consumption.”14 The article found that the flexibility of loads associated with charging EVs could be a way to utilize that over-generation. Customers enrolled in a dynamic rate would be “incentivized to charge during periods in which the share of output from non-dispatchable generators is highest.”15

C40 Declaration

In 2017, a group of mayors from cities around the world signed a voluntary, non-binding C40 Fossil Fuel Free Streets Declaration to show their commitment to reducing carbon emissions.16 Specifically, the mayors “pledge to transition to Fossil Fuel Free Streets by: 1) procuring, with our partners, only zero-emission buses from 2025 and 2) ensuring a major area of our city is zero emission by 2030.”17 C40 Cities is an international climate action organization. American cities engaged in the Fossil Fuel Free Streets Declaration include Los Angeles, Seattle, Honolulu, Santa Monica, and West Hollywood.18

Load Growth

The U.S. Department of Energy’s National Renewable Energy Laboratory (NREL) conducted a study to project growth in the use of electricity through 2050. Within medium and high electrification adoption scenarios, NREL predicted that transportation would be one of the sectors with the highest growth in load.19 NREL found that “the transportation sector could dramatically increase total electricity demand, with concurrent impacts on petroleum trade and tailpipe emissions. Impacts in this sector could be especially magnified because transportation currently accounts for less than 1 percent of U.S. electricity demand but accounts for nearly 30 percent of primary energy consumption.”20 Under its high electrification scenario, NREL predicts that electric vehicles— including fleets, light- and heavy-duty trucks, electric transit buses, and personal vehicles—could account for more than 75 percent of vehicle miles traveled by 2050.21 As electric utilities’ load has generally flattened, a transition to EVs, in addition to electrification of other end uses, could create new demand for electricity in stagnant markets. Under NREL’s medium electrification adoption scenario, U.S. electricity consumption would increase by 20 percent, while under the high adoption scenario consumption would jump by 38 percent.22

Since greater adoption of EVs and EV fleets will affect load, it will become even more important for electric utilities to understand fleet operators’ long-term plans, including their master plans for charging infrastructure, load projections, load locations, and EV charging habits. Uncontrolled charging that is concurrent with peak demand will require an increase in generation capacity, which is why utilities are exploring ways to manage charging. In 2018, the Electric Power Research Institute (EPRI), in collaboration with Arizona’s Salt River Project (SRP), conducted a study on EV driving and charging habits of residential customers. This analysis allowed the utility to adjust its load projections to incorporate EV adoption and understand how much, and when, additional generation would be needed to supply the increased demand from EV adoption.23 The study found that when residential EV owners were enrolled in time-of-use (TOU) rates, the TOU rates were an efficient tool to shift the peak load generated by EV charging into the evening and early morning hours. Fleet operators might have less flexibility to charge their vehicles during off-peak times. A utility should explore how incorporating TOU rates could impact the load shapes of electrified fleets.

17 Ibid.
20 Ibid.
21 Ibid.
22 Ibid.
Operations and Maintenance Savings

Reduced operations and maintenance (O&M) costs are a key motivator for fleet electrification. EVs are typically less expensive to maintain because they have fewer moving parts compared to ICE vehicles, no need for oil changes, and, according to a Columbia University study, require less frequent brake replacements.24 These savings can be factored into the total cost of ownership (TCO) of EVs. Calculating the TCO often includes capital costs of procuring the vehicle, operating costs, and fuel costs. Some calculations also include the costs of fueling infrastructure, such as charging equipment for EVs or fueling centers for diesel or compressed natural gas (CNG) vehicles.25

However, not all fleet operators would see O&M savings with current commercially available technology. When charging infrastructure costs are included, EVs might not reach parity with comparable gas, diesel, or CNG vehicles on the TCO given that EVs often have a higher purchase price. Additionally, fleets with longer routes might opt for vehicles with larger batteries, which can increase the TCO.

Fuel costs for EVs are typically less expensive than gas, diesel, or CNG. As shown in Figure 1, DOE's Alternative Fuels Data Center found that electricity prices are consistently lower than any other vehicle fuel.26 Figure 1 also highlights how electricity pricing has been more consistent and less volatile than gasoline or diesel pricing from 2002 through 2018.

Lead by Example

Some utilities see electrifying their fleet as an opportunity to educate their customers on EVs and any EV-specific or TOU rates or demand charges that they might offer or require. Using EVs in their fleets also allows utilities to showcase the diverse roles EVs can fill. By deploying EVs in their own fleets, utilities can speak to the challenges and considerations that go into the decision to electrify a fleet and operating and maintaining the vehicles.

According to a report released by The Climate Group, 23 companies have committed to accelerate their fleet electrification and to electrifying 145,000 fleet vehicles by 2030.28 U.S. companies that have signed the Climate Group’s EV100 pledge include Bank of America, Clif Bar & Company, HP, Inc., Pacific Gas and Electric Company, the Port Authority of New York and New Jersey, and Unilever.29 Companies that signed the pledge cited a leadership role in fleet electrification and reputational benefits as two of the top three key drivers for electrifying their fleets.30 According to the report, “pioneers of new solutions such as EVs tend to look long term, seeking to safeguard enduring corporate value by positioning themselves ahead of the curve on vital societal shifts.”31

Figure 1: Average Retail Fuel Prices in the U.S.

Source: Department of Energy, Alternative Fuels Data Center27

26 This figure references retail electric rates not inclusive of demand charges.
31 Ibid.
Environmental

Fleet operators are often motivated to electrify their fleets for environmental reasons. In the EV100 report, reducing GHG emissions and protecting the environment were the top motivators for companies to electrify their fleets. ICE vehicles are run on fossil fuels and release criteria pollutants and carbon dioxide into the atmosphere through their tailpipe emissions. Some types of EVs, including BEVs, release zero tailpipe emissions. This lack of direct emissions could be enticing to fleet operators that are looking for ways to reduce GHG emissions or be perceived as environmentally friendly.

EVs are considered even more environmentally friendly when the electricity used to recharge their batteries is generated from renewable resources. Even if the electricity source is not renewable, EVs still emit fewer GHG on a mile-for-mile basis. EVs are up to three times more energy efficient than ICE vehicles. According to the U.S. Department of Energy, EVs convert approximately 60 percent of the energy they receive from the grid to power the vehicle, compared to conventional gas-powered vehicles which convert approximately 20 percent of the energy stored in gasoline to power the vehicle.

A 2018 report by M.J. Bradley and Associates models and quantifies the environmental costs and benefits associated with GHG reductions due to EV adoption. Specifically, the report considered the monetary value of reductions in GHG, nitrogen oxide, and particulate matter emissions resulting from EV adoption. The report calculated a direct environmental benefit of $144 billion by 2050 under a moderate EV adoption scenario and $226 billion by 2050 under a high EV adoption scenario.

Public Health

Public health impacts are a major motivator for local governments, school districts, and public transit agencies when considering electrifying their fleets. Cities have identified electrifying their public transit fleets as a way to improve air quality for residents. A 2015 report from EPRI and the Natural Resources Defense Council found that electrification of light- and medium-duty vehicles, in addition to certain off-road equipment, could lead to reductions of 430-550 million metric tons of emissions annually by 2050. The report also found that transportation electrification would lead to reductions in ground-level ozone and particulate matter in both urban and rural areas of the country.

Fleet operators might also be motivated to electrify their fleets due to the environmental justice issues associated with disproportionately low-income and minority neighborhoods in congested cities, which are often closer to traditional public transit depots and seaports, and therefore subject to greater exposure to tailpipe emissions. According to a 2019 report by the Union of Concerned Scientists, “Latinos, African-Americans, Asian-Americans and low-income communities are exposed to substantially more air pollution from cars, trucks, and buses than other demographic groups in California.”

The report found that particulate matter pollution in low-income homes was 10 percent greater than the state average. It also found that African-Americans and Latinos in California were exposed to approximately 40 percent more particulate matter than white California residents, while Asian-Americans in California were exposed to 20 percent more particulate matter pollution than white Californians.

Noise Reduction

In a Bloomberg report, cities reported noise reduction as one of the motivators for electric fleet adoption, as electric public transit buses “run more quietly than diesel or CNG buses.” For example, at slow speeds (around 12 miles per hour), it would take 25 electric buses running at once to equal the noise emitted by a single ICE bus. These differences decrease as the speed of the EV increases. The noise pollution reduction could be the greatest for fleets when EVs are left on at planned stops.

Using electric buses on routes filled with ICE vehicles does not lead to any perceivable noise reduction. However, switching to electric buses on residential routes with less traffic—where buses account for a larger portion of the total noise pollution—could lead to a noise reduction of as much as 5 decibels (dB(A)).
When deciding whether or not to electrify, fleet operators have many factors to consider including cost, model availability, routes, distance traveled, climate, operational needs, and availability, type, and siting of charging infrastructure.

**Coordination**

Early coordination between public power utilities and fleet operators will help both parties. Utilities can assist in developing timelines for installing charging infrastructure and explain the utility's rate structure so that the fleet operator can understand charging costs. Coordination allows the utility to incorporate the additional load into their system planning, and to ensure that the load growth will not impact reliability. Early discussions also allow fleet operators to discuss any specific requests or constraints such as reliability needs or plans for distributed energy resource investment at the charging site.

**Cost**

Operators are often drawn to electrify their fleets by the opportunity for lower fuel costs, but there are many other economic factors to consider. Financial considerations include upfront purchase price, available federal and state incentives, maintenance, electric rates, the potential for leasing instead of outright ownership, and the availability and costs of charging infrastructure. When all these factors are considered, some fleet owners and operators can achieve cost savings or parity to fossil fuel-powered fleets.

**Upfront Cost**

A major factor when considering electrifying a fleet is the upfront cost. EVs often have higher upfront costs, which might discourage some fleet operators from investing in EVs, even if the TCO (including infrastructure) is lower than other vehicle options. The main driver of higher prices for electric buses and trucks is the cost of the electric battery and increased manufacturing costs because of smaller scale production compared to ICE equivalents. The remaining physical parts of EVs are comparable in cost to ICE vehicles.

Fleet operators should also consider the cost for EVSE deployment. New charging stations might need to be installed on routes or in depots to support an EV fleet, and the cost of any electrical infrastructure upgrades associated with serving these new stations might be borne by the operator. This additional cost of EVSE installation will increase total upfront costs of electrifying a fleet.

There are various incentives to bring the upfront purchase price of an EV down, such as tax credits, tax exemptions, rebates, grants, and loans. Incentives include:

- **Tax credits.** The federal government provides tax credits for the purchase of light-duty EVs that range from $2,500 to $7,500 depending on the type of vehicle and battery. The tax credits are available by manufacturer and until that manufacturer has sold 200,000 EVs, at which point the tax credit will be phased out. While municipal utilities and local governments do not qualify for these tax credits, other fleet operators might be able to leverage them. A federal tax credit for the purchase of EV charging infrastructure expired in 2017, however, in fall 2019, the Alternative Fuel Vehicle Refueling Property Credit (30C) was proposed in both the House and Senate tax extenders packages. Some states also provide tax credits.

- **State and local funding.** Some fleets might be eligible for financial assistance through the Volkswagen Environmental Mitigation Trust, which provides funds for states to allocate to eligible projects as part of a settlement reached between the Environmental Protection Agency and Volkswagen which “resolved allegations that Volkswagen violated the Clean Air Act.” The Federal Transit Administration is another source of funding and has developed a “Low or No Emission Vehicle Program” which provides funding to state and local governments for public transit bus electrification and EVSE.

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32 Bloomberg NEF. Electric Buses.
34 To learn more about local policies, laws, and regulations that may impact EV adoption in your community, read Creating an Electric Vehicle Blueprint for your Community: Public Power Strategies.
35 This phase out has already occurred for GM and Tesla.
36 Because they are exempt from federal tax, public power utilities cannot directly benefit from tax credits. The tax code accommodates this, however, by providing that the 30C tax credit, as well as the existing 30D Qualified Plug-in Vehicle Tax Credit, is transferred to the equipment seller when the purchaser is exempt from tax. Therefore, the incentive to purchase fleet vehicles (and refueling equipment if the credit is reinstated) is comparable for public power utilities and other entities.
• **Manufacturer rebates and discounts.** Manufacturers might run promotions for rebates for a certain length of time or offer discount codes on the purchase price of their EVs.

• **Exemptions.** State laws might exempt EV or other fuel-efficient vehicle purchasers from paying excise tax on their vehicle.

• **Utility incentives.** Utilities might also offer rebates for customers to purchase EVs or charging equipment.

• **Grants and loans.** At both the state and federal level, grants or loans might be available for fleet operators to electrify their fleet.

Since most fleets are in the early stages of electrifying, orders placed are typically lower volume. Low volume orders contribute to higher battery prices as purchasers are not able to negotiate lower costs for bulk orders. If purchasing increases in the U.S., prices on batteries could come down more quickly. Fleet operators might consider partnering with each other to place joint purchasing orders to increase the volume and allow for greater negotiation on battery price. Supply chain constraints, such as increases in global market price of lithium, cobalt, or other precious metals used in the manufacturing of EV batteries, could change this trajectory.

### Leasing vs. Owning

As discussed above, the upfront costs of purchasing an electric vehicle are typically higher than the upfront costs of diesel, CNG, or gasoline-fueled vehicles. Even when the TCO of an EV is shown to be less, some cities and transit agencies find it difficult to make the upfront investment all at once. Leasing instead of outright ownership provides an opportunity to reap the benefits of EVs, while avoiding an upfront investment that might be too costly. Fleet operators may not need to lease the entire bus, either. A Bloomberg report on innovative ways to lower the cost of fleet electrification explored options such as paying for the vehicle upfront but leasing the battery, where the leasing company absorbs the maintenance and repair and/or replacement costs. For example, the transit agency in Park City, Utah purchased several electric buses for the same price as diesel buses, but leased the buses’ batteries from the manufacturer for a fixed fee. In this scenario, the lease payments could be funded from the EV buses’ O&M cost savings. Another option would be to lease the entire vehicle under conditions typically utilized when leasing ICE vehicles. As this industry evolves, other financing arrangements are being explored. For example, Orlando Utilities Commission is purchasing the vehicle battery and charging stations for a fleet operator, the Central Florida Regional Transportation Authority (LYNX), and has setup a service agreement to recover capital costs.

### Maintenance

Maintenance costs should also be considered when deciding whether to electrify a fleet. Maintenance costs for EVs are expected to be lower because electric motors are more efficient and have fewer moving parts than the engines typically found in ICE vehicles. EVs do not require oil and filter changes, which translates to cost savings. Bus drivers, once properly trained in new driving techniques, have been shown to slow down differently when driving electric buses with regenerative brakes, which leads to tires and brake pads wearing down more slowly than conventional buses and higher efficiency. New York City found that maintenance cost savings between 40-50 percent per bus could be achieved when switching buses from diesel or CNG to electric, while NREL found a more modest 13 percent cost savings on maintenance when switching from a diesel bus to a BEV. At the midlife point, medium- and heavy-duty ICE vehicles often complete an engine overhaul (depending on typical load weight and route), while EV trucks or buses will likely need to replace their electric battery at the midlife of the vehicle. While EVs may be less expensive to maintain, only a small portion of auto mechanics are qualified to work on EVs, and a majority of those mechanics are employed by franchise auto dealers. Fleet operators might employ their own mechanics who will need to be trained in how to service EVs. Many medium- and heavy-duty fleet manufacturers offer maintenance care for vehicles they produce and will also need to train staff on how to repair EVs.

### Operations

Utility rate structures directly impact the cost of charging EVs, which can impact EV fleet adoption. Public power utilities should consider how options such as TOU rates, demand charges, and special offerings such as free charging at select locations or during certain times might encourage or hinder fleet electrification. Some utilities have rates that are specific to EV charging, which typically include a TOU structure. Most utilities include demand charges in their commercial rate structure, which can impact charging station site hosts, who may also be fleet operators. According to the Public Power Guide to Understanding the U.S. Plug-in Electric Vehicle Market, “the demand charge is related to the peak power used during a monthly billing cycle.” EV charging, especially direct current (DC) fast charging or large-scale fleet charging, could incur demand charges, if not properly managed. High demand charges can eat away at cost savings of transitioning a fleet.

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50 Ibid.
51 Ibid.
52 Bloomberg NEF. Electric Buses.
53 Ibid.
55 Ibid.
58 Ibid.
59 Ibid.
60 Ibid.
62 Bloomberg NEF. Electric Buses.
63 Ibid.
to EVs. A report produced by CALSTART in collaboration with the Energy Foundation looked at the impact demand charges could have on electric buses and trucks and found that “vehicle deployments should be optimized to maximize the load factor, the amount of kWh used per each kW of demand. This can be achieved for E-Buses charging on-route by deploying the optimum number of buses using a single fast charger in order to maximize fast charger usage and spread demand charges over more E-Buses.”

TOU rates have become a popular way for utilities to encourage EV charging during off-peak hours. However, depending on routes and schedules, not all fleet operators may be able to take advantage of TOU rates and similar programs. Charging during higher-cost times of day can erode some of the projected operational savings to be achieved by switching to EVs. Public transit agencies and cities have also expressed reservations about the potential for electricity rates to increase when electricity demand increases from the deployment of electric buses.

### Charging Infrastructure Availability

Fleet operators considering electrification should take stock of current EV infrastructure deployment, if any, and consider the cost of installing the additional chargers needed to serve the fleet before deciding to electrify.

Though all EV market segments face charging interoperability challenges, light-duty vehicles have the highest level of standardization. An important consideration in infrastructure deployment and availability is the interoperability of charging stations and EVs. As detailed by EPRI, the EV market faces interoperability challenges. One obstacle is the lack of DC fast charger standardization across EVSE manufacturers, which can pressure fleet operators to stick with one manufacturer for any future purchases so that they do not have to invest in additional charging infrastructure.

Interoperability of the physical interface of charging ports can be another obstacle. As detailed in Figure 2, there are three distinct DC fast charging ports for light-duty vehicles, each affiliated with a different group of manufacturers. If fleet operators are expecting to charge at public charging stations along their route, they should investigate the charging infrastructure available to make sure that they will be able to plug into the equipment. There are several groups working to improve standardization for electric fleet vehicle charging, including Assured for buses and CharIN for heavy-duty trucks.

There may also be interoperability challenges once a charging station has been installed. Generally, charging stations are built to be supported by a specific vendor’s network, without the ability to change network providers over the lifetime of the equipment. However, in December 2018, ChargePoint and Greenlots, two of the leading EV charging networks in the U.S., announced a roaming partnership which allows customers of either network access to the other’s network of chargers at no additional cost. While momentum is growing to develop more interoperability between charging networks, the current status of interoperability can create challenges for fleet operators who might be making a large-scale charging infrastructure investment and would prefer greater flexibility.

### Figure 2: EV Charger Connector Types

<table>
<thead>
<tr>
<th>DC Standard Charging System (CCS)</th>
<th>Used By</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAE Combined Charging System</td>
<td>GM, Ford, Honda, KIA, Hyundai</td>
</tr>
<tr>
<td>CHAdeMO</td>
<td>Nissan, Mitsubishi, BMW, Mercedes, Audi, VW</td>
</tr>
<tr>
<td>Tesla Supercharger</td>
<td>Tesla</td>
</tr>
</tbody>
</table>

Source: Interoperability of Public Vehicle Charging Infrastructure, EPRI, August 2019

Commercial trucking fleet operators cite a lack of adequate charging infrastructure in public places, as well as at their own facilities, as one of the top two barriers to fleet electrification. In a survey conducted by UPS in collaboration with GreenBiz, 92 percent of respondents from large organizations “indicated their organization is not well-equipped with onsite EV charging infrastructure for commercial vehicles.” Fleet operators should collaborate with their local utilities when planning to outfit their facilities with EV chargers, as a fleet of several hundred EVs will need up to four times the power of a traditional diesel truck facility.

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57 Bloomberg NEF. Electric Buses.
58 The cost to deploy new charging infrastructure may be born in part or in full by the fleet operator.
60 Bloomberg NEF. Electric Buses.
65 Ibid.
66 Ibid.
### Charging Infrastructure Types

There are a variety of charging technologies to choose from when deciding on the best option to power your fleet. The three main types of infrastructure for charging electric fleets are: plug-in chargers, pantograph chargers, and inductive chargers. Efficiencies and maximum power outputs vary across the charger types. Fleet operators should consider their charging and operations needs as well as any space constraints prior to investing in a specific technology.

#### Plug-in

The most common technology is plug-in charging. The technology involves a dispenser (typically a Level 2 or DC fast charger) that connects to the vehicle. EVs need to be stationary for plug-in charging, which requires space for the equipment and the vehicle that is not in the way of other operations. Depending on the type of charger and battery capacity, it can take 30 minutes to 12 hours to fully charge a battery with available charging technology. Plug-in chargers would work best for fleets where the vehicles all return to a specific location, such as a depot, and have enough flexibility in the timing and length of routes to allow for full charging.\(^7^1\)

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### Pantograph

Pantograph charging connects equipment mounted on the EV to a charging source and is most often used to charge electric buses. The pantograph charger must make physical contact with the equipment on the vehicle to begin a charge. The charging equipment is often mounted overhead, but can

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### Table 1: EV Charging Options

<table>
<thead>
<tr>
<th></th>
<th>Plug-in Charging</th>
<th>Pantograph Charging</th>
<th>Inductive Charging (Wireless Charging)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Technology</strong></td>
<td>Charging stations (e.g., Level 2 and DC fast chargers) with cords that plug in to the vehicle</td>
<td>Charging technology is located on the vehicle (often on its roof). The charger must make contact with the EV’s pantograph equipment to initiate charge</td>
<td>Wireless charging between coils installed under a surface and receptor panels installed on the vehicle</td>
</tr>
<tr>
<td><strong>Charging speed</strong></td>
<td>30 minutes-12 hours, depending on the type of charger and battery capacity</td>
<td>Faster in comparison to plug-in and inductive charging, for example it takes 10 minutes to fully charge a 100 kWh battery to travel 30 miles(^7^2)</td>
<td>1-2 hours for full charge, depending on battery capacity(^7^3,7^4)</td>
</tr>
<tr>
<td><strong>Costs</strong></td>
<td>Lower initial investment</td>
<td>Higher investment costs</td>
<td>Higher investment costs</td>
</tr>
<tr>
<td><strong>Charging location</strong></td>
<td>Charge at depot or stops along route</td>
<td>Charge at depot or at short stops along route</td>
<td>Stationary chargers should be installed at depots, while dynamic charging could happen while the bus drives along its route(^7^5)</td>
</tr>
<tr>
<td><strong>Specialized Infrastructure</strong></td>
<td>None</td>
<td>Requires equipment to be installed on the vehicle and at designated stationary charging locations</td>
<td>Requires coils to be placed under a surface and collaboration with city departments and utility. Also requires a device to be attached to the vehicle.</td>
</tr>
</tbody>
</table>

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\(^7^1\) Bloomberg NEF. Electric Buses.


\(^7^4\) Misalignment of a vehicle parked over an inductive charger can result in dramatic power losses.

\(^7^5\) Dynamic charging along routes are still in pilot phase without a commercial option available to date.
also be configured to connect with equipment underneath a bus. Pantographs provide fast charging of the battery and are recommended to be installed along a route at locations where buses are stopped for a couple minutes, for a quick top-up. Pantograph chargers can also be installed at bus depots where buses can charge for longer periods. Pantograph infrastructure is costly to install but allows for more flexibility in charging, which could be of value to fleet operators whose schedules do not allow for long-term charging.

**Inductive**

Inductive charging, also known as wireless charging, is an emerging field of charging technology still in development. Charging can be achieved by installing coils underneath a surface, such as a road, and positioning the EV above the coils. Inductive charging provides fast charging of the battery and, in addition to pantographs, is recommended for quick charging along routes. There are two types of inductive chargers: stationary, which require the EV to be at a standstill to charge, and dynamic, which can charge a vehicle while it moves over the coils. Installing inductive chargers can be costly and utilities should be prepared to coordinate with fleet operators to install the coils. Exposure to potentially dangerous electromagnetic fields is the primary safety concern associated with inductive charging. Researchers are currently investigating how to mitigate this exposure.

Table 1 (on the previous page) provides further details on charging options for EV fleets.

**Routes and Distance Traveled**

Fleet operators should review their routes when considering whether to electrify. Some routes that fleets make might not be as conducive to a transition to electric in the current landscape. Routes that would make good options to electrify are those that allow enough time for charging during the day or where the EV has enough capacity to support daily operations and can be charged overnight. Routes and the battery capacity of an EV should be considered when selecting specific models for a fleet. EVs with smaller capacity batteries should be matched with fleet vehicles on shorter routes or routes where on-route charging is available, while EVs with larger capacity batteries should be utilized on longer routes. For example, early applications that take advantage of shorter routes are expected to include urban, refuse, and port trucks. Fleet operators should also take road grade, vehicle speed on the route, number of stops, and passenger load or freight weight into consideration when deciding which routes to electrify. Fleet operators might conduct route modeling under these various conditions prior to electrification to better understand energy requirements.

Fleets with unknown routes, such as ride sharing companies or commercial trucking, might experience range anxiety as EV charging stations are not yet as commonly available as gas stations. Some of this anxiety can be relieved by researching charging sites in the general area prior to starting on the unknown route or selecting PHEVs. Fleet operators should also conduct a search for charging infrastructure along their route prior to deciding to electrify. Utilities could work with fleet operators to identify electricity needs along a given route and how that aligns with existing electricity infrastructure.

One of the considerations that has the biggest impact on TCO for electric fleets is the total distance traveled. EVs with longer daily routes have been found to have a greater cost savings than EVs on shorter routes due to lower refueling costs. Higher annual mileage for EVs leads to lower costs of operation. This means, for example, that electric buses might work best in large cities where buses run longer routes, have higher mileage, and are active for more of the day. For commercial electric trucks, medium-duty trucks and all trucks on medium length routes were found to be the best choice for electrification.

**Operational Needs**

Fleet operators should review their operational needs when considering electrifying their fleets. For example, fleets with predictable routes and shorter distances can plan for charging more easily. A Bloomberg report found that “electric buses can be less flexible than diesel buses, due to their range and reliance on different charging options. This makes it difficult to incorporate them into bus routes running for 24 hours. The lack of long-term experience with running e-buses on a commercial scale is also creating challenges for cities choosing to go electric.” Before committing to widespread deployment of EVs, fleet operators can roll out pilot programs to understand how EVs could be incorporated into their operations.

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76 Ibid.
79 Bloomberg NEF. Electric Buses.
81 Bloomberg NEF. Electric Buses. P. 12.
Climate

Fleet operators should take the climate of the location of their fleet into consideration when deciding whether to electrify. Ambient temperature is known to have an impact on EV batteries. Both very hot and very cold ambient air temperatures have a negative impact on battery life. Running the HVAC system for heating or cooling will also drain the battery faster and will result in reduced range. Full battery capacity returns once the air temperature becomes more moderate. Fleet operators can mitigate climate-related concerns by studying the impact of weather on specific batteries and oversizing the battery to account for increased degradation and include a buffer in their charging plans to account for the temporarily shortened battery life.

City and public transit agency officials have expressed concern with transitioning to electric fleets in the case of extreme weather events when an area might lose power for a long time. If entire fleets are electrified and a natural disaster causes an area to lose power, fleet operators are concerned their fleet might not be fully operational. Medium- and heavy-duty trucks are important assets in natural disaster recovery efforts, such as to bring relief supplies to a community. In addition, some fleet operators might have performance contracts, a requirement to serve at all times, or other obligations to provide service that will impact their transition to electric. While EVs would be unable to charge during a power outage, EVs could become a valuable asset in a different way during outages—by providing a source of backup energy to power homes or shelters. Fleet operators should consider how to maintain fleet operations during extended power outage events as well as how to charge their vehicles if deployed to other communities in mutual aid events. One option is for fleets to consider having backup generators to maintain service during outages.

Vehicle Options

Depending on the business, a fleet operator might need a variety of vehicle types and options. In recent years, there has been rapid growth of EVs across different consumer vehicle classes. EV versions of passenger vehicles and limited truck models are available for the general public to procure. There are several electric bus brands for public transit agencies or school system fleet operators to choose from. Electric vehicle model options are more limited for medium- and heavy-duty vehicles than for light-duty vehicles.

Age of Vehicles

Fleet operators should take the age of their existing fleet into consideration when pursuing electrification. Once a fleet vehicle has reached the end of its useful life, an operator should consider the TCO of any replacement vehicle. As the costs of EVs continue to decrease, fleet operators may find that it makes financial sense to replace a retiring ICE vehicle with an EV. For example, the city of Seattle has committed to transitioning its municipal fleet to electric by replacing ICE vehicles with EVs when possible and committing to installing additional EV charging stations in the city to boost its EV infrastructure.

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82 Bloomberg NEF. Electric Buses.
**Charging Infrastructure**

Limited charging infrastructure and range anxiety may pose significant barriers to widespread EV adoption. Utilities can help fleet operators both through education about and in deployment of charging infrastructure. Utilities can share their expertise on the various levels and types of charging stations, including their relative costs, charging times, and typical locations. The utility can also help with the deployment of charging infrastructure. In some cases, the utility may be the one to own, operate, and maintain the charging infrastructure, while in other cases, the utility might install the infrastructure needed to operate the charging station, but a third party or customer pays for and installs the charging station. Another option for utilities is to consider incentives for installing charging infrastructure or helping customers and third parties select a location for the charging station.

With charging infrastructure, utilities will be involved in any upgrades or work up to the service meter. By being a part of the conversation, utilities may be able to help site charging infrastructure in areas that minimize stress to the local distribution system. Discussions with site hosts can reveal plans for future electrification efforts, which can be useful information for utilities as they plan for infrastructure upgrades. Fleet operators, like public transit, could be interested in charging depots, which can add significant load to the system. Other fleet operators, like transportation network companies, may also be interested in fast charging options on route, which adds greater demand to the grid than Level 1 or Level 2 charging. Figure 3 offers a summary of charging infrastructure specifications.

**Education**

Knowledge and awareness of EVs and EVSE technology is another challenge in the EV market. Public power entities can help fleet operators by advising and educating them on this technology. Education is a common component of each of the potential roles outlined in this section, as utilities can provide guidance on charging infrastructure, rate options, vehicle-grid integration pilots or opportunities, available incentives, and grid impacts. Educational offerings can range from information on the utility’s website to participation in community ride and drive events, meetings with fleet operators, and tools to help customers evaluate impacts from transitioning to an electric fleet. Utilities can also educate fleet operators by sharing lessons learned from their own fleet. Ultimately, customer education is a service offering that provides an additional means for public power to stay connected to the communities they serve.

**Rate Design**

As discussed earlier, some utilities are exploring or implementing specialized rate designs for electric vehicles, such as TOU rates or demand charge alterations for

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**Figure 3: Charging Station Power Delivery and Charge Time**

<table>
<thead>
<tr>
<th>LEVEL 1</th>
<th>LEVEL 2</th>
<th>DC FAST CHARGING</th>
<th>DC ULTRAFAST CHARGING</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHARGING MILES</td>
<td>1 h</td>
<td>10 - 20</td>
<td>20 min</td>
</tr>
<tr>
<td>CHARGING MILES</td>
<td>2 - 5</td>
<td>60 - 200</td>
<td>60 - 80</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DC FAST CHARGING</th>
<th>DC ULTRAFAST CHARGING</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.4 kW maximum</td>
<td>400 kW maximum</td>
</tr>
<tr>
<td>3.3 kW to 19.2 kW</td>
<td>50 kW to 150 kW</td>
</tr>
</tbody>
</table>

Source: A Public Power Guide to Understanding the U.S. Plug-in Electric Vehicle Market, American Public Power Association
GETTING INVOLVED IN FLEET ELECTRIFICATION

commercial customers. Advanced metering infrastructure or smart meters are needed to implement these advanced rate options. Whether or not public power utilities implement EV rates, utilities can help fleet operators understand the electric rates available so that they can estimate their operating costs. Utilities can help by explaining the rate structures behind the cost to charge, ideal times to charge vehicles, and ways to mitigate increased costs if they cannot charge at optimal times. This education can also involve clarifying key terms such as customer charge, energy charge, demand charge, and kilowatt versus kilowatt-hours. By explaining this information upfront, utilities can mitigate confusion for EV fleet operators later.

Vehicle-Grid Integration
Public power utilities might be interested in vehicle-grid integration efforts such as smart charging (V1G) or vehicle-to-grid (V2G). With V1G, utilities may slow down or turn off vehicle charging. With V2G, vehicles can supply power back to the grid. Both of these technologies help utilities manage and optimize load. Fleet operators might be interested in benefits or incentives utilities offer to customers who participate in managed charging. V2G pilots are limited, but there is interest in using this technology not only among residential customers, but with large fleet operators, such as school districts. Integration opportunities might be more suitable for certain types of fleets, and obstacles such as vehicle warranties will need to be addressed. For example, school buses that are rarely used outside of the school year could be used as backup batteries for the grid during the summer. Utilities can partner with fleet operators in piloting the feasibility and cost effectiveness of V2G on their system.

Incentives
The higher upfront cost of an EV is still considered a major obstacle for mass adoption. Therefore, utilities might consider providing incentives for customers to purchase or lease a new or used EV. This incentive could be appealing to fleet operators looking to purchase new vehicles. Utilities can also offer charging infrastructure incentives, which could benefit fleet operators looking to deploy charging stations to support an EV fleet. As discussed earlier, another option for utilities might be to develop a service agreement with a fleet operator whereby the utility purchases a vehicle battery and/or charging stations.

EV Adoption and Grid Impacts
Public power utilities should monitor EV adoption, including EV fleet adoption, within their communities in an effort to understand, manage, and integrate the new load. Utilities can start to understand the scale of impacts from potential electrification within their territory by looking where customers such as school districts, transit agencies, and large fleet operators reside.

Utilities might also want to relay to fleet operators the generation mix used to produce the electricity that in turn is used to charge the vehicle. For example, Austin Energy in Texas advertises that their vehicles are charged by wind, since vehicles are charged at night when there is abundant supply of wind power. Other utilities may consider using RECs or other programs to offer a green charging option for residential EV owners and fleet operators. Public power utilities can also consider capturing EVSE data to analyze charging behaviors to help with integrated resource planning. Public power utilities might also form data sharing partnerships with EVSE companies that operate within their community.
Sacramento Municipal Utility District (SMUD) is the public power utility serving the Sacramento area in California. The region has some of the highest ozone pollution levels in the nation, an issue that EVs can help address. Both SMUD and the Sacramento community have been involved in transportation electrification since the 1990s. SMUD started building out a charging infrastructure network in the 1990s using funding from the federal government and General Motors. Since then, the city has invested in EV fleets, deployed charging stations, and partnered with automakers. The City of Sacramento, considered a leader in US green fleets, has established a goal of 75,000 ZEVs by 2025. As of May 2019, the city operates a fleet with 50 percent AFVs, where 51 vehicles are ZEVs. The city also has a Fleet Sustainability Policy that includes a commitment that at least 50 percent of annual light-duty vehicle purchases be ZEVs by 2018 and at least 75 percent of annual light-duty vehicle purchases be for ZEVs by 2020.

In 2018, Electrify America selected Sacramento to receive a $44 million Green City award to advance EVs, an effort being supported by SMUD. The Green City funding will go towards efforts such as charging depots, buying at least 430 EVs for ride sharing programs, and deploying electric buses. Envoy Technologies Inc., a car sharing platform where customers use an app to reserve a vehicle and pay per minute, is one of the ride sharing funding recipients. The second ride sharing funding recipient is Gig Car Share, a platform where customers use an app to reserve, pick up, and drop off vehicles anywhere within the city. Twelve electric buses will be added to a bus line connecting the University of California, Davis main campus to the UC Davis Medical Center and three smaller electric buses will provide a shuttle service in a low-income neighborhood.

In 2016, SMUD decided to “focus on three broad areas – investing in activities that reduce barriers and increase market adoption, increasing awareness and support of EVs in our community and conducting charging research to gain more insight into how to minimize impacts to the grid brought on by increased charging activities and increase the integration of renewable energy on to the grid.” SMUD expects EVs to help with utility revenue, but also help achieve sustainability goals. SMUD’s CEO, Arlen Orchard, serves on the Alliance to Save Energy’s 50 x 50 Commission, which is an effort to reduce energy use in the U.S. transportation sector 50 percent by 2050. The utility is also part of the California Public Power Utility: Sacramento Municipal Utility District
Sacramento Area PEV Collaborative and the Sacramento Autonomous Transportation Open Standards (ATOS) coalition.\textsuperscript{95}

SMUD’s program, EV Charging Strategies for Fleets and Workplaces, reveals the utility’s drive to increase commercial adoption.\textsuperscript{96} This demonstration program includes studying options for the utility’s EV fleet as a model that can be used by other customers. SMUD’s fleet conversion includes 19 plug-in hybrid bucket trucks and most of its light-duty fleet as PHEVs or BEVs.\textsuperscript{97} The utility is also proactively studying the implications for EV adoption, and in 2017 completed a study, Field Measurement of Plug-In EV Grid Impacts, which was funded through the Association’s Demonstration of Energy & Efficiency Developments (DEED) program.

To boost adoption and alleviate range anxiety, SMUD is working with EV charging service providers to get more charging infrastructure into its service territory.\textsuperscript{98} SMUD helps fleet operators with charging station location and sizing, rate analysis, and operational energy analysis.\textsuperscript{99} SMUD is also studying managed charging, charging stations for long-haul trucking, and pairing DC fast charging stations with energy storage.\textsuperscript{100}

SMUD educates customers through efforts such as its online EV estimator, ride and drive events, and advertising on TV, radio, billboards, buses, and trains.\textsuperscript{101,102} To help manage grid impacts, SMUD encourages off-peak charging through a 1.5 cent per kWh discount for EV owners who charge between midnight-6 am.\textsuperscript{103}

SMUD further supports the EV market in its community with incentives. SMUD provides a $599 incentive for residential electric vehicles\textsuperscript{104} or a Level 2 240 volt EV charger.\textsuperscript{105} Businesses qualify for up to $6,500 for a Level 2 charger and up to $80,000 for a DC fast charger.\textsuperscript{106} SMUD also manages a dealer engagement program that includes dealer training and incentives for sales staff and management.\textsuperscript{107} Moreover, SMUD has worked with Nissan and BMW to offer vehicle rebates for utility customers, which are paid for by the automaker.

\textsuperscript{97} Ciampoli. “Electric transportation expansion.”
\textsuperscript{98} Ibid.
\textsuperscript{99} SMUD’s program, EV Charging Strategies for Fleets and Workplaces, reveals the utility’s drive to increase commercial adoption. This demonstration program includes studying options for the utility’s EV fleet as a model that can be used by other customers. SMUD’s fleet conversion includes 19 plug-in hybrid bucket trucks and most of its light-duty fleet as PHEVs or BEVs. The utility is also proactively studying the implications for EV adoption, and in 2017 completed a study, Field Measurement of Plug-In EV Grid Impacts, which was funded through the Association’s Demonstration of Energy & Efficiency Developments (DEED) program.

\textsuperscript{101} Venema. “Electric Transportation Activity Summary.”
\textsuperscript{102} Ciampoli. “Electric transportation expansion.”
\textsuperscript{103} This translates to the estimated cost to charge an EV for two years.
\textsuperscript{106} Venema. “Electric Transportation Activity Summary.”
Burlington Electric Department (BED) and the community of Burlington, Vermont have a bold plan for their future that includes transportation electrification. BED’s 2030 vision is to “Make Burlington a Net Zero Energy city across electric, thermal, and ground transportation sectors by managing demand, realizing efficiency gains, and expanding local renewable generation, while increasing system resilience.” In 2018, BED began creating a roadmap to reach net zero energy. The utility also has a strategic initiative, Promote Innovation, which defines a plan to “Serve more customers through electrification programs across all modes of transportation.”

BED first started deploying charging stations in 2013 and currently has 14 stations with 27 ports. The utility is also advocating for Electrify America to build charging stations within Burlington. To help manage grid impacts from new load, BED leverages rate design. The utility has a residential EV charging rate that enables EV drivers to charge vehicles off-peak for the equivalent of $0.60 per gallon of gasoline. When determining off-peak hours, the utility factors in Vermont’s peak demand, which is shifting to later in the day as solar deployment expands.

Roughly one-third of BED’s vehicle fleet is fully electric or hybrid. The utility owns one Nissan LEAF and one Chevy Bolt, and plans to add more EVs to its fleet as other vehicles reach the end of their useful life.

BED is a trusted partner within the community and has been instrumental in the deployment of electric buses within the community. BED is also encouraging the city to transition to EVs. Education and awareness are key components of BED’s EV efforts. The utility EVs are BED branded and brought to EV showcases throughout the year, including events by Drive Electric Vermont. BED also looks for ways to integrate EV education into community events. For example, in 2019, the utility set up a tent at Summervale, a seasonal event at a local urban farm, and created a banner featuring the tagline “Go Electric.” BED also successfully worked with the local Minor League Baseball team, the Vermont Lake Monsters, to transition the mascot, CHAMP, from driving a fossil fuel ATV to a BED-branded electric golf cart. BED is exploring branding charging stations within the community as well. Furthermore, the utility features EV information on its website and in Burlington’s monthly newspaper.

BED incentivizes customers’ transitions to EVs by helping with the challenge of upfront costs. BED offers a rebate program for the lease or purchase of EVs and PHEVs ($1,200), and provides an additional incentive for low- to moderate-income buyers of $600 for an EV and $300 for a PHEV. BED has partnered with Nissan to provide rebates of up to $5,000 on the LEAF for utility customers. The utility has also worked with credit unions within the community to help offer low- and no-interest loans for the purchase of an EV.

BED’s general manager, Darren Springer, shared: “Burlington Electric views the opportunity to electrify transportation as good for both the environment and the economy. Our business model involves utilizing our 100 percent renewable electricity in a new way – to power transportation across all modes, including electric vehicles, electric transit buses, and even electric bikes. Moving in this direction benefits our customers and our community, and helps Burlington make progress as we seek to achieve our net zero energy city goal.”
Elk River Municipal Utilities (ERMU) is located 40 miles northwest of Minneapolis/St. Paul, Minnesota. ERMU has leveraged an Association DEED grant to help build an EV program for its community. The grant helped ERMU to develop a branding plan, purchase a new vehicle, explore best practices for implementing TOU rates, and work on initiatives related to beneficial electrification, environmental stewardship, community engagement and partnerships, public charging, and fleet assessments.

The grant funding was also used for FleetCarma to conduct a suitability study for the utility fleet. ERMU wanted to have quantifiable data to take to the commission to support its request to purchase an EV, and ultimately purchased a fully electric Chevy Bolt. Range was a major consideration in the FleetCarma analysis. Data loggers were put in SUVs and pickup trucks for nine months. The utility found that there was a difference between the perception and reality of how often utility staff drove the vehicles on a given day. Study results showed that based on EV model range and the distance fleet vehicles traveled, the utility could transition to BEVs or PHEVs for their passenger vehicles. The fleet vehicle assessment estimated total cost of ownership savings for the eight best-suited vehicles to be at $76,000.

ERMU purchased an EV to use for customer visits, trips to Minneapolis/St. Paul for regulatory and legislative work, and marketing. The vehicle is branded with the words EV ER. ERMU wants to be a leader in the community and plans to have more EVs in their fleet in the future.

ERMU staff have also reached out to other fleet operators within the community. As part of the DEED grant, ERMU helped the city look at the suitability of its fleet by putting loggers into 12 city vehicles. Ultimately the city got approval for a PHEV and leased a Mitsubishi Highlander. ERMU has proactively reached out to parks and recreation, school boards, and nearby transit agencies to offer education on EV technology. The police department ordered two Ford Explorer Hybrid Interceptor® patrol vehicles, which it expects to receive by the end of 2019.

To demonstrate environmental stewardship, ERMU purchases renewable energy credits so that EV drivers can charge with 100% renewable energy when charging their vehicle at home or at ERMU’s three public charging stations. ERMU deployed two public Level 2 and a public DCFC within the community as part of the grant program.

ERMU is managing the new electric load by incentivizing drivers to charge off peak with a TOU rate. The utility found that in 2018, 82 percent of home charging was done off peak.

ERMU sees their EV role in the community as a leader, educator, advisor, and partner. Staff educate the community at in-person events and on social media on topics such as available rates and how to use charging stations. ERMU showcases the technology at community events and during National Drive Electric Week.

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118 Sagstetter, Tom, interviewed by Patricia Taylor. 2019. (May 13).
A Public Power Joint Action Agency: Massachusetts Municipal Wholesale Electric Company

The Massachusetts Municipal Wholesale Electric Company (MMWEC) is a joint action agency that provides power generation, wholesale power services, energy efficiency, and demand management programs to public power utilities in Massachusetts. MMWEC supports both residential and commercial EV deployment by working with its member utilities to provide free or rebated residential EV chargers, engaging automotive dealers at a local and national level to promote EV growth, and providing incentives for commercial and industrial customers to switch to EVs. Massachusetts has a plan to reduce emissions to 80 percent below 1990 levels by 2050, a target set by the 2008 Global Warming Solutions Act. Electrification of the transportation sector is a key component of this plan.

MMWEC views EVs as a means to maintain stable rates, grow load, and improve environmental quality and health in the communities it serves, provided that EVs avoid charging during system peaks. In addition to providing economic benefits to the public power utilities and their customers, support of EV deployment within Massachusetts public power communities is also expected to help meet regional and state goals for emissions reductions, provide a new channel for utilities to engage with their customers, and satisfy key accounts. With a gradual shift towards fleet and residential vehicle electrification, MMWEC and its member utilities expect to reduce the trend of load reduction through energy efficiency and begin to again grow loads in its service territories. With this expected growth, MMWEC continues to monitor for any constraints on the distribution and transmission system.

MMWEC currently operates a company fleet of three vehicles. To demonstrate leadership with EV fleets, MMWEC plans to replace these vehicles at the end of their useful life with EVs. MMWEC has deployed a Level 2 ChargePoint station at its administrative office building. In addition, MMWEC is helping public power utilities in the state conduct fleet assessments and work towards electrifying their fleets in smart ways that balance the need to maintain rate stability with the need to demonstrate leadership in fleet electrification. This includes leveraging dealer discounts to procure EVs for meter reading and other uses and grant funding to drive adoption of plug in hybrid bucket trucks which require no idling when on a work site.

Education, access to charging infrastructure, and competitive rates are three major ways that MMWEC plans to assist non-utility fleet operators’ transition to electric. MMWEC and its members regularly work to increase EV awareness in member communities through participation in National Drive Electric Week, attending farmers markets and community events, and educating local sustainability groups on the low carbon generation being used to charge EVs. Additionally, MMWEC members’ off peak TOU rates and rebates to install charging equipment provide customers an economic incentive to go electric and charge when wholesale power costs are at their lowest.

120 Sewell, Brian, and Jason Viadero, interview by Patricia Taylor. 2019, (May 9).
Local Government

Local government entities might consider deploying EVs across their vehicle fleets, which could include passenger vehicles, police cars, pickup trucks, garbage trucks, street cleaning vehicles, buses, and more. Overall, various municipal vehicles might operate on fixed routes of limited distance, easing the transition to electric.121 These vehicles might be parked in central depots, allowing for a charging station hub. Electrification of these vehicles can help facilitate energy savings and emissions reductions.

As public power utilities are often part of local government, they can assist other local government departments in the transition to electric as well as transition their own fleets to electric vehicles. For example, Comanche Public Works Authority in Oklahoma received a grant from the Association’s DEED program to support deployment and analysis of an EV police car. In addition, several public power utilities have explored options beyond electrification of passenger vehicles, and have integrated plug-in hybrid bucket trucks into their fleet.

In the U.S., the Climate Mayors Electric Vehicle Purchasing Collaborative uses collective buying power to assist in the transition to EV fleets.122 An online portal enables users to bid on EVs and EVSE and explore best practices. The founding cities for the collaborative include the public power communities of Aspen, Colorado; Austin, Texas; Burlington, Vermont; Long Beach, California; Los Angeles, California; Cleveland, Ohio; Cuyahoga County, Ohio; Orlando, Florida; Fayetteville, North Carolina; and Phoenix, Arizona.123 In June 2019, 127 cities and 15 counties committed to purchase at least 2,100 EVs by 2020.124

Municipal government may have procurement guidelines or targets that require the purchase of AFVs or EVs. The Alliance for a Sustainable Future, a joint effort of the U.S. Conference of Mayors and Center for Climate and Energy Solutions, conducts a sustainability survey of cities. In the 2018 survey, nearly 60 percent of the 158 respondents identified having a green vehicle purchasing policy and 26 percent of respondents answered that they are considering implementing one.125 Each year, cities cumulatively lease or purchase roughly 5,000 passenger vehicles, 4,000 light-duty vehicles, 3,000 medium-duty and heavy-duty trucks, and 1,000 buses.126

Motivations for municipal electric fleets reflect those presented earlier in this report, and include leading by example, environmental benefits, public health benefits, and operations and maintenance savings. Like other fleet operators, key challenges include higher upfront costs and charging infrastructure access and costs. Fleet operators will also want to compare fuel costs for an EV versus any applicable fuel contract guarantees for an ICE vehicle. In New York City, the lower operations and maintenance costs are expected to save the city money over the lifetime of the assets.127

The Association’s DEED program supported the development of a Public Power EV Planning Toolkit and Guidebook, which provides utilities with resources to conduct an economic analysis of municipal EV fleet operations and customer EV adoption.128

Austin, Texas

Austin City Council Resolution 20160505-025 asked the city to "work with Rocky Mountain Institute, Vulcan, Inc., and Electric Vehicle Coalition on an assessment to determine the benefits, timelines, and feasibility of increasing electric vehicle adoption into the city’s fleet services vehicles."129 Austin has over 6,500 vehicles in its fleet, 80 percent of which are AFVs or hybrids. The city cited benefits such as operations...

124 Climate Mayors. “Climate Mayors Electric Vehicle Purchasing Collaborative.”
126 Ibid.
128 Readers can learn more about this product and other efforts funded by DEED using the DEED project database and Association Product Store. Access these resources via publicpower.org.
and maintenance savings; supporting the local public power utility, Austin Energy, by buying energy from them; reducing exposure to fuel price volatility; fuel independence; diversification; and leading by example.

The city conducted an analysis of over 1,000 city vehicles and identified that vehicles which were older, expensive to operate (e.g. minivans and SUVs), had lower daily mileage, and high lifetime mileage were candidates for electrification. The city plans to add 330 PEVs by 2020. To support these vehicles, the city plans to expand fleet charging to 330 charging stations by 2020 as well.

School Districts

There are roughly 480,000 school buses across the U.S., of which 95 percent run on diesel. North America accounts for roughly 48 percent of the global school bus market. In other countries, students rely on public transit instead of school buses to ride to school.

Electric school bus benefits include improved air quality, reduction in carbon emissions, lower operating costs, and reduced noise. Technavio expects the electric school bus market to grow globally, with North America and China in the lead. However, it can be a challenge for a school district to electrify its fleet without subsidies. School districts may be able to leverage V2G in the future, selling excess electricity to utilities, and helping offset purchase and operations costs.

The U.S. market for electric school buses picked up when California started creating demand. California now has over 140 electric school buses, and the technology has been deployed in other states including Massachusetts, Minnesota, and New York. Electric school buses are eligible for funding in the Volkswagen Beneficiary Mitigation Plans in Vermont, New York, Connecticut, Massachusetts, Maine, and New Hampshire. In Michigan, the state is putting $3 million towards electric buses and charging stations, covering up to 70 percent of the costs for the school districts.

Public Transit

Public transit fleets operate roughly 70,000 buses, 60 percent of which run on diesel and have high nitrogen oxide emissions. Sales of electric buses in the U.S. quadrupled from 2016 to 2018, with over 140 agencies deploying examples of utilities supporting electric school bus deployment include SMUD, San Diego Gas & Electric, Duke Energy, and the New York Power Authority. Electric school bus manufacturers include Bluebird, Lion, GreenPower, Starcraft, Trans Tech – Navistar, and Thomas.

Sacramento County, California

SMUD partnered with the Sacramento Metropolitan Air Quality Management District and three school districts to help with the deployment of electric school buses and the associated charging infrastructure. Elk Grove Unified School district deployed 10 electric school buses, Twin Rivers Unified School District deployed 16 electric school buses, and Sacramento City Unified School District deployed 3 electric school buses. This effort is one of the largest electric school bus deployments in the U.S., and the buses will mainly serve students in disadvantaged communities.

The project was funded by a $7.5 million grant from the California Air Resources Board. The grant was available through California Climate Investments, which leverages proceeds from the state cap-and-trade program. An additional $6.9 million in cash and in-kind funds came from project partners: First Priority GreenFleet, Motiv Power Systems, Lion Bus, Trans Tech, EV Connect, California Strategies, SMUD, Phil Haupt Electric, and Kisensum. The three school districts are also able to loan their electric school buses to other school districts as part of the program.
roughly 300 electric buses. Cities deploying electric buses include New York; Chicago; Seattle; Los Angeles, San Francisco, Sacramento and Santa Barbara, California; Austin and San Antonio, Texas; Burlington, Vermont; Chattanooga, Tennessee; and Tempe, Arizona - among many others. Some areas have made commitments to electric buses, such as Los Angeles converting its bus fleet to electric by 2030.148 As part of the Innovative Clean Transit Plan, the California Air Resources Board will require only zero-emission buses by 2040,149 which the Union of Concerned Scientists estimates to be about 14,000 buses.150

Electric buses are also receiving attention because of their eligibility under the Volkswagen Environmental Mitigation Trust. For example, Virginia plans to use approximately 15 percent of its funding, or $14 million, to electrify the state’s bus fleet.151

Bloomberg New Energy Finance found that globally, the electric bus fleet grew 32 percent in 2018, with China leading the market.152 China has roughly 99 percent of all electric buses worldwide.153 Electric bus manufacturers include Proterra, BYD, New Flyer, CCW, Double K, Ebus, Gillig, Green Power, and Nova Bus.154

McKinsey projects that with supportive policies, electric buses could reach 50 percent penetration in cities by 2030.155 Bloomberg New Energy Finance predicts a penetration of 80 percent by 2040.156 Motivations for bus operators echo those described earlier in the report. According to the Bloomberg report, “there are two main environmental issues that the cities hope electric buses will help them address: reducing carbon dioxide emissions from transport and most importantly lowering local pollution levels by eliminating emissions of nitrogen oxides and particulates.”157 A New York City study recommended that the city convert their bus fleet to all electric and specifically cited the health benefits to their citizens as a key motivator for making the transition.158 Policies and regulations can also drive fleet operators to electrify.159 A National Academy of Sciences survey found that half of U.S. transit agencies with battery electric buses pursued the technology because of a combination of board direction, environmental or sustainability programs, and environmental regulation.160

Electric buses are getting more cost competitive.161 In 2018, Bloomberg New Energy Finance re-launched a report on behalf of Financing Sustainable Cities Initiative C40 Cities, World Resource Institute, and the Citi Foundation which closely examined the TCO for electric buses. The report found that “in certain configurations…e-buses have lower total cost of ownership than comparable diesel or CNG buses. Operational savings were one of the more important arguments supporting e-buses introduction in many cities.”162 As the cost of batteries decrease, Bloomberg NEF expects the purchase prices of electric buses to reach parity with diesel buses by 2030, and that increased adoption of EVs could advance that timeline.165 In some cases, the TCO for an electric bus is already equal to diesel and CNG buses when routes and distance traveled are taken into consideration. The Center for Transportation and the Environment estimates the typical cost of a 40-foot transit bus to be $450,000-$500,000 for diesel, $550,000-$600,000 for CNG, and roughly $800,000 for battery electric. The Chicago Transit Authority has experienced $25,000 in annual fuel savings by switching to electric buses.164

157 Bloomberg NEF. Electric Buses.
158 Ibid. Electric Bus Analysis.
162 Bloomberg NEF. Electric Buses.
163 Ibid.
164 von Kaenel. “Electric buses are all the rage.”
One survey found that only half of transit agencies factored electricity rates and demand charges into their electric bus purchasing decision.\(^{165}\) Fleet operators face the challenges of transitioning to a new technology, higher upfront costs, and access to charging infrastructure.\(^{166}\) There are also many options to consider for the technology. For example, electric buses may use plug-in, pantograph, or inductive charging at depots or along routes.\(^{167}\) Vehicle range is another challenge that varies by fleet operator based on operating conditions.\(^{168}\) Depending on the routes, electric buses might also require on-route charging.

**Burlington, Vermont**

In 2016, the BED and VEIC began discussions with Green Mountain Transit (GMT) about transitioning from a diesel bus fleet to an electric bus fleet.\(^{169}\) The move towards electric buses will help reduce carbon emissions. In addition, because BED is 100 percent renewable, the electricity used to charge the buses will be generated from renewable energy resources.\(^{170}\) BED and Burlington Mayor Miro Weinberger have been promoting electric buses as part of the city’s net zero energy strategy.\(^{171}\) In April 2017, BED and the Mayor held an event that included a ride on an electric bus during a two-week pilot. BED worked with the bus manufacturer to get the electric bus loaned for the pilot and built a temporary charging station for the bus.

Also in 2017, the Vermont Agency of Transportation (VTrans) was awarded a $480,000 grant to deploy two electric buses for GMT in Burlington.\(^{172}\) In addition to the VTrans funds, BED will be providing incentive funding to help GMT purchase new electric buses for deployment within the Burlington community.\(^{173}\) The buses are expected to be on the road by fall 2019. It is expected that a GMT electric bus that travels 30,000 miles each year could save the transit agency $8,900 in annual operating and maintenance costs, reduce carbon emissions by 70-77 tons, and increase the utility’s load factor with overnight charging.\(^{174}\)

In BED’s 2018 Beneficial Electrification Plan, the utility described additional activities to support electric buses in Burlington, such as having conversations with electric bus manufacturers Proterra and BYD, providing incentives to GMT for electric buses, and monitoring electric bus performance to help inform future decision-making.\(^{175}\)

**Commercial Trucking**

Commercial trucks are another area where there is interest in, and increasing deployment of, EVs. Unlike light-duty passenger vehicles, which are traditionally powered by gasoline, commercial trucks are traditionally powered by diesel.\(^{176}\) Major companies including UPS, Amazon, FedEx, DHL, and Ikea are deploying electric delivery trucks as part of their fleet.\(^{177}\) In fall 2019, Amazon announced it ordered 100,000 electric delivery vehicles from Rivian, with deployment starting in 2021.\(^{178}\) Companies making or planning to make electric trucks include Rivian, Tesla, Daimler, Volkswagen, Navistar, Paccar, Thor, Volvo, and BYD.\(^{179,180,181,182}\)

Business Insider expects the electric truck market will have a 30 percent compound annual growth rate by 2026.\(^{183}\) Electrification will happen sooner for trucks that travel shorter distances than long haul trucks. The footprint and range for these vehicles will allow fleet operators to more easily manage charging plans.\(^{184}\)

McKinsey expects strong adoption of EVs among light-duty and medium-duty commercial vehicles, citing economics and regulatory environment as key drivers.\(^{185}\) They project that medium- and light-duty commercial EVs could reach anywhere from 8-34 percent of sales by 2030, and expect costs of electric light-duty trucks to reach a break-even point by 2021, with some applications already at cost parity.

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165 The National Academies. “Battery Electric Buses.”
166 Heid et al. “Fast transit.”
167 The National Academies. “Battery Electric Buses.”
173 Burlington. “Mayor Miro Weinberger and Burlington Electric Promote E-Buses.”
175 Burlington. “Mayor Miro Weinberger and Burlington Electric Promote E-Buses.”
178 Fehrenbacher. “How IKEA plans to deliver its goods via electric trucks and vans.”
184 Fehrenbacher. “How IKEA plans to deliver its goods via electric trucks and vans.”
185 Heid et al. “Fast transit.”
International politics also play a role with large companies who may do business in countries outside of the U.S.\textsuperscript{186} Other nations may have vehicle, carbon emissions, or sustainability policies or goals. For example, Chinese regulators are considering transitioning diesel trucks to cleaner options, such as electric trucks.\textsuperscript{187} Some ports and cities in China have already banned diesel trucks. Emissions targets and diesel bans are expected to accelerate the electric truck market, and regulation for commercial vehicles tends to be faster than for passenger vehicles.\textsuperscript{188}

In some cases, TCO for electric trucks are already equal to or less than that of a diesel truck. Trucking companies such as UPS and Ryder have found electric trucks can be deployed at an upfront cost similar to that of a diesel vehicle once governmental incentives and tax breaks are taken into consideration.\textsuperscript{189} According to a UPS and Greenbiz report, TCO savings are the result of reduced fuel costs, a major expense for fleet owners, as well as reduced maintenance and supplies costs, as electric vehicles have fewer and less complex parts compared to their diesel counterparts.\textsuperscript{190}

A challenge for electric trucks, as with EVs in general, is charging infrastructure and range anxiety.\textsuperscript{191} Trucks will likely use depot charging and long-haul trucks may need on-route charging.\textsuperscript{192} This topic is being studied by several western states. In 2019, California, Oregon, and Washington announced the West Coast Clean Transit Corridor Initiative, which will explore how to support electric trucking along Interstate 5 and connecting routes.\textsuperscript{193} The initiative includes public power representation from SMUD, Los Angeles Department of Water & Power, Northern California Power Agency, and Southern California Public Power Authority.

Fast charging for commercial trucks will create significant demand on the grid that utilities will need to monitor. Trucks that have established and regular routes can plan more easily for access to charging infrastructure.\textsuperscript{194} The batteries for electric trucks are large, leading to challenges associated with battery weight.\textsuperscript{195} The larger battery also leads to longer recharge times and may require higher powered chargers.\textsuperscript{196} Another obstacle for commercial truck operators is that there are not many electric truck models available, so McKinsey projects that EV adoption among the commercial segment will be slower than with passenger EVs because of limited model options and risk aversion.\textsuperscript{197} Currently, medium- and heavy-duty electric trucks are being produced in small order and have yet to be developed at scale.\textsuperscript{198} Tesla made headlines in 2017 when its CEO, Elon Musk, announced the development of an electric semi-truck.\textsuperscript{199} Production of these 600-mile range EVs is expected to begin in 2020. Walmart, UPS, and Anheuser-Busch InBev have already placed orders for Tesla’s truck.

### UPS

UPS works with government entities, manufactures, and nonprofits to test and deploy new vehicle technologies.\textsuperscript{200} UPS’ delivery fleet consists of more than 300 EVs in the US and Europe and approximately 700 HEVs.\textsuperscript{201} The company states that “UPS’ goal is to make the new electric vehicles a standard selection, where appropriate, in its fleet of the future.”\textsuperscript{202} UPS also has the “goal of one in four new vehicles purchased by 2020 being an alternative fuel or advanced technology vehicle. The company also has pledged to obtain 25 percent of the electricity it consumes from renewable energy sources by 2025 and replace 40 percent of all ground fuel with sources other than conventional gasoline and diesel.”\textsuperscript{203}

In 2018, UPS announced plans to deploy 50 ZEV delivery trucks at an acquisition cost similar to a traditionally fueled delivery truck.\textsuperscript{204} UPS is collaborating with Workhorse Group, Inc. to design the ZEV. UPS’ President of Global Fleet Maintenance Carlton Rose explained, “With our scale and real-world duty cycles, these new electric trucks will be a quantum leap forward for the purpose-built UPS delivery fleet. The all-electric trucks will deliver by day and recharge overnight. We are uniquely positioned to work with our partners, communities and customers to transform freight transportation.” These new vehicles will have an approximate range of 100 miles and will be tested in Atlanta, Dallas, and Los Angeles, helping those communities become cleaner and quieter. UPS expects operating costs for these vehicles to be lower than ICE vehicles.

\textsuperscript{186} Fehrenbacher, "How IKEA plans to deliver its goods via electric trucks and vans."


\textsuperscript{188} Heid et al. "Fast transit."

\textsuperscript{189} UPS. Curve Ahead.

\textsuperscript{189} Ibid.

\textsuperscript{189} Carey, "Truck makers rev up."

\textsuperscript{190} Heid et al. "Fast transit."


\textsuperscript{192} Heid et al. "Fast transit."


\textsuperscript{194} Heid et al. "Fast transit."


\textsuperscript{196} UPS. Curve Ahead.

\textsuperscript{197} Carey, "Truck makers rev up."

\textsuperscript{198} Carey, "Truck makers rev up."


\textsuperscript{200} UPS. Curve Ahead.

\textsuperscript{201} UPS. Curve Ahead.

\textsuperscript{202} UPS. Curve Ahead.

\textsuperscript{203} UPS. Curve Ahead.

\textsuperscript{204} UPS. Curve Ahead.

\textsuperscript{203} UPS. Curve Ahead.
UPS issued several other electric delivery truck announcements in 2018, including a collaboration with Thor Trucks, Inc. to test an electric delivery truck in Los Angeles for six months\(^{205}\) and a partnership with ARRIVAL to test 35 electric delivery vehicles in Paris and London.\(^{209}\) UPS press releases in 2017 included the announcement that the company reserved 125 of Tesla's new electric semi-trucks,\(^{207}\) and that the company became the first commercial customer to deploy Daimler electric delivery trucks in the U.S.\(^{208}\) A partnership with the New York State Energy Research and Development Authority was also announced in 2017, with the purpose of converting diesel pack-age delivery trucks to electric to support the state’s plans to cut GHG emissions.\(^{209}\)

### Transportation Network Companies and Autonomous Vehicles

Transportation network companies (TNCs) are those that offer ride hailing and/or car sharing services for customers. The markets for autonomous vehicles (AVs) and TNC platforms are linked, and in both cases, EVs are a key trend. Compared to an average passenger vehicle, TNC vehicles travel more miles, with full-time TNC drivers driving roughly 136 miles per day.\(^{210,211}\) TNC EVs will often use public fast charging stations.\(^{212}\)

The major ride hailing companies operating in the U.S. are Uber and Lyft. EVs constitute less than 0.2 percent of the fleets of both companies.\(^{213}\) Analysis by the International Council on Clean Transportation revealed that a majority of ride hailing companies have made a public commitment to EVs.\(^{214}\) Commitments to EVs can be presented in terms of the number or percentage of EVs in the fleet or by the amount of EV trips taken, and will often include a time frame and region. In California, the Air Resources Board and Public Utilities Commission are working together to develop a clean miles standard for TNCs.\(^{215}\) Additional examples of ways that ride hailing companies are supporting EVs include: auto industry partnerships, EV requirements, financial incentives, charging infrastructure investment, charging infrastructure partnerships, utility partnerships, driver education, app features for EVs, EV pilots, EV research, and rider education.\(^{216}\)

Several companies have launched electric car sharing programs in the U.S. Electrify America and Envoy announced in 2018 that 142 Volkswagen e-Golfs would be deployed in Sacramento at 71 locations.\(^{217}\) Envoy has on-demand EVs across California and in one New York location.\(^{218}\) Another example is in Los Angeles, where BlueLA's entire car sharing fleet of 100 vehicles is electric.\(^{219}\) Maven car sharing, available in select US cities, provides drivers the option to select eco vehicles like the PEV Chevy Volt.\(^{220,221,222}\)

AVs have self-driving capabilities that leverage sensors to analyze the surrounding environment.\(^{223}\) Automakers, technology companies, and ride sharing software companies such as Uber and Google are investing in and testing AV technology.\(^{224}\) Motivations behind AV deployment include enhanced safety through lower accident and fatality rates, a decrease in vehicle traffic, and improved mobility access. This technology is expected to have applications across vehicle types ranging from light- to heavy-duty.\(^{225}\) Just as with TNC vehicles, AVs will drive more than a typical passenger vehicle. AVs could drive upwards of 75,000 miles per year, whereas an average car drives 11,000 miles per year.\(^{226}\)

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\(^{214}\) Ibid.


\(^{216}\) Slovik et al. “Assessing ride-hailing company commitments.”


\(^{220}\) US cities include Ann Arbor, Michigan, Chicago, Illinois, Los Angeles, California, Washington, District of Columbia, Baltimore, Maryland, Detroit, Michigan, New York City, New York, Boston, Massachusetts, Denver, Colorado, and San Francisco, California.


\(^{225}\) Fleetcarma. “Autonomous vehicles.”

\(^{226}\) Weiss et al. “The electrification accelerator.”
Cost is a major reason why TNCs are expected to transition to electric. According to Greentech Media, if full-time TNC drivers switch to an EV, maintenance and repair savings can equate to at least $2,700 in the first year and as much as $21,000 over five years.\textsuperscript{227} The TCO over the lifetime of a TNC EV is expected to make them a lower cost option compared to ICE vehicles. Greentech Media recommends EVs for TNC drivers who drive more than 20 hours per week and/or drive vehicles with a model year of 2007 or older.\textsuperscript{228} AVs are also expected to be electric due to potential TCO savings.\textsuperscript{229} TNCs are interested in electric AVs because of the potential to reduce transportation costs, lower emissions, and improve vehicle utilization. Technological, regulatory, and legal hurdles remain for AVs, along with the need for social acceptance and trust.

\textbf{Jaguar and Waymo}

In March 2018, Jaguar and Waymo announced a partnership for the autonomous Jaguar I-PACE.\textsuperscript{230} Both companies cite goals such as improving vehicle safety and enhancing mobility. The Jaguar I-PACE will feature Waymo’s self-driving technology. Data gathered from test and real-world drives will enable the companies to optimize the self-driving technology. The testing phase is scheduled from 2018 through the official rollout in 2020. The I-PACE is Jaguar’s first all-electric SUV.

\textbf{Uber}

In 2017, Uber announced its goal to have all its drivers in London “drive electric vehicles” by 2025.\textsuperscript{231} Starting in 2019, a clean air fee per mile has been added to all Uber trips in London. This revenue generated will support a grant fund to help transition drivers to EVs. In addition, Uber has partnered with home charging infrastructure providers such as BP ChargeMaster, EO Charging, EVBox, Franklin Energy, NewMotion, Pod Point, and Swarco EVolt to help drivers gain access to home charging options. To help with public charging infrastructure access, Uber has also partnered with charging infrastructure provider ChargePoint to deploy fast charging stations.

Uber launched its first EV program in the U.S. in 2017 in Portland, Oregon.\textsuperscript{232} The company partnered with Forth to deliver a pilot program that included both rider and driver training and education. Uber also worked with Xchange Leasing to help drivers acquire EVs.

In 2018, Uber launched the EV Champions Initiative pilot program in the U.S. and Canada, with the goal of reaching 5 million EV rides within one year.\textsuperscript{233} Uber selected Montreal, San Diego, San Francisco, and the public power communities of Austin, Los Angeles, Sacramento, and Seattle to participate in the pilot program. Program partners include Association des Véhicules Électriques du Québec, Electric Mobility Canada, Forth, Plug-in America, Rocky Mountain Institute, UC Davis Institute of Transportation Studies, Duquesne Light Company, Portland General Electric, and public power utility SMUD.

The program is built around three key themes, the first being EV education and resources. Educational offerings include informing EV drivers of state, local, and utility incentives. In some cities, drivers are receiving a monetary incentive to drive EVs. For example, in Sacramento, SMUD leverages marketing funds and low carbon fuel standard credits to provide $1.25 per trip in a ZEV, and Uber rounds this up to $1.50.\textsuperscript{234,235} Another perk in Sacramento is that drivers can charge for free at SMUD’s DC fast charging stations. PHEV and BEV drivers in San Diego and San Francisco can receive $1 per trip from Uber. The second aspect of this program is an in-app feature where drivers receive an advanced notification for longer trips to help combat range anxiety.\textsuperscript{236} A third and final aspect of the program is its support of EV advocacy to boost awareness of this technology. Riders in the U.S. will receive an in-app notification when they ride in an EV. Drivers in the pilot cities may have EV educational materials in their vehicle for riders to explore.

\textsuperscript{227} Fitzgerald. “Electric Cars Could Save Ride-Sharing Drivers.”

\textsuperscript{228} Ibid.

\textsuperscript{229} Weiss et al. “The electrification accelerator.”


\textsuperscript{232} Slowik et al. “Assessing ride-hailing company commitments.”


\textsuperscript{236} Gromis. “Electrifying our network.”
CONCLUSION

The decisions of fleet operators regarding whether to electrify will be an important part of how public power utilities monitor and prepare for electrification of transportation in their service territories. By better understanding the various motivators driving fleet operators to consider transitioning to EVs, public power utilities can be more prepared to support operators in the decision-making process and in coordinating a mutually beneficial transition.

Public power utilities can play a vital role in helping local fleet operators plan for, deploy, and manage EV fleets and related charging infrastructure. Electric utilities might consider electrifying their own fleets, where they can gain insight into costs, charging infrastructure, and vehicle operations. Knowing where infrastructure such as fast charging stations and charging depots could be sited and what it would take (and cost) the utility to supply such infrastructure prepares public power utilities to be energy advisors to fleet operators. The location and expected utilization of charging infrastructure is also important for utilities to understand because it could have a significant impact on electric load in their territories.

As fleet operators such as local government, public transit, school districts, commercial trucking, and transportation network companies consider EVs, public power has the opportunity to forge new partnerships with community customers.