Fleets
Electric Vehicle Charging

Table of Contents

About Plug-in San Diego 3
Background 3
Types of EV Charging 5
Level 1 charging
Level 2 charging
DC fast charging (DCFC)
Typical Cost Drivers 6
Trenching
Electrical service upgrades
Ongoing costs
Estimating Your Demand 7
Basic Installation Design 7
Low-cost option – Level 1 charging
Midlevel Installation Design 8
Moderate-cost option – Level 2 charging
Advanced Installation Design 11
Higher-cost option – Level 1 or 2 + DC fast charging
EVSE Leasing Option 12
Cost Recovery 12
Reduced fueling and maintenance costs
Incentives and tax credits
Employee and public charging revenue
Low Carbon Fuel Standard (LCFS) credits
Getting Started – A Recap 13
Additional Resources 14

Fleet Electric Vehicle Charging

Driving the San Diego Region Into the Future

About Plug-in San Diego (Plug-in SD)

Plug-in SD is a partnership between the San Diego Association of Governments and Center for Sustainable Energy with funding from the California Energy Commission. Its mission is to assist property owners in acquiring electric vehicle (EV) charging and better understanding the technologies, incentives and installation options available.

Among Plug-In SD's services, it provides no-cost consultations to businesses and public agencies in San Diego County interested in installing EV charging infrastructure for their fleet vehicles. While each installation is unique, many businesses and public agencies have similar questions and challenges when planning for fleet electrification. This document summarizes common **Fleet EV charging solutions** for both private business and public agencies and provides guidance and resources that can help you get started on installing fleet EV charging, as well as tools to find incentives to help fund projects and identify vendors to design and implement EV charging solutions.

Background

EVs are an increasingly popular choice for public and private fleets, due largely to lower maintenance and fuel costs. Battery electric vehicles (BEVs) without an internal combustion engine do not require oil, filters or spark plug changes, and plug-in hybrid electric vehicles (PHEVs) require them much less frequently if they are utilized primarily in the electric mode. Best of all, the fuel cost per mile for an EV is approximately one-third that of a gasoline vehicle with 25 miles per gallon fuel efficiency.[1]

Alameda County in California recently purchased 64 PHEVs and 23 BEVs for use across 10 county and municipal fleets, with an estimated fuel savings of $500,000 and a greenhouse gas (GHG) reduction level of 1.5 million pounds over five years.[2] In New York City, officials recently released data indicating that annual maintenance costs for BEVs are between $1,200-$1,600 less than for gas vehicles.[3] Further, they said that despite the higher upfront

Considerations important to EV charging

- **Estimate demand**
  What is your current EV charging need, and do you plan to expand your EV fleet soon?
- **Choose design level**
  What level of charging will meet your fleet's needs? Do you require advanced usage analytics and billing functionality? Is DC fast charging appropriate for your fleet?
- **Choose access model**
  Will you allow employee and/or public charging? How will you restrict access to charging after business hours?
- **Evaluate cost recovery options**
  Are incentives or tax credits available to help cover the upfront costs of installing EV charging? Can you generate ongoing revenue through public charging and sale of Low Carbon Fuel Standard (LCFS) credits?

[1] This assumes an electricity cost of $0.23 per kilowatt-hour and a gasoline cost of $4 per gallon.
[2] https://www.georgetownclimate.org/files/report/Capturing-the-Federal-EV-Tax-Credit-for-Public-Fleets.pdf.
[3] https://afdc.energy.gov/files/u/publication/evse_cost_report_2015.pdf.

acquisition costs, the city estimates the total nine-year cost of ownership of a BEV, including installing charging equipment, is about $9,000 less than for a comparable gasoline vehicle.

In addition to cost savings, electrifying public fleets greatly reduces GHG emissions and contributes to a businesses' or jurisdiction's sustainability goals. This is especially true in California, where grid electricity is relatively clean, and many jurisdictions and business have adopted aggressive GHG reduction targets.

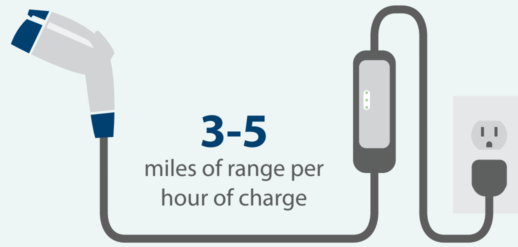
Installing adequate EV charging infrastructure is a key component to effectively electrifying a public or private fleet. While fleet vehicles may utilize public EV charging infrastructure, the higher cost of charging is likely to negate fuel savings, and access to public charging is often unreliable.

Types of EV Charging

Electric vehicle charging is available at three levels, based on the rate at which a vehicle is able to recharge. Higher levels indicate faster charging rates but are also typically costlier and may require upgrades to a site's electrical infrastructure. The following sections provide a brief overview of the various levels of EV charging. Table 1 includes common use cases for each charging level.

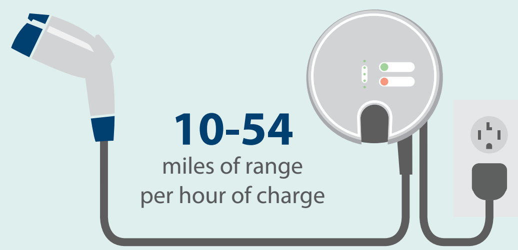
Level 1 charging

Level 1 charging uses a standard 120-volt alternating current (VAC) outlet available in all residential and commercial locations. Almost all EVs come with a Level 1 cord set charger as standard equipment. Level 1 charging is the lowest cost and slowest EV charging option, providing around 3-5 miles of electric range per hour. Level 1 charging is a good option for homes and workplaces, where a vehicle can charge for upwards of eight hours at a time. Level 1 charging may also be a good option for fleet vehicles that cover relatively short distances each day (<40 miles per day) and are able to reliably plug in overnight.



Level 2 charging

Level 2 charging uses 240 VAC and provides between 10-54 miles of electric range per hour. The amount of range gained per hour depends both on the capacity of the EV charging station (EVCS), as well as the capacity of the vehicle's onboard charger. Level 2 uses the same connector and charge port as Level 1. Level 2 charging units are more expensive than Level 1, are available with more advanced controls and monitoring capabilities and are a good option for workplaces or public agencies with longer range EVs that need to recover more electric range than can be provided by Level 1.



Level 2 offers networked and nonnetworked charging. A networked EVCS transmits data over the internet to a network host, allowing for more advanced controls, billing options and usage analytics. A nonnetworked Level 2 charger will have no internet connection and essentially provides a driver with an access point to simply plug in and charge.

DC fast charging (DCFC)

Direct current fast charging (DCFC) is the fastest and most expensive EV charging option. DCFC uses commercial-grade 208, 440 or 480 VAC that is converted into direct current (DC) to add 75-300 miles of electric range per hour. Because of its high power demands, DCFC often requires upgrades to a site's electrical service. DCFC is ideal for sites where EVs need to gain a maximum amount of range in a short time, such as along highway corridors, as well as dedicated charging depots for high-use vehicles. DCFC is typically not recommended for fleet charging, unless there is a specific need for rapid recharging of vehicles. Additionally, not all EVs are equipped with the hardware required for DCFC.

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Table 1 *Electric Vehicle (EV) charging levels and common use cases*

	Level 1	Level 2	DC fast charging
Charging Speed	3-5 miles of range/hour	10-54 miles of range/hour	75-300 miles of range/hour
Typical Locations	Single- and two-family homes Townhomes Multifamily dwellings Commercial office buildings	Single- and two-family homes Multifamily dwellings Commercial office buildings Public and private fleets	Highway corridors Public charging depots Retail shops Hospitality & recreation facilities

Typical Cost Drivers

The cost of installing EV charging varies considerably based on specific site requirements. Aside from the actual cost of the EV charging equipment, typical installation costs include trenching for electrical conduit, upgrades to electrical service panels and, in the case of larger installations, upgrades to the local electrical distribution grid.

Additionally, site hosts must consider the ongoing costs of EV charging. These consist primarily of the cost of electricity and any other impacts to utility bills, such as increased service or demand charges, but also may include monthly or annual payments to network service providers.

Trenching

Installing EVCS in an existing paved parking lot may require digging trenches to bury electrical conduit. Trenching and patching an asphalt surface typically costs around $100 per foot and can add significantly to installation costs. When possible, run electrical conduit above ground and install EV charging stations close to the electric service panel to reduce the length of electrical runs. If a project requires trenching, consider any plans to expand EV charging and include extra electrical runs to avoid additional future trenching costs.

Electrical service upgrades

The addition of EV charging can add significant electrical load to a site and may require upgrades to electrical service panels. Larger Level 2 and DCFC installations also may require upgrades to the local electrical distribution grid, such as transformer upgrades, which can cost between $10,000-$25,000.[4]

For smaller installations, the site's electrical service panel may have room to install several Level 2 chargers without requiring an upgrade. A professional electrician can examine a panel to determine if there's room for additional capacity. Each Level 2 EV charger will typically require its own 40-amp circuit. Should a panel not have room for the additional circuits, it may require a panel upgrade.

Ongoing costs

The primary ongoing cost for EV charging is the cost of electricity and any other utility bill impacts, such as increased monthly service or demand charges.[5] These costs vary greatly, depending on the size of the installation and level of utilization. While a fleet operator that switches to EVs can expect a higher electricity bill, the lower relative cost of electricity represents a cost savings over gasoline. A typical BEV or PHEV can travel approximately 3.5 miles per kilowatt-hour (kWh) of electricity consumed, at a cost of approximately $0.06 per mile.[6] The fuel cost for a gasoline vehicle with an industry-average 25 miles per gallon fuel economy is 2-3 times that, at around $0.16 per mile.[7]

For a networked charging system, typical network fees cost between $100-$900 annually, depending on the installation.[8]

[4] https://afdc.energy.gov/files/u/publication/evse_cost_report_2015.pdf.
[5] Demand charges apply to some, but not all, commercial electricity rates. Consult your latest utility bill or speak with a utility customer service representative to learn more about your current electric rates and potential impacts to your utility bill.
[6] Assumes an average electricity cost of $0.20/kWh.
[7] Assumes a gasoline price of $4.00/gallon.
[8] https://afdc.energy.gov/files/u/publication/evse_cost_report_2015.pdf.

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Estimating Your Demand

An important first step to installing fleet EV charging is to estimate the number of electric vehicle charging stations (EVCS) required. Most fleet charging will occur after normal business hours when vehicles are parked overnight, with limited ability to rotate vehicles. Plug-In SD therefore recommends installing one EVCS per EV, so each vehicle will have its own dedicated charger. An exception to this would be if procuring higher-range EVs that do not need to recharge daily. For example, a BEV with a range of greater than 200 miles may not need to charge daily and will be able to obtain a full charge in 4-10 hours of Level 2 charging.

Additionally, consider plans for future expansions of the EV fleet. It can be more cost-effective to make appropriate upgrades to electrical service and installation of conduit in one action, rather than in repeated incremental upgrades.

Once you have estimated the number of EVCS you will require, the following section provides a description of typical installation design and guidance on which installation is most appropriate for your fleet.

Basic Installation Design

Low-cost option – Level 1 charging

The easiest and least expensive EV charging design is to install multiple 120-volt, weather-resistant wall outlets at the parking spots located nearest to your company's subpanel. The outlets can be served by wall-mounted conduit, avoiding the need for expensive trenching. EV charging spots should be located as close to the electric service panel as possible, to minimize the cost of running electrical conduit.

Almost all EVs come with a Level 1 cord set charger as standard equipment that can be used with 120-volt outlets. An EV charging for 12 hours overnight would gain between 40-60 miles of electric range. This may be adequate for fleet vehicles that are used for less than 40 miles per day, as well as PHEVs with 20-60 miles of electric range.

If your property is accessible after hours, Plug-in SD recommends the use of simple mechanical timers that can be programmed to cut electricity to outlets not in use by fleet vehicles after hours, thus preventing illicit charging. Additionally, to minimize utility bill impacts, you may wish to cut power to the outlets between 4:00-9:00 p.m. during summer peak time-of-use (TOU) periods.

This option uses simple 15/20-amp, single-pole breakers on the electrical panel. Your subpanel may already have room for adding breakers. Work with a licensed electrical contractor to determine if your electrical service panel can accommodate additional load. If required, a service panel upgrade can add significant costs to a project.

Assuming no trenching or electrical service panel upgrades are needed, a low-cost Level 1 charging solution for six vehicles can be installed for **around $2,000-$3,000**, including the cost of an electrician's labor and permitting. While this option is a relatively inexpensive way to meet charging needs, it does not offer more advanced usage analytics and controls that allow allocation of charging costs across different users or departments. If you require this level of analytics, a networked Level 2 charging solution, described in the next section, may be better suited to your needs.

Figure 1 *120-volt outlets mounted along an external wall provide easy access to Level 1 EV charging.*

Midlevel Installation Design

Moderate-cost option – Level 2 charging

Level 2 charging requires installing a 240-volt, wall-mounted or bollard style charging unit next to parking spots located as close as possible to the subpanel or electrical room. Ideally, the units would be served by wall-mounted conduit, avoiding the need for expensive trenching. Bollard style units will likely require trenching, so that electrical conduit is protected and does not present a tripping hazard.

Nonnetworked Level 2 charging

Level 2 offers networked and nonnetworked charging. A nonnetworked Level 2 charger will have no internet connection and provides a driver with an access point to simply plug in and charge. A nonnetworked Level 2 charger is not able to track energy usage or the duration of time they are connected and charging, making it difficult to account for building energy usage versus fleet vehicle usage if served by a common electrical meter. Some nonnetworked Level 2 chargers can be controlled by a building's energy management system, allowing them to participate in utility demand response programs, which can reduce the overall cost of ownership.

For a nonnetworked charger, you will need to ensure that access to charging can be restricted during off hours to prevent illicit charging. If you are not able to restrict access to your parking lot after hours, you may consider purchasing chargers that can be controlled by the building energy management system or installing mechanical timers that can cut electricity to the circuit at a predetermined time. Another option offered by some nonnetworked chargers is keypad access, requiring users to enter a code to unlock the charging connector. Finally, some Level 2 chargers can be padlocked when not in use (Figure 2).

Figure 2 *A simple padlock can secure a nonnetworked Level 2 charger in publicly accessible parking lots.*

A nonnetworked charger will be less expensive, with wall-mounted or bollard style Level 2 charging units costing between $500-$2,000. Level 2 EVCS installation costs can vary widely depending on the site, but average around $3,000 per unit,[9] bringing the total cost for a nonnetworked solution to **$3,500-$5,000 per unit**.

Networked Level 2 charging

A networked Level 2 charger transmits data over the internet to a network host, allowing for more advanced controls, billing options and usage analytics. This functionality allows a fleet manager to separate EV charging from overall electricity usage, allocate costs across individual users or departments and establish different charging rates and accessibility for different user groups. For example, fleet vehicles may have their electricity costs allocated to a specific department, employees may be allowed to charge at one rate and guests or customers may be allowed to charge at a different rate or during specified hours. Alameda County makes their EVCS available to the public during business hours, when their fleet vehicles are in operation, and restricts access after hours to allow the fleet vehicles to recharge overnight.

Additionally, usage analytics allow a fleet manager to better evaluate vehicle utilization. This is especially important for PHEVs to ensure that they are charged regularly and used in electric only mode as much as possible to realize fuel and maintenance cost savings. Usage analytics also are important for reporting advances toward sustainability goals, such as GHG reductions.

Finally, the use of a networked EVCS may allow a business to participate in utility programs, like demand response, which can result in utility bill credits and reduce the overall cost of EV ownership. Level 2 EVCS with network capabilities typically cost between $1,500-$6,000, not including the cost of installation and ongoing network fees. While installation costs are similar for a nonnetworked solution, the increased cost of the networked EVCS brings the total cost to **$4,500-$9,000 per unit**.

[9] https://afdc.energy.gov/files/u/publication/evse_cost_report_2015.pdf.

Load management

A Level 2 charger typically requires a dedicated 40-amp circuit in the building's electrical panel. While some electrical panels may have room to accommodate a few Level 2 chargers, most will not have room for larger installations. A professional electrician can examine a panel to determine if there's room for additional capacity. Should a panel not have room for the additional circuits, it may require a panel upgrade.

Alternatively, adaptive charging (also referred to as load management or charge management systems) allow multiple Level 2 chargers to operate on one circuit by modulating the power demand of each individual charger (Figure 3). Fleet vehicles will typically remain parked and plugged in for 10-12 hours overnight. However, each vehicle may only require an hour or two of Level 2 charging to obtain a full charge. An adaptive charging system manages the power output across a series of chargers on the same circuit, allowing all connected vehicles to obtain a charge without the need to rotate vehicles.

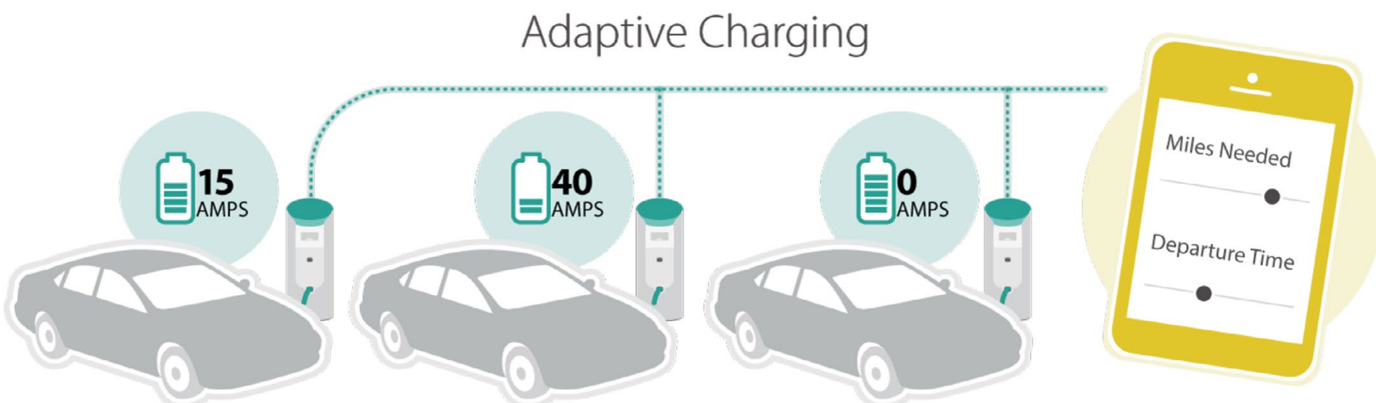

Figure 3 *An adaptive charging system shares electricity from one circuit across multiple EVCS, eliminating the need to rotate vehicles. A user can program desired range and departure time to ensure that EVs have an adequate charge by the required time.*

Similarly, a rotational charging system with an integrated charge controller rotates power supply from one circuit between multiple connected Level 2 chargers (Figure 4). The connected vehicles essentially take turns charging, without the need for drivers to rotate vehicles or move charge connectors. One **apartment complex in San Diego** was able to support 60 Level 2 chargers on electrical infrastructure that would normally only support 15 Level 2 chargers by using a load management solution.

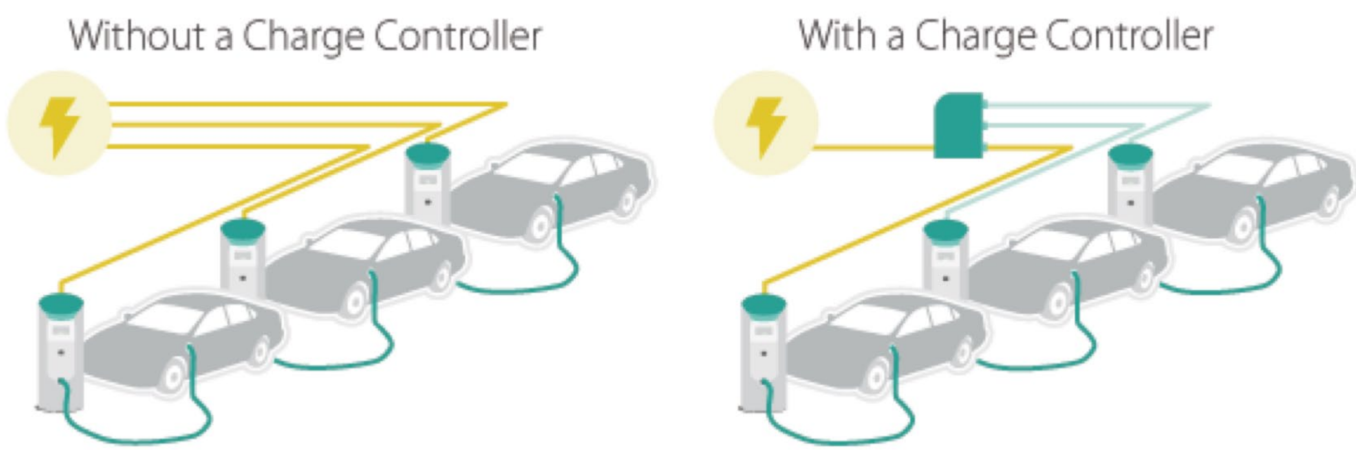

Figure 4 *A rotational charging system utilizes a charge controller to redirect electricity from one building circuit across multiple connected Level 2 chargers. Without a charge controller, each Level 2 charger would require its own dedicated circuit.*

Advanced Installation Design

Higher-cost option – Level 1 or 2 + DC fast charging

The most advanced, and highest cost, option would include DCFC for rapid charging of longer-range EVs in tandem with either Level 1 or 2 charging. This would require up to 480-VAC, three-phase power and a 40- to 80-amp dedicated circuit to provide a direct current (DC) output range between 31-62 kW. Due to the higher energy demands, this option would be much more likely to require expensive electrical upgrades to the site's electrical service and potentially to the electric distribution grid transformer that serves the site.

Plug-in SD recommends placing these charging stations away from the building, preferably in the center of a four-car parking area to maximize vehicle rotation. This option will require a dedicated meter and possibly a dedicated line from the utility transformer.

While most fleets can meet their EV charging needs with either Level 1 or 2 charging, DCFC may be appropriate in the following situations.

- **"Pit stop" charging** – Delivery, taxi or transportation services may require rapid recharging of EVs and wish to minimize vehicle downtime.
- **Space constraints** – If your facility is unable to accommodate many EVCS, DCFC may be able to meet your charging needs by rotating vehicles through fast charging sessions.
- **Emergency recharging** – Having DCFC installed provides a safety net that allows you to quickly recharge a BEV if it were to become depleted unexpectedly.

Note that PHEVs are typically not equipped with the hardware required for fast charging. Most BEVs are capable of DCFC but automakers differ in the type of connector that can be used (Tesla, CHAdeMO or CCS). Be sure to confirm vehicle compatibility and consider DCFC units that have both CHAdeMO and CCS connectors to avoid any future compatibility issues if purchasing different makes of EV.

DCFC units range in price from $10,000-$40,000, and transformer upgrades to accommodate the increased power demands can cost between $10,000-$25,000. While average DCFC installation costs are around $21,000, they can range anywhere between $8,500-$51,000.[10] Along with equipment costs, installing a DCFC can cost **between $30,000-$100,000 per unit**.

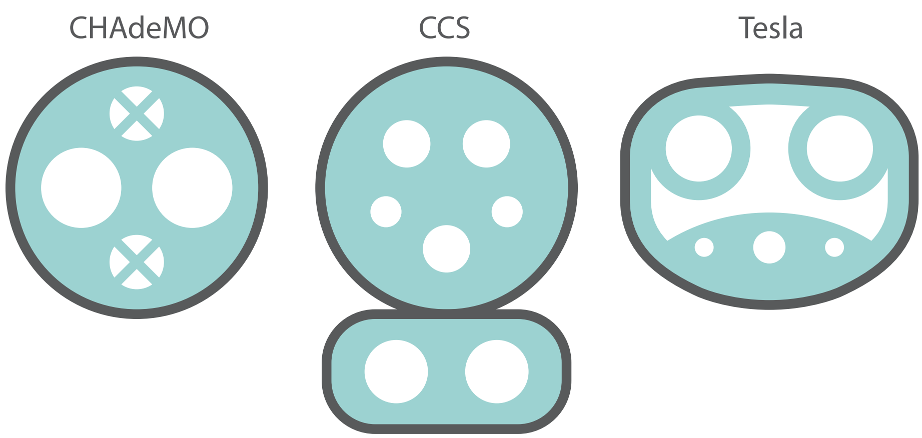

Figure 3 *The three DCFC connectors used in the U.S. – (from L to R) CHAdeMO, Combined Charging System (CCS) and Tesla.*

[10] https://afdc.energy.gov/files/u/publication/evse_cost_report_2015.pdf.

Cost Recovery

In addition to reduced fuel and maintenance costs, businesses and public agencies may be able to recover some of the cost of installing EV charging through incentives and tax credits, revenue from public charging and the sale of Low Carbon Fuel Standard (LCFS) credits.

Reduced fueling and maintenance costs

An EV can typically travel 3.5 miles per kilowatt-hour (kWh) of energy used. At an average electricity cost of $0.20 per kWh, that translates to approximately $0.06/mile. A comparable internal combustion engine vehicle with an average fuel efficiency of 25 miles per gallon (mpg) and at a gasoline price of $4 per gallon will have a fuel cost of approximately $0.16 per mile. For a vehicle that travels 10,000 miles per year, this represents a cost savings of nearly $1,000 per year in fuel costs.

Additionally, maintenance costs for EVs are lower due to the reduced or avoided need for oil changes and spark plug and air filter replacements. Additionally, regenerative braking, which uses resistance from the motor to recharge the battery and slow the vehicle in lieu of braking, reduces wear on the vehicle's braking system.

Incentives and tax credits

Incentive programs and tax credits can help property owners recover some of the upfront costs of installing EV charging. Air pollution control districts (APCDs) and electric utilities are common sources for rebate programs. Incentive availability changes frequently. The California Electric Vehicle Infrastructure Project (**CALeVIP**) website maintains a list of additional incentive projects and the California Air Resources Board offers an incentive search tool on the **DriveClean.ca.gov** website.

CALeVIP offers incentives for Level 2 charging for light-duty fleets in specific areas throughout the state.

While not a rebate, the California Capital Access Program (**CalCAP**) provides financing with favorable terms for EV charging projects for small businesses, lowering the overall cost of ownership. Public agencies are not eligible for CalCAP loans.

Finally, EVCS can be depreciated like any other business asset, reducing your organization's tax liability. Be sure to consult with a tax professional regarding depreciation of EVCS.

EVCS Leasing Option

While most EVCS are purchased, some equipment manufacturers offer lease options as an alternative. This may be a useful option if a fleet charger system requires expensive units that offer networked keycard access and billing management. Most lease offerings require the building owner to provide the conduit and wiring to the installation site. The charging equipment manufacturer will then install, maintain and update and/or upgrade the equipment throughout the lease term. Leasing may be a good option if your company has a shorter-term property lease or is planning to move locations soon and does not want to purchase the EVCS. Most charger unit lease terms are three, five or 10 years. When the agreement schedule is complete, the manufacturer will remove the chargers unless the lease term is extended.

Employee and public charging revenue

Fleet managers may make EVCS available to employees and/or the public during times when fleet vehicles do not need to charge. With a networked Level 2 system, the fleet manager can set different usage profiles and charging rates, with revenue from employee and/or public charging helping to offset the cost of installing EV charging infrastructure.

Low Carbon Fuel Standard (LCFS) credits

In 2009, the California Air Resources Board created the Low Carbon Fuel Standard (**LCFS**) to encourage the use of less carbon-intensive transportation fuels. Electricity is considered a lower-carbon fuel, and fleet operators that install EV charging can generate credits that may be sold in California's LCFS market. The sale of LCFS credits can provide an additional revenue stream, offsetting the cost of installing and operating your EV charging stations. Businesses may choose to capture and sell these LCFS credits for themselves, or they may cede their credits to their EV service provider. Discuss with your service provider how ownership of LCFS credits will be treated and how your business will be compensated if you choose to cede your right to your credits.

Getting Started – A Recap

Follow the four main steps to starting an EV charging project.

1. **Estimate demand** – Determine your current expected EV charging need, based on the number of EVs you currently own or plan to procure soon and how many miles per day each vehicle will typically travel. Plug-In SD recommends a 1:1 EVCS to EV ratio so that all EVs can recharge overnight without the need to rotate chargers. Additionally, be sure to account for future EV procurement and consider having adequate EV charging infrastructure installed ahead of time.
2. **Choose design level** – Based on your fleet vehicle demand, consider what level of charging is appropriate for your need and budget. Will simple, inexpensive Level 1 charging meet your need, or will you require faster charging speeds and advanced controls and monitoring of networked Level 2 charging?
3. **Choose ownership model** – Access to EVCS may be restricted to only fleet vehicles, or you may allow employee and/or public access to EVCS when not in use by fleet vehicles. Additionally, your organization may require the advanced billing and cost allocation capability offered by a networked Level 2 charger.
4. **Evaluate cost recovery options** – In addition to fuel and maintenance cost savings associated with fleet electrification, research available incentives and/or tax credits for installing EV charging infrastructure. Determine if you will charge employees and/or visitors to offset increased energy costs. Speak with your EV service provider about who will capture the value of the LCFS credits generated by your EVCS.

Once you have worked through the four steps, you'll be well prepared to begin speaking with EV service providers and electrical contractors who will be able to recommend solutions suited to the needs and constraints of your fleet and property. The following section includes tools for finding incentives to defray costs and identify vendors to design and implement electric vehicle charging solutions.

Additional Resources

CALeVIP – The California Electric Vehicle Infrastructure Project (CALeVIP) is a California Energy Commission-funded project that provides incentives for Level 2 and DC fast charging in select locations throughout the state.

CALeVIP Connects – CALeVIP Connects is a free online directory that allows you to connect directly with EV service providers and request information for potential EV charging projects.

Fleets for the Future – Fleets for the Future is a coalition of regional councils and industry experts that maintains a website with useful resources on alternative fuel fleets.

Incentive Search Tool – DriveClean.ca.gov provides a search tool to help you find incentives for EVs and charging infrastructure.

Plug-In SD FAQ – A list of frequently asked questions from Plug-In SD covering the basics of charging, costs, incentives and more.

The Alternative Fuels Data Center (AFDC) – An information clearinghouse maintained by the U.S. Department of Energy (DOE) that is home to useful resources, as well as a list of relevant laws and incentives.

Veloz/PEVC Case Studies – Veloz provides several useful case studies and fact sheets on their website.

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