Electric Vehicle Charging: Basics and Beyond

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Electric Vehicle Charging: Basics and Beyond

Presented by: ChargePoint, Inc.
254 East Hacienda Avenue
Campbell, CA 95008

Description: The sales growth of electric vehicles (EVs) and the behavior of EV drivers are increasing the demand for public and workplace charging. This education course explains the different types of charging available and their suitable applications, and discusses the planning and installation considerations for electric vehicle supply equipment (EVSE).

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Purpose and Learning Objectives

Purpose: The sales growth of electric vehicles (EVs) and the behavior of EV drivers are increasing the demand for public and workplace charging. This education course explains the different types of charging available and their suitable applications, and discusses the planning and installation considerations for electric vehicle supply equipment (EVSE).

Learning Objectives:

At the end of this program, participants will be able to:

- Identify the benefits of driving electric vehicles and state how industry trends are influencing sales of EVs
- List three levels of charging stations, describe how they work and specify the applications they are best suited for
- Recall the needs of EV drivers and charging station owners and explain how these needs can be met by networked stations
- Discuss various site assessment and selection considerations and how they impact both the safety and cost of EVSE installations
- Explain the importance of assessing electrical needs and availability, upgrading services and planning for the future

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An Introduction to Electric Vehicles

Glossary of Acronyms

Common acronyms as defined by the U.S. Department of Energy:

ICEs (internal combustion engines) generate mechanical power by burning a liquid fuel (such as gasoline, diesel or biofuels) or a gaseous fuel (such as compressed natural gas). They are the dominant power source used in on-road vehicles today.

PEVs (plug-in electric vehicles) derive all or part of their power from electricity supplied by the electric grid. They include EVs (or BEVs – battery electric vehicles) and PHEVs.

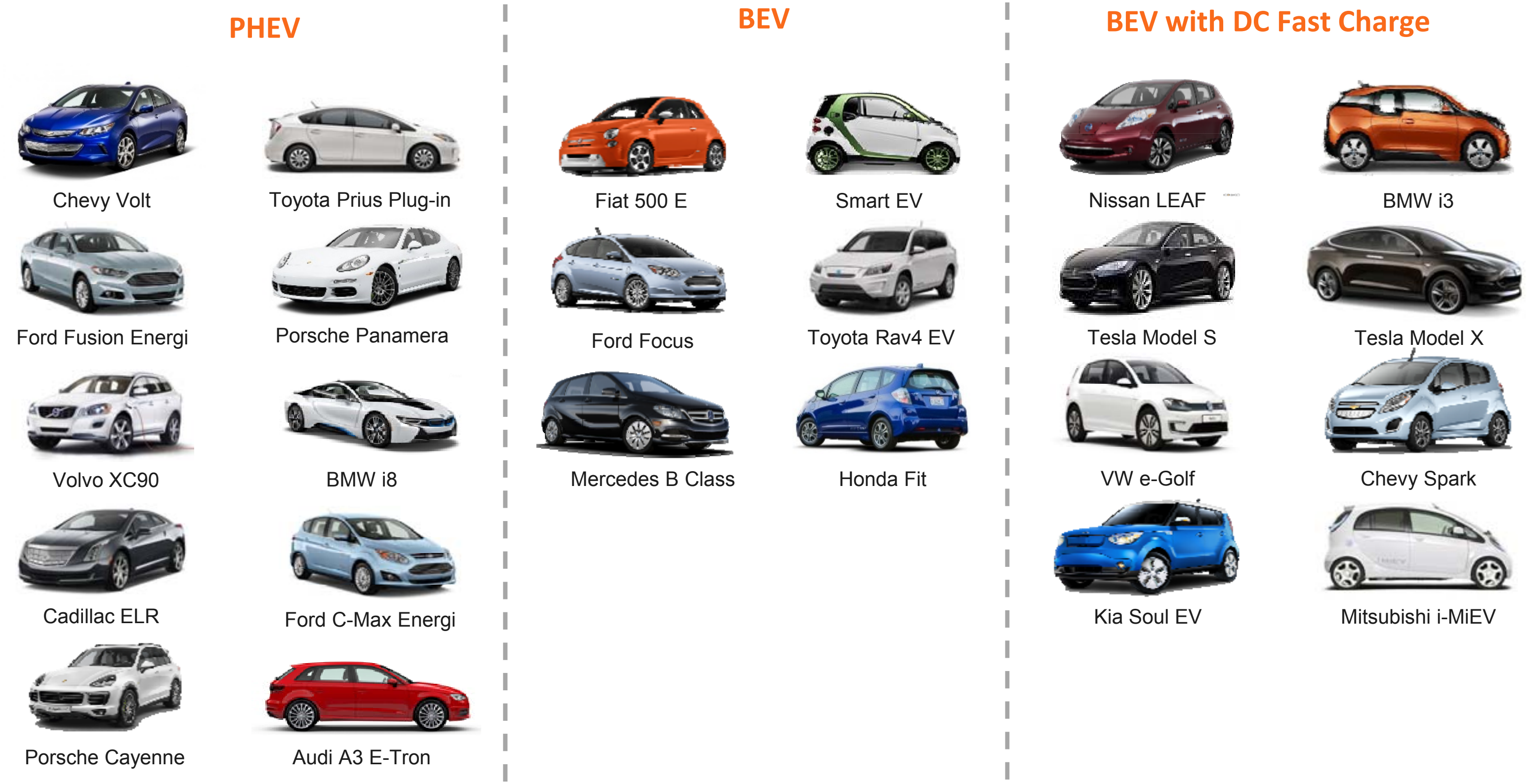
- **EVs** (all-electric vehicles) are powered only by one or more electric motors. They receive electricity by plugging into the grid and store it in batteries. They consume no petroleum-based fuel while driving and produce no tailpipe emissions.
- **PHEVs** (plug-in hybrid electric vehicles) use batteries to power an electric motor, plug into the electric grid to charge and use a petroleum-based or an alternative fuel to power an ICE (internal combustion engine) or other propulsion source.

HEVs (hybrid electric vehicles) combine an ICE or other propulsion source with batteries, regenerative braking and an electric motor to provide high fuel economy. They rely on a petroleum-based or an alternative fuel for power and are not plugged in to charge. HEV batteries are charged by the ICE or other propulsion source and during regenerative braking.

EVSE (electric vehicle supply equipment) delivers electrical energy from an electricity source to charge a PEV's battery. It communicates with the PEV to ensure that an appropriate and safe flow of electricity is supplied. EVSE units are commonly referred to as "charging stations."

Automakers Are Embracing EVs

From plug-in hybrids to all-electric, there is an EV for everyone. Given that electric vehicles can help increase energy security, improve fuel economy, lower fuel costs and reduce emissions, consumer demand for EVs is increasing.



Automakers Are Embracing EVs

Volkswagen
Aiming for “market leadership in electric mobility by 2018” and all new models will have a plug-in option

BMW
Built a sub-brand with BMW i—expects all models by 2025 to have a plug-in electric option

Porsche
All new models will have a plug-in option

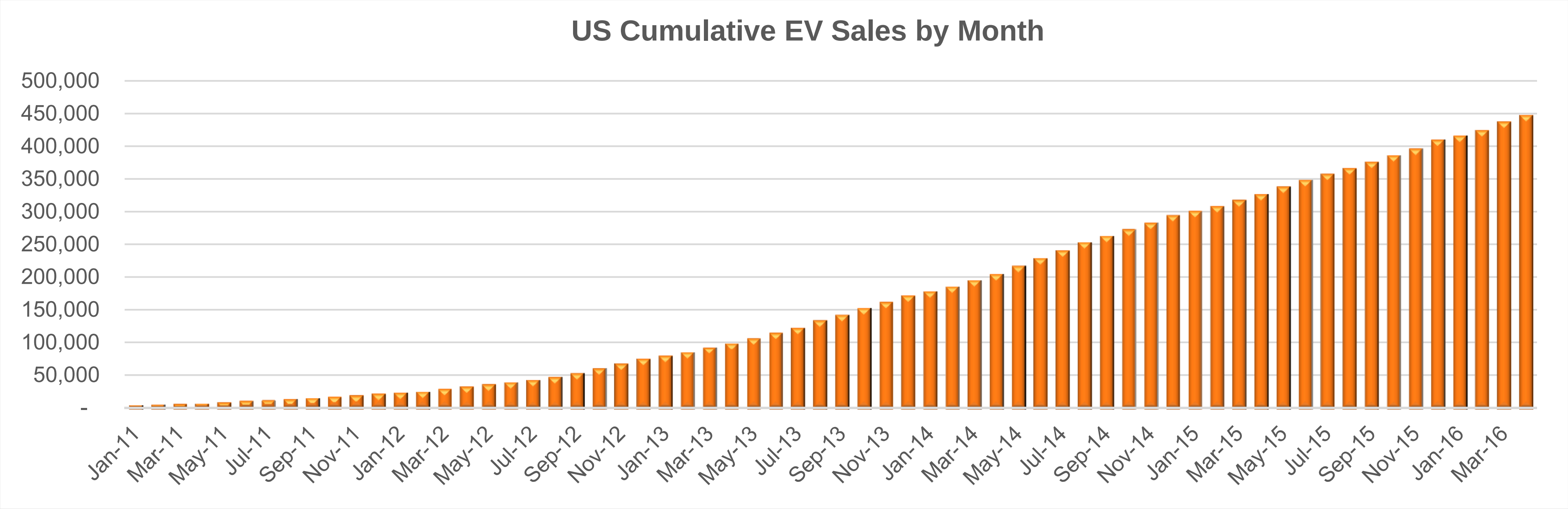
Audi
Five new PHEVs on the roadmap

Daimler
Three additional PHEVs and four BEVs on the roadmap

Tesla
Model X on sale and Model 3 announced

EV Sales Are Growing

Electric vehicle sales will grow rapidly over the next ten years, so it is a great time to take advantage of the opportunity to show leadership in sustainability by helping propel adoption of this cleaner, more efficient technology.

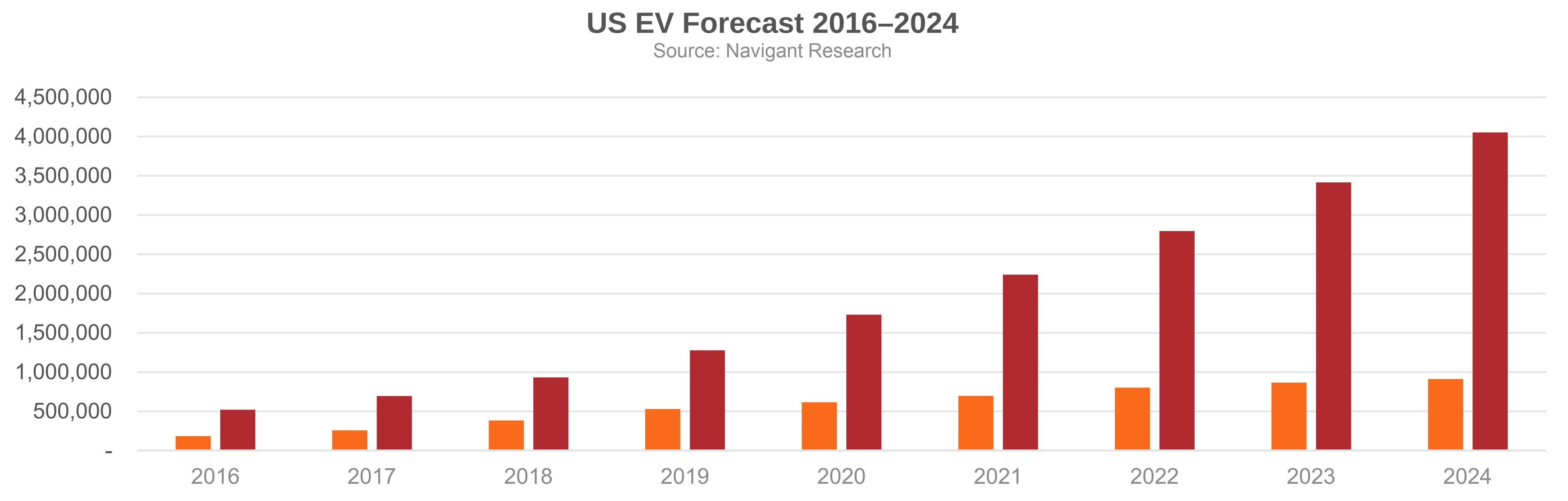


Over 446,000 cumulative EVs sold

Source: Inside EV Sales Scorecard
http://insideevs.com/monthly-plug-in-sales-scorecard/

Electric Vehicle Projections

Research projections have estimated that over four million EVs will be on the road by 2024. Due to this forecasted demand, automakers are adding new models to their lineup as previously noted.



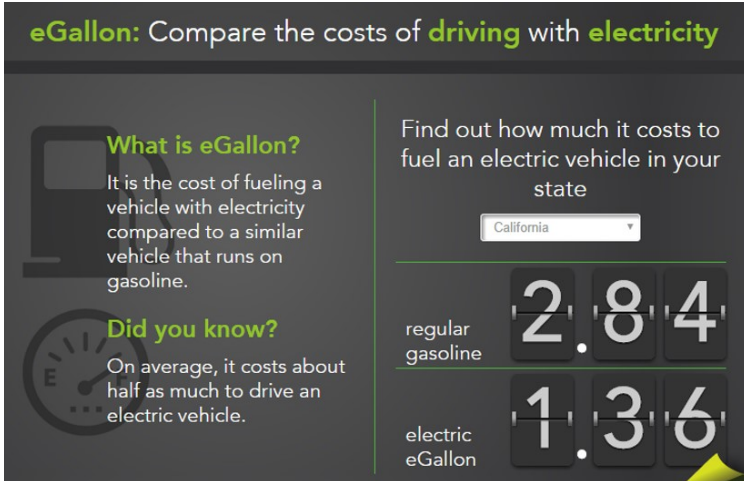
Source: Navigant Research
www.navigantresearch.com/research/electric-vehicle-geographic-forecasts

Benefits of EVs

EVs produce zero tailpipe emissions, and PHEVs produce no tailpipe emissions when in all-electric mode. The total life cycle emissions of an EV or PHEV depend on the sources of electricity used to charge it, which vary by region. To compare electricity sources and annual vehicle emissions by geographic location, visit the U.S. Department of Energy's Alternative Fuels Data Center. (http://www.afdc.energy.gov/vehicles/electric_emissions.php Accessed March 2016)

Benefits of EVs

It costs between one-third to one-half the price for electric vehicles to travel the same distance as similar-sized gasoline powered vehicles would on a gallon of fuel. The cost of lifetime fuel consumption for an electric vehicle is dramatically lower compared to the lifetime fuel consumption of gas powered vehicles and hybrid vehicles.



This U.S. Department of Energy online tool calculates eGallon prices using the most recently available state by state residential electricity prices. (http://energy.gov/articles/egallon-and-electric-vehicle-sales-big-picture Accessed March 2016)

Lifetime Gasoline Consumption and Fuel Costs

Electric Vehicles	40,000 kWh $4,800	Savings of $10,200
Gas Powered Vehicles (24 MPG)	5,000 gal $15,000	

Gasoline – 12,000 miles/year

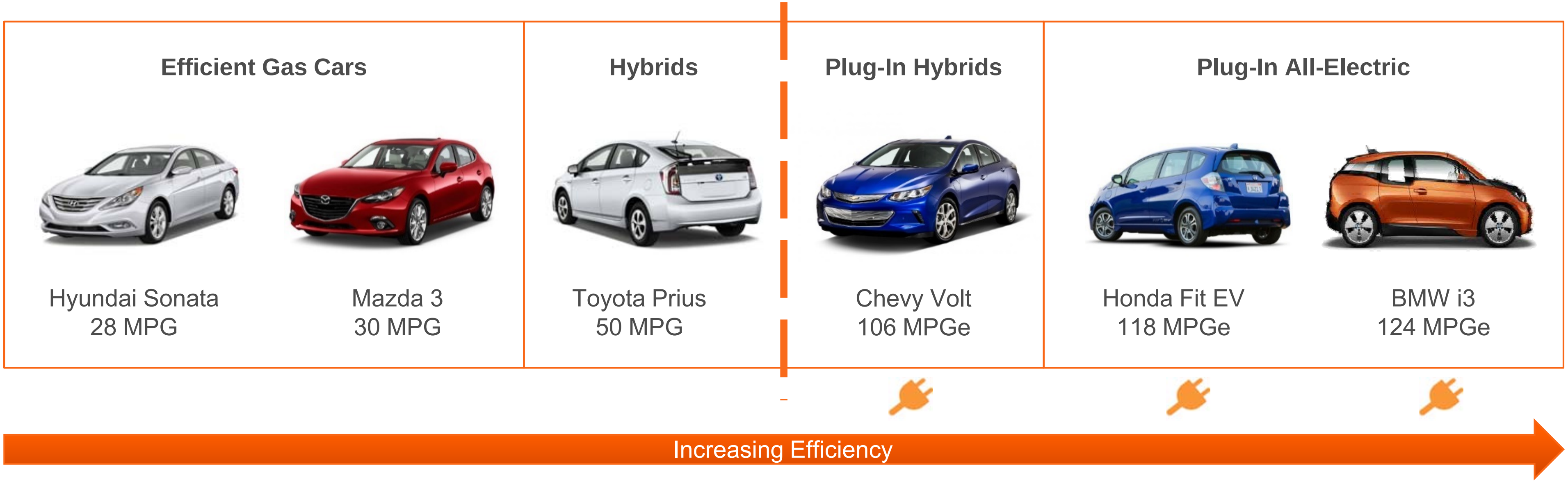
- Car = 24 MPG
- Gasoline used = 500 gal
- Average gas price = $3.00
- Annual cost = $1,500
- Lifetime cost (10 yrs) = $15,000

Electric Vehicle – 12,000 miles/year

- Average EV = 3 miles/kWh
- Electricity used = 40,000 kWh
- Average electricity cost = 12¢/kWh
- Annual cost = $480
- Lifetime cost (10 yrs) = $4,800

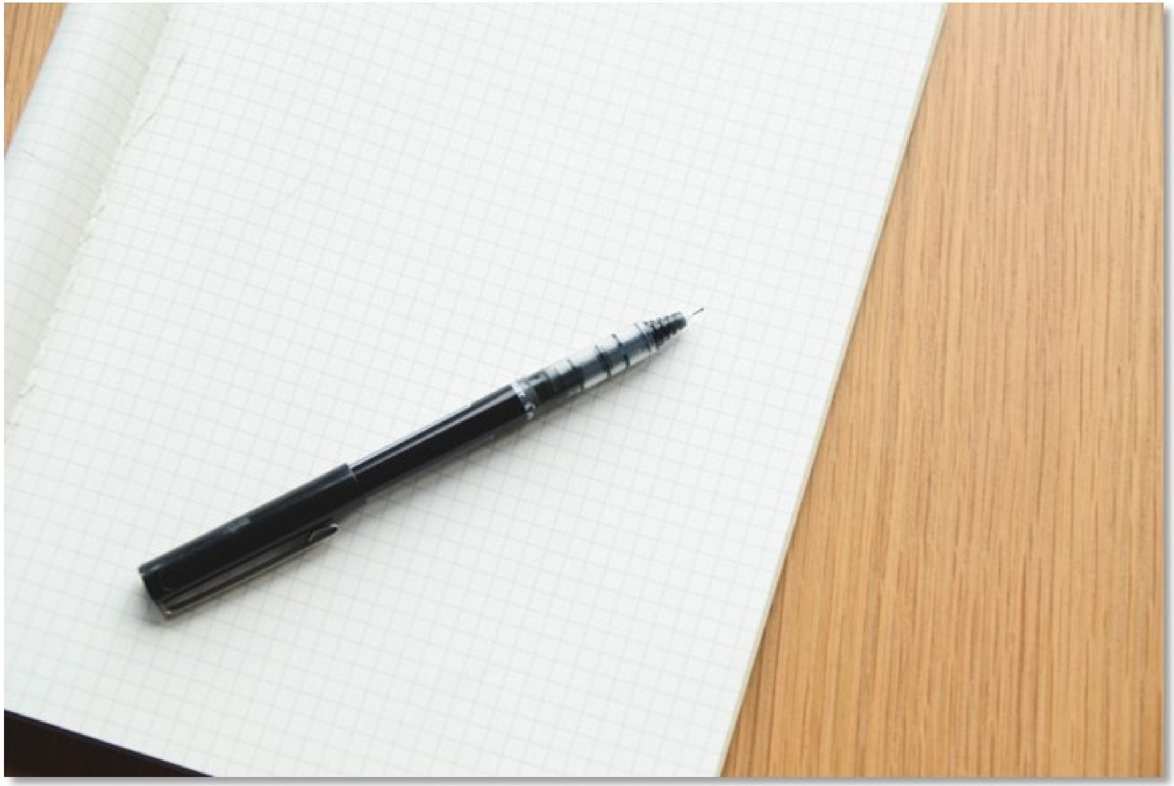
Benefits of EVs

This is a comparison of a sample of vehicles from relatively efficient gas vehicles, to hybrids and plug-in hybrids, to all-electric vehicles. On an MPGe basis, the all-electric vehicles are about four times as efficient as the gas vehicles. Plug-in hybrids offer the convenience of a gas tank for back-up, but are still incredibly efficient—and the more you drive on electricity, the better these vehicles perform.



Electric Vehicle Industry Trends

- EVs are becoming more affordable across the industry.
- Range is the current focus for EV manufacturers. Second generation EVs have increased ranges over their predecessors.
- Battery costs are set to fall. Navigant Consulting, Inc. indicates that battery packs for electric vehicles could plunge to $150/kWh or lower within ten years.
- Consumer awareness is a driving factor in EV sales. Consumers are realizing that EVs offer a number of advantages and businesses are realizing they can attract these drivers by offering EV charging stations.
- Government programs, such as the California Zero Emission Vehicle (ZEV) rule, are requiring automakers to offer more environmentally friendly vehicles. In addition, a variety of consumer incentives exist, including tax rebates and credits to encourage EV sales.



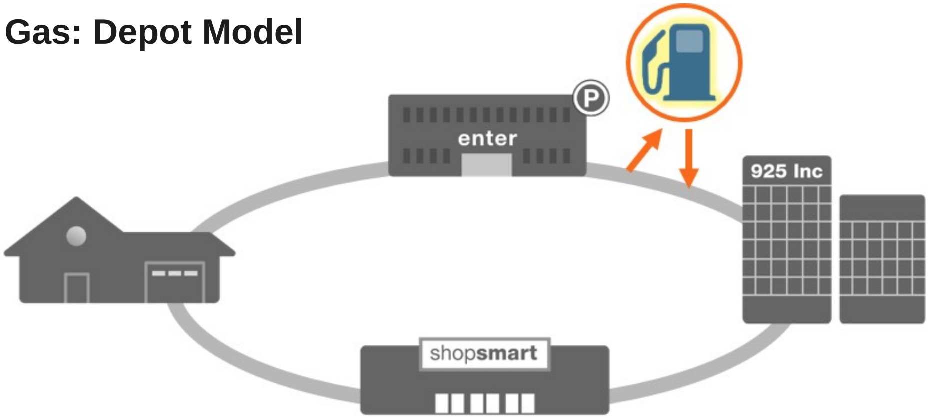
Charging Station Basics

Fueling Models

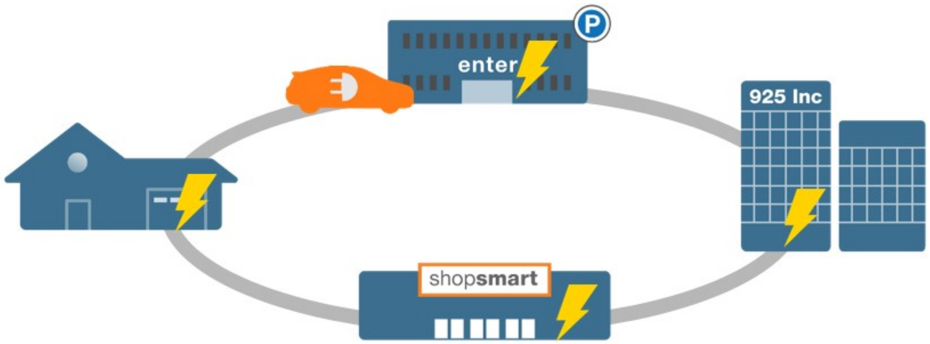
As fuel options have evolved to include electricity, the fueling model has also transformed from a depot-based model to a top-off model. In a depot-based model, drivers leave their intended route to a particular destination to stop and quickly refuel.

EV drivers prefer to use the opportunity to top-off their cars wherever they are parked. EV drivers don't wait until their cars reach empty to refuel. This top-off model is more convenient and efficient as the drivers can connect their cars to a charging station as they park and continue with their normal activity, such as work, shopping, etc.

Gas: Depot Model



Electric: Top-off Model



Electric Vehicles and Charging Time

As defined earlier in the course PEVs (plug-in electric vehicles) derive all or part of their power from electricity supplied by the electric grid. They include EVs (or BEVs – battery electric vehicles) and PHEVs. As a rule of thumb, and depending on an individual's driving behavior, BEV and PHEV cars get 3–4 miles on average per kWh. Charging time depends mainly on the two factors below.

Battery size, charging station capacity and onboard charger capacity limit charging speed.

- Capacity is measured in kilowatt hours (kWh).
- This ranges from 4 to 90 kWh depending on the type of electric vehicle.

Power

- This refers to the rate of energy delivered.
- The rate at which the car can accept power as measured in kilowatts or kW.
- Each vehicle has its own maximum rate based on its internal charging capacity and may or may not have a separate DC charging port.

Electric Vehicle Charging Stations

EVSE for plug-in vehicles is classified according to the rate at which the batteries are charged. AC Level 1 and AC Level 2 provide alternating current (AC) to the vehicle, with the vehicle's onboard charger converting AC to the direct current (DC) needed to charge the batteries. The third type—DC fast charging—provides DC electricity directly to the vehicle battery. Charging times range from less than 20 minutes to 20 hours or more, based on the type or level of EVSE; the type of battery, its capacity and how depleted it is; and the size of the vehicle's internal charger.

Level 1 Charging

Level 1 charging uses the standard household 120 V AC outlet to charge the EV and offers 2–5 miles of range per hour or RPH. Depending on the car and the battery, it takes 8–20 hours to add 40 miles of range, which is more than the average miles driven per day in America. It uses the three pronged NEMA 5-15 standard household plug, and the charging cable has an SAE J1772 connector that plugs into the vehicle inlet.

Electric Vehicle Charging Stations

Level 2 Charging

This uses either the household or commercial 208–240 V mains power supply to charge the EV using the vehicle's onboard charger. It offers 10 to 30 miles of range per hour or RPH at 30 amps.

This type of charging is offered by installing a Level 2 charging station that has a cord with the standard SAE J1772 connector. The Level 2 charger protects the users from the power components. Commercial stations are hard wired so there are no exposed power outlets and the electricity does not flow until connected to the vehicle. They are built to be safe for commercial outdoor use. Level 2 stations can be networked stations or non-networked stations.

DC Fast Charging

Previously called Level 3 charging, this type of charging requires 208 V or 480 V three-phase AC power supply. The DC charger performs AC to DC conversion and supplies DC power directly to the battery.

This type of charging offers an estimated maximum 100–200 miles of range per hour or RPH. It takes 15 to 45 minutes to charge from 0 to 80 percent, depending on the vehicle. DC chargers can also be networked or non-networked and are safe for commercial outdoor use as well.

Issues with Level 1 Charging

In general, Level 1 charging stations are not a scalable or practical solution.

- Financial liability: Most Level 1 stations enable unrestricted access to electricity. Hosts do not have the ability to charge drivers for utilization.
- No control: Most Level 1 stations are non-networked and unable to control who has access to the charging station.

Specific issues in different parking scenarios:

- Long-term Parking
  - More costly installation: For a given EV charging need, Level 1 outlets cost more due to lack of power sharing and panel sharing capability.
    - Level 1 stations may require additional panel upgrades.
    - Level 1 stations require more wiring compared to Level 2 stations that have power sharing capability.
    - Level 1 stations do not protect hosts from higher utility demand charges.
- Short- and Medium-term Parking
  - Not scalable: Level 2 charging offers faster charging that enables shared use of stations to support multiple drivers, thereby reducing the number of ports required and the cost per driver served (in terms of total project cost). Trenching and wiring for Level 1 charging provides only a fraction of the charging capacity compared to Level 2.
  - Not future proof: More 200+ mile battery range EVs are entering the market. Level 1 charging cannot support the expected charging requirements.
  - Impractical: Level 1 charging takes much more time and drivers often need to bring their own cords.

Charging Levels Summary

EVSE Options						
	Amperage	**Voltage**	**Kilowatts**	**Typical Charging Time**	**Connector**	**Primary Use**
AC Level 1	12–16 amps	120 V	1.3–1.9 kW	12–18 hours 2–5 miles RPH	J1772 connector	• Only several narrow uses
AC Level 2	6–80 amps	208 V or 240 V	Up to 19.2 kW	2–4 hours 10–30 miles RPH	J1772 connector	• Park and charge • Residential, commercial and public charging
DC Fast Charging	70–125 amps	208 V or 480 V	24–150+ kW	15–45 minutes 100–200 miles RPH	SAE Combo, Tesla, ChaDeMo connector	• Commercial, public • Charging while traveling long distances

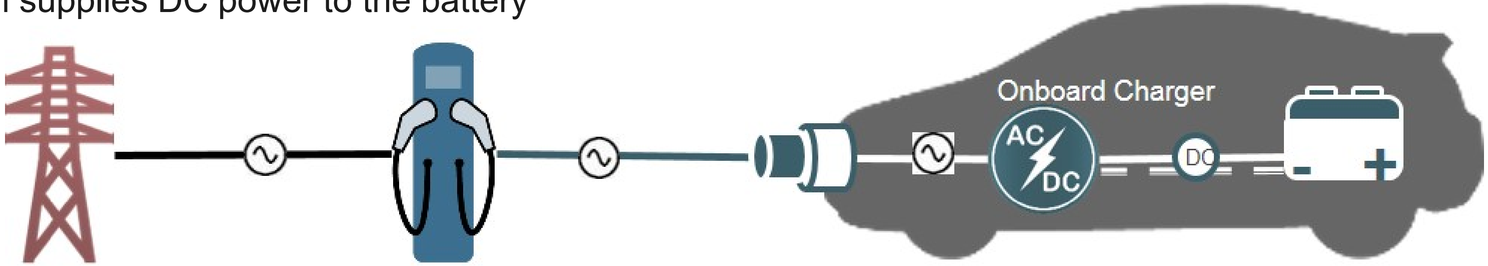
EV Charging Station Features

In "Costs Associated With Non-Residential Electric Vehicle Supply Equipment," the U.S. Department of Energy identifies the following common charging station features:

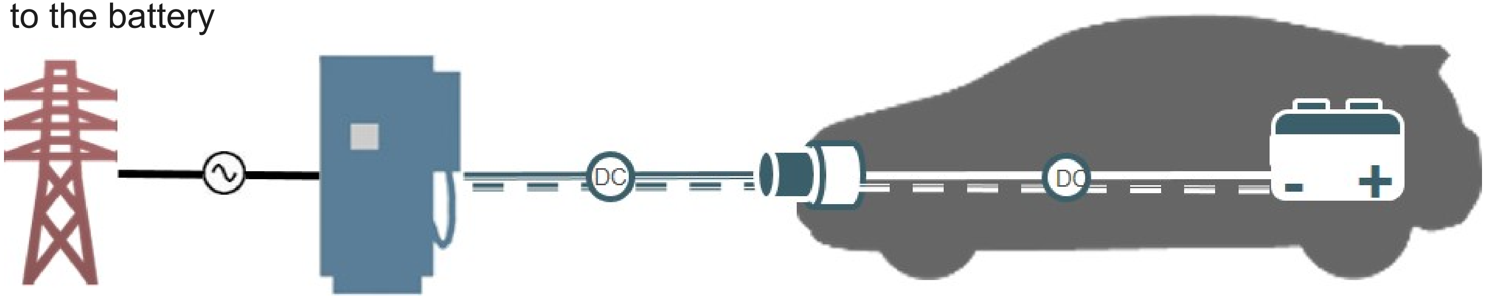
- Communication capabilities allow EVSE units to offer different levels of communication with the user, site host, utility grid and the Internet.
- Access control restricts the use of EVSE to specific people. Systems range from the simple, e.g., padlock or keypad, to the more complex, e.g., granting access through radio-frequency identification (RFID) cards or mobile phone applications.
- Point of sale (POS) options calculate the amount owed by the customer and provide payment methods. They could include a credit card reader, RFID reader or mobile phone application.
- Energy monitoring tracks the EVSE's energy consumption and provides reports on greenhouse gas emission reduction.
- Energy management and demand response features can optimize load management to maximize charging during low-rate periods and minimize during high-rate periods. Energy management can also allow the unit to connect to a smart grid.
- Advanced display screen can provide advertising and brand promotion.
- Retractable cord protects the cord and connector from damage, and reduces the risk of tripping on the cord. Automated diagnostics are used to troubleshoot issues or malfunctions that occur with the EVSE.
- Remote on and off enables users to control when their vehicle starts and stops charging.

Key Difference Between Level 2 and DC Fast Charging

Level 2 Charging - AC power is supplied from the charging station to the onboard charger, which supplies DC power to the battery



DC Fast Charging - the charger is off-board the vehicle and supplies DC power directly to the battery



DC Chargers

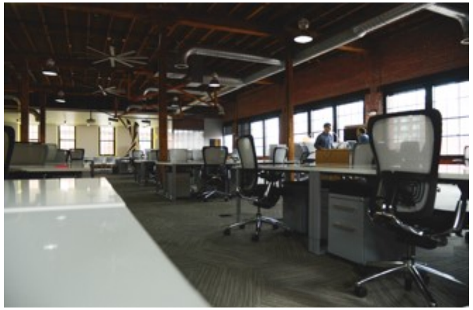
Three types of DC fast charging exist in the marketplace today. The SAE J1772 combined charging system (CCS), which uses a single port for either AC Level 1 and 2 or DC fast charging, was recently introduced. Additionally, Tesla has their own supercharger network, which is based on their own connector and currently charges only their own vehicles.

CHAdeMO

SAE Combo (CCS)

Tesla Supercharger

Charging at Home, Work and Public Places

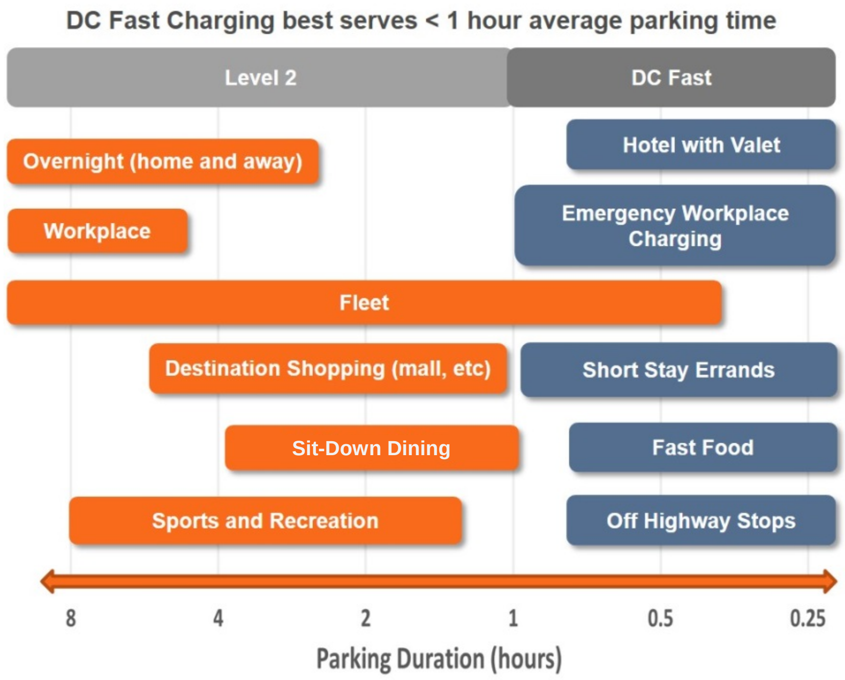



	Home	Work	Around Town	Out of Town
Type of Person	Home owners and tenants	Employees	General public, customers	Long distance drivers
Level of Charging	Level 1 and 2 charging	Level 2 charging	Level 2 charging, DC charging	DC fast charging
Timing	Overnight	Daytime	Business hours	Occasional, emergencies
Common Locations	Residential garage/driveway	Workplace parking	Commercial locations, public parking	Along major highways

Appropriate Charging for Various Activities

Level 2 charging best serves scenarios where parking times are longer than an hour, which covers overnight charging at home or a hotel, workplace charging, charging for fleets, sit-down dining, sports and recreation, destination shopping etc.

DC fast charging best serves businesses and locations where the average parking time or natural dwell time of the customer is less than one hour. It can be used to complement Level 2 chargers. Putting a DC fast charger where the natural dwell time is longer leads to bad user experience. The shorter charging time can disrupt users when charging is complete and they need to move the car—if they are watching a game, in a meeting or busy otherwise. Not moving cars on time can lead to frustration for other users who are looking for a spot to charge. Some locations have both long stay shopping as well as short stay businesses where both DC fast charging and Level 2 charging would be appropriate.



(Visually, DC fast charge times look similar to Level 2 charge times because of logarithmic scale)

EV Driver Needs

Station Availability and Use

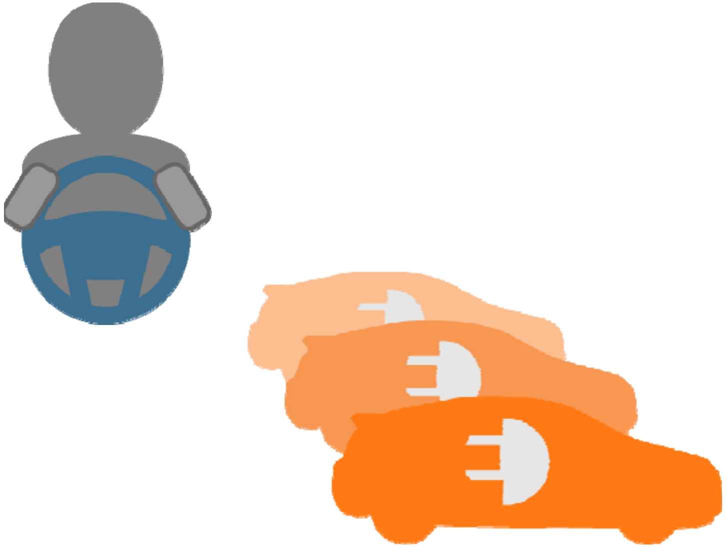
- Reliable and easy
- Simple payment mechanism and ease of use

Locate Stations

- Find available stations on web/mobile app
- Know "status" of the station before they arrive
- Know charging rate

Charging Alerts

- Charging status to inform EV drivers and alert to critical situations



EV Station Owner Needs

Control Access

- Restrict by groups of people or by time of day

Monitor and Plan

- Monitor energy, session length etc.
- Remote monitoring of station performance
- Forecast usage, station revenue, electricity cost etc.

Connect with Drivers

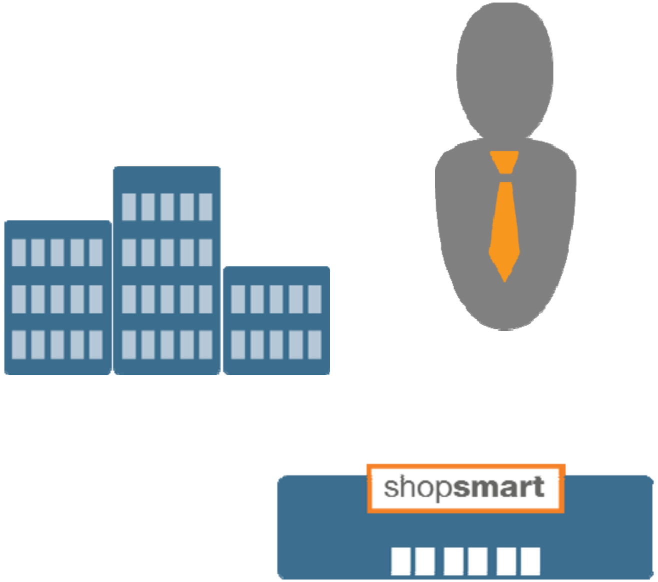
- Drivers find station location and status before they arrive
- Message drivers on display of the station

Recover Money

- Bill drivers different rates by identity (guest vs. employee) or by time (weekday vs. weekend)

Energy Management

- Ability to participate in future utility programs like demand response, time-of-use rates etc.
- Manage energy loads and demand charges



Charging Station Network Business Models

Not all models are created equal.

<u>Model 1</u>

- The charging station company owns the stations.
- The company makes money by marking up electricity (not profitable).
- The host DOES NOT control station pricing or access.
- Most of these companies are going bankrupt.

<u>Model 2</u>

- The charging station company sells the station and the software to the host.
- The host has complete control of station pricing and access, and decides on how to use them.
- It is a better experience for both driver and the host.

Non-Networked Charging Stations

Non-networked stations provide electricity and do not communicate with a central system.

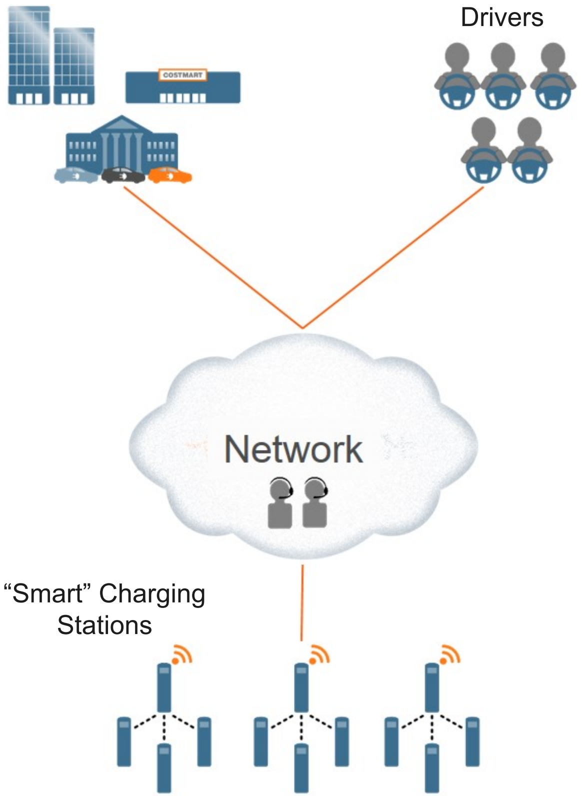
The non-networked charging stations may appear to be a low-cost option initially, but may actually cost more in the long run due to unrecoverable electricity costs given that the stations are open to the public and don’t provide the ability to either regulate who uses them or charge the drivers for electricity usage. There is no visibility to costs or usage data, and not being able to manage loads during peak hours drives up energy costs. The more non-networked charging stations are used, the more the owner’s cost goes up.

With no ability to communicate with, control or bill drivers, the result is frustrated employees and customers, and wasted investment. Any business advantages are lost when employees or customers don’t have access to charging because others are using the station for free electricity. There is no easy way to attract EV drivers or let them know if the station is functioning or available, which increases downtime.

Networked Charging Stations

Networked charging stations are called “smart” charging stations because they are connected to a cloud-based network connecting station owners to their stations and drivers. Charging can be offered as a benefit and optimized for the target audience—employees, customers, tenants etc.

Networked stations provide the control and flexibility to optimize EV charging operations, including access control, visibility and pricing structures for billing based on electricity usage.



Networked Charging Stations

Networked stations provide a better experience for EV drivers and therefore the owners.

With mobile apps and real-time data, drivers can find available stations and charging rates before arriving. Networked stations can also provide driver support remotely so the burden is not on the station owner.

Networked vs. Non-Networked Summary

- Non-networked stations are only able to deliver electricity and have limitations
- Networked stations meet the needs of EV drivers and station owners

Capability	Networked Chargers	Non-Networked Chargers
Offer electricity	✓	✓
Visibility and station status to drivers (through mobile app, in-dash navigation)	✓	✗
Ability to charge and recover cost (by kWh, hours of usage, time of use, etc.)	✓	✗
Access control (employees only, public, loyalty rewards)	✓	✗
Remote access and maintenance (check status, availability, etc.)	✓	✗
Analytics (usage, # of unique drivers, charging behavior, utilization, revenue and costs)	✓	✗
Sustainability reporting (GHG savings, fuel savings)	✓	✗

Charging Station Design and Planning

Codes and Regulations

Many state and local governments are encouraging the development of EV charging station infrastructure. It is being incorporated into parking regulations, building codes and transportation demand management plans. Many cities are also incorporating electric vehicle related topics into their sustainability goals.

For example, in New York, Mayor Bloomberg announced:

"We'll work with the City Council to amend the Building Code so that up to 20 percent of all new public parking spaces will be wired and ready for electric vehicles."

Codes and Regulations: CALGreen

California, known for its commitment to sustainability and clean energy, requires “EV capable” parking spaces in new construction under its statewide building code. This section of the code is Title 24, Part 6, otherwise known as CALGreen (California Green Building Standards Code). EV capable is defined as the raceway, paneling and capacity needed to install a charging station.

The current code requires that 3% of parking spots at non-residential new construction be EV capable. For multifamily housing, if the building has 17 or more units and is also new construction, 3% of the parking spots and one common area spot are required to be EV capable.

The California Building Standards Commission is currently considering an updated Title 24, Part 6 for new commercial construction. The new proposal would require that starting in 2017, 6% of parking spaces in non-residential new construction to be EV capable.

Codes and Regulations: City Examples

City of Cupertino

- Pre-wiring for 5% of parking spaces in new multifamily buildings
- Pre-wiring for 10% of parking spaces in new non-residential buildings

New York City

- Conduit and panel capacity for up to 20% of newly created parking stalls
- Applies to garage and surface parking lots

City of Pasadena

- EV chargers required for a new development or renovation that requires 250 parking spaces or more

LEED 2009: Applicable Credit and Option

EV charging stations can potentially earn points in the USGBC LEED green building certification program. There are four options to meet this credit requirement and Option 2 is alternative fuel stations—a subset of which is electric charging stations.

Category: Sustainable Sites

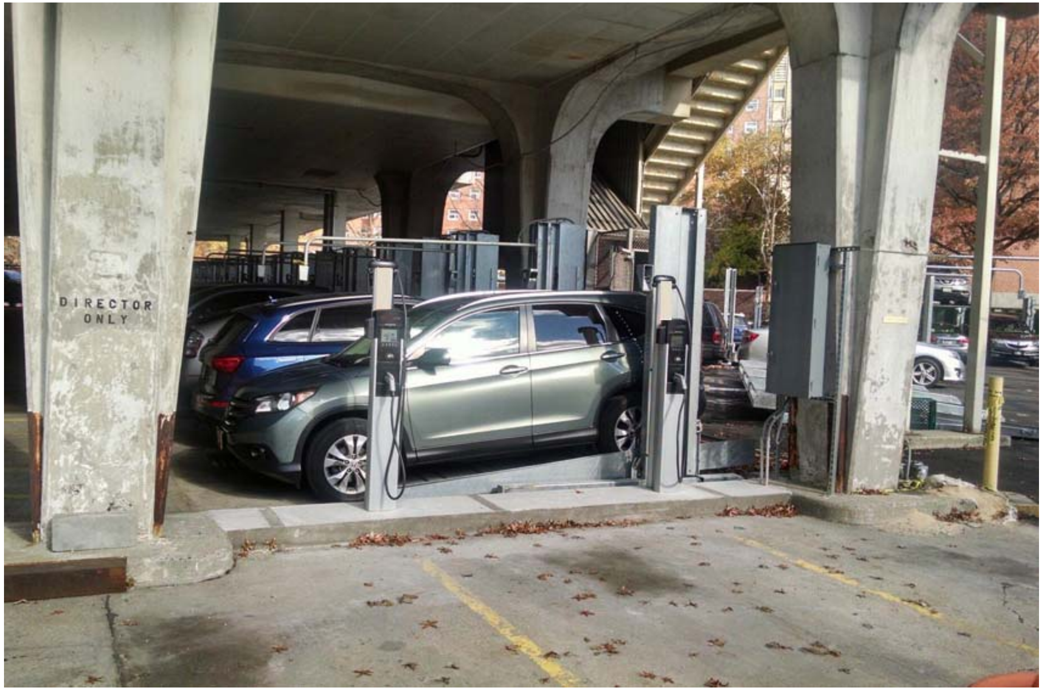
Credit: Alternative transportation – low-emitting and fuel-efficient vehicles – 3 points

Intent: To reduce pollution and land development impacts from automobile use.

Requirements (four options available)

Option 2: Alternative fuel

Install alternative-fuel fueling stations for 3% of the total vehicle parking capacity of the site. Liquid or gaseous fueling facilities must be separately ventilated or located outdoors.



LEED v4: Applicable Credit and Option

Category: Location and Transportation (LT)

Credit: Green vehicles – 1 point

Intent: To reduce pollution by promoting alternatives to conventionally fueled automobiles.

Requirements: Designate 5% of all parking spaces used by the project as preferred parking for green vehicles. Clearly identify and enforce for sole use by green vehicles. Distribute preferred parking spaces proportionally among various parking sections. There are also two options, and for electric vehicle charging, Option 1 must be met.

Option 1. Electric vehicle charging

Install electric vehicle supply equipment (EVSE) in 2% of all parking spaces used by the project. Clearly identify and reserve these spaces for the sole use by plug-in electric vehicles. Parking spaces that include EVSE must be provided separate from and in addition to preferred parking spaces for green vehicles.

The EVSE must:

- Provide a Level 2 charging capacity (208–240 volts) or greater.
- Comply with the relevant regional or local standard for electrical connectors, such as SAE Surface Vehicle Recommended Practice J1772, SAE Electric Vehicle Conductive Charge Coupler or IEC 62196 of the International Electrotechnical Commission for projects outside the U.S.
- Be networked or Internet addressable and be capable of participating in a demand-response program or time-of-use pricing to encourage off-peak charging.

Safety: North American Standards

There are a number of safety standards that should be considered for an EV charging station project.

Standard	Scope
NFPA 70® - National Electrical Code® Article 625	Covers installation of all EV charging systems.
UL 2202 - Standard for Electric Vehicle (EV) Charging System Equipment (UL)	Covers DC charging stations.
UL 2594 - Standard for Electric Vehicle Supply Equipment (Tri-national)	Covers AC charging stations.
UL 2231 - Standard for Safety for Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits	Covers ground fault, earth fault and isolation monitoring requirements for AC and DC stations.
UL 2251 - Standard for Plugs, Receptacles, and Couplers for Electric Vehicles	Covers the plug, cord, receptacle, connectors and other items related to the charging cord set.
UL 50E - Enclosures for Electrical Equipment, Environmental Considerations (Tri-national)	Defines enclosure environment requirements for types called out in UL 2202 and UL 2594.
SAE J1772 - SAE Electric Vehicle and Plug in Hybrid Electric Vehicle Conductive Charge Coupler	Covers the general physical, electrical, functional and performance requirements to facilitate conductive charging.

Safety: Cord Management

Electric cords on the ground present a tripping hazard and are a liability. Cords left on the ground will get dirty and wear down sooner. The visual appearance is messy and leads to the assumption that the station is unmanaged.

A proper cord management system is preferable and provides a better user experience.

Disconnects

Disconnects aren't necessary for Level 2 charging stations that operate below 60 amps, but they should be used for DC stations.

There are two main reasons AHJs (authority having jurisdiction) may request disconnects for Level 2 charging stations:

- NEC 625.42
  - "625.42 Disconnecting Means. (2014) For electric vehicle supply equipment rated more than 60 amperes or more than 150 volts to ground, the disconnecting means shall be provided and installed in a readily accessible location. The disconnecting means shall be lockable open in accordance with 110.25."
  - This clause is often misinterpreted and does not apply to 208/240 V stations rated less than 60 A because they are NOT more than 150 V above ground.
- Fire safety
  - If the vehicle detects an unsafe condition, it will automatically shut down the charging session and stop the flow of power. However, fire inspectors may desire to have a disconnect to manually shut off voltage.

Always defer to the code enforced by the authority having jurisdiction (AHJ).

Disconnects

Some AHJs request disconnects to be installed at each Level 2 charging station. A dual port station would require two pole disconnects or a four pole disconnect. There are a number of disadvantages to this approach, including:

- Added complexity and cost
- Unsightly equipment near the stations
- Difficult to locate—separate pole needed
- Minimal benefit to the station owner or the driver
- Risk of station shutoff by nefarious individuals
- Often found with the enclosure unsecured
- Potentially fewer charging stations available to drivers due to added cost

Planning: Equipment Needs

The first consideration should be the appropriate level of charging and the number of stations and parking spaces required for the project application. Many sites may be best suited to a combination of charging levels.

- Level 2 charging is best suited for commercial, workplace or residential applications where the driver will spend at least a few hours engaged in an activity.
- DC fast charging, which enables drivers to recharge quickly, requires more extensive planning and utility involvement than do the installations of the other levels of charging.

Service Upgrades

- Some EVSE projects require upgrades to the electrical service, such as the utility distribution line or transformer. DC charging stations or projects with many Level 2 stations are more likely to require a service upgrade than a single Level 2 EVSE. Engage the local utility early in the project to determine who is responsible for covering service upgrade costs. (Smith and Castellano)

It is also important to determine the software requirements for the project.

- Non-networked charging stations deliver unmanaged electricity to the vehicle.
- Networked EVSE offer differing levels of communication supporting services with the user, site host, utility grid and the Internet, depending on model and manufacturer.

Estimate Current and Future EVSE Demand

The first step is to estimate the number of EV charging stations the project will require both now and in the future.

Many projects choose to "make ready" 5–15%, or more, of total parking spots for EV charging. The number varies by region, property type, electrical infrastructure and project specific factors. For example, in California's Title 24 building code, at least 3% of parking spots must be EV make-ready for new development projects.

Example:

- There are 300 total parking spaces and you wish to have 10% of the parking spaces made EV charging station ready, with 5% of the spaces to have EV charging stations installed immediately. The remaining 5% of spaces will be available for EV charging stations to be installed at a later date.

Planning ahead for this number of EV ready parking spots will allow for a scalable solution and permit the property owner or tenant to cost effectively add charging stations as more EVs arrive.

Calculating Electrical Load

- To assess electrical service requirements, calculate the kVA load of all planned EV charging stations to be installed (now and in the future).
- The utility service must accommodate the total kVA load of all charging stations.
- It is more cost effective on a per port basis to upgrade electrical service and account for future demand as part of the initial construction project.

Scenario:

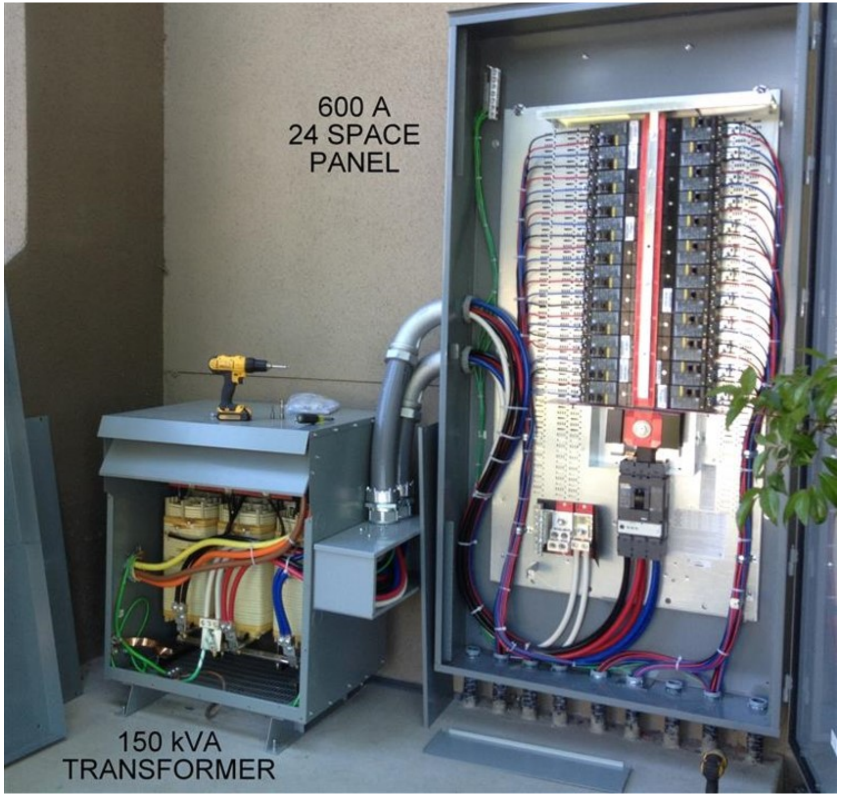
- There are 300 total parking spaces and you wish to have 10% of the parking spaces made EV charging station ready, with 5% of the spaces to have EV charging stations installed immediately. The remaining 5% of spaces will be available for EV charging stations to be installed at a later date.
  - To assess the immediate impact to electrical service, 5% of spaces (15) will have an EV charging station installed.
  - For 208 V/30 A electrical service, use kVA load of 6.2 for each parking space. For 15 parking spaces, the load will therefore be 93 kVA.
  - To assess the long-term impact to electrical service, 10% of spaces (30) in total will have EV charging stations installed.
  - For 208 V/30 A electrical service at 30 parking spaces, the load will be 186 kVA.

Electrical Panel Considerations

For new construction, install an electrical panel that accommodates all make-ready spots so that upgrades are not required as demand grows and new stations are installed.

- A 225 A electrical panel fed by a three-phase electrical service may accommodate up to seven EV charging ports, and a 400 A electrical panel fed by a three-phase electrical service may accommodate up to 15 EV charging ports.
- This assumes that the panel capacity is subject to continuous load requirements.

In retrofit environments, consider using existing electrical panel capacity for an initial small number of make-ready EV parking spaces, and compare costs associated with adding an electrical panel dedicated for EV charging.



Electrical Panel Example

Level 2 charging stations are considered continuous load devices (EVs draw maximum load for long durations), so the circuits must be sized to 125% of the load in accordance with the National Electrical Code. This means that for a maximum 30 A output to an EV, 40 A breakers are required.

The wiring must be sized in accordance with the NEC, typically 6 AWG or 8 AWG wire depending upon distance or voltage drop between the electrical panel and charging station.

Dedicated EV Panel	Breaker Size	EV Circuit	Max # Make-Ready EV Spaces
Three-phase 225 A	40 A	30 A / 208 V	7
Three-phase 400 A	40 A	30 A / 208 V	15
Three-phase 600 A	40 A	30 A / 208 V	22

Electrical Considerations: NEC and Article 625

The National Electrical Code, NEC, is adopted by all 50 states and is the relevant code that covers the installation and inspection of EVSE. The NEC is part of the National Fire Protection Association. Be sure to check the edition adopted by your AHJ.

NEC Article 625 covers the wires and equipment used to supply electricity for charging an electric vehicle.

Planning: Site Assessment and Selection Considerations

The “Electric Vehicle Charging Station Guidebook” identifies the following considerations:

Proximity to Power Source

The proximity of adequate power is a major cost variable of an EVSE installation. The closer the station is to a service panel, the better. A site assessment looks at the available space within the service panel. Dedicated circuits are required for the EVSE and a complete site assessment will determine the available space within the service panel.

Potential Trenching

A location that requires more trenching and conduit from the electrical panel will result in higher installation costs. Digging up and replacing landscaping can increase the cost of installation. If trenching goes through asphalt or concrete, the installation costs increase further.

Lighting and Security

The site should be assessed for lighting and security. If none is available, factor in the cost of providing lighting and possibly shelter where deemed necessary for the safety, comfort and convenience of EVSE users. EVSE users may require light to read signs and instructions, and to operate the EVSE easily.

Pooled Water and Irrigation

EVSE users will be more comfortable in locations with level ground not subject to pooling water irrigation system spray.

Planning: Site Assessment and Selection Considerations

The “Electric Vehicle Charging Station Guidebook” identifies the following considerations:

<u>Visibility and Signage</u>

Although high visibility is the goal for most commercial and municipal EVSE owners, often the most visible sites are not affordable. Proper and adequate signage should clearly direct drivers to the charging stations.

General service

- Direct EV drivers from a major highway to charging station location
- Locate chargers within a complex like a parking garage

Regulatory

- Restrict use of parking space to the charging of electric vehicles
- Inform drivers about time duration and permissible days of the week

Planning: Site Assessment and Selection Considerations

The “Electric Vehicle Charging Station Guidebook” identifies the following considerations:

Length of Parking Spaces

When surveying existing parking spaces, if there is a difference in their length, longer parking spaces will allow for greater room to fit a charging station. The additional length will maintain usability and limit the risk of vehicle impact. The installation of the charging station should not shorten parking spaces to below minimum local zoning requirements.

Width of Parking Spaces

Wider parking spaces allow for movement around the vehicle and decrease the risk of a cord set being damaged if it lies to the side of the PEV, connected or otherwise. They provide space for the proper operation of the charging station and plugging the PEV in should the charge port be located in the side of the vehicle rather than the front or back. Longer and wider spaces are simply more convenient but not necessary. Standard parking space dimensions will be adequate for charging station operation.

Proximity to Building Entrance

In locations where PEV charging is being used as an incentive, such as retail locations and the workplace, it is ideal to have some charging stations close to the building entrance and other stations at a different location to prevent misuse of parking without charging.

Planning: Site Assessment and Selection Considerations

Avoiding Hazards

Cords and wires associated with EVSE should not interfere with pedestrian traffic or present tripping hazards and should utilize a cord management system. For example, the EVSE can be placed at a curbside. PEV charging spaces should not be located near potentially hazardous areas. (Smith and Castellano)

Aesthetics and Usability

Businesses trying to portray a positive image to customers may want the area around their charging stations to be aesthetically pleasing. Some people may choose to use existing landscaping or walls to screen equipment from view. When installing new landscaping, keep root systems in mind when locating near stations. Hiding conduit is more visually appealing, but also more expensive. Avoid having people walk through or stand in mud or gravel, or pooling water. (Smith and Castellano)

Planning: Site Assessment and Selection Considerations

Accessibility

Evaluate and address requirements for complying with the Americans with Disabilities Act, as well as state, local and organizational accessibility policies. ADA compliance can require special curb cutouts, van accessible parking spaces, level parking spaces and specific connector heights, which all affect the design and cost of the project. ADA requires public parking to be accessible by people in wheelchairs or with mobility impairments. The U.S. Access Board establishes accessibility standards for public facilities, such as parking areas and fueling stations, but has not yet taken action on specific ADA requirements for EV charging stations. As accessibility code is updated, facilities are generally required to upgrade to the current standard. It may be more cost effective to be proactive and provide accessible charging stations to reduce legal liability, prevent costly retrofits in the future and be inclusive to drivers with mobility impairments.

★ Please remember the **exam password PANEL**. You will be required to enter it in order to proceed with the online examination.

Planning: Perpendicular vs. Parallel Parking

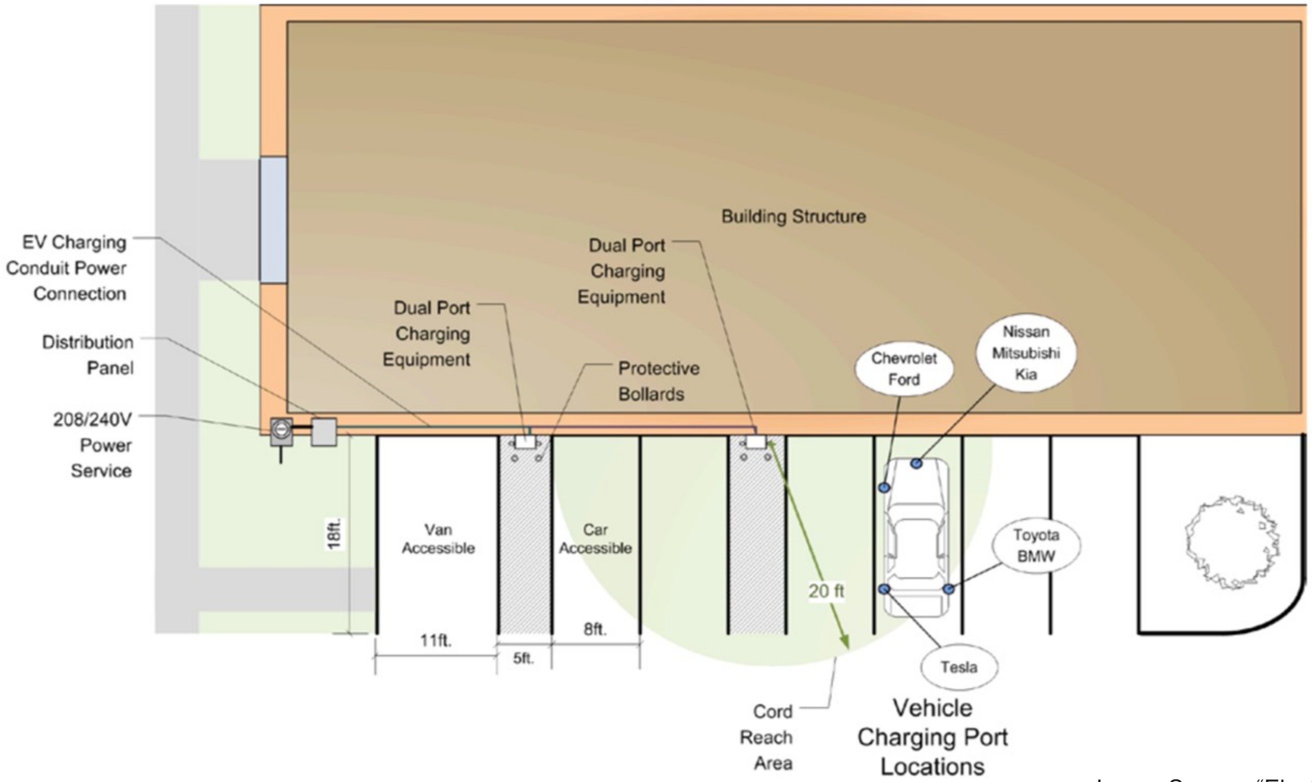
The "Electric Vehicle Charging Station Guidebook" states charging stations for perpendicular parking is generally the best option, and most workplace and public EV charging stations will be located in parking lots with perpendicular parking.

- Bollard and pole- or pedestal-mount works best in carports/driveways, parking lots and on-street parking locations.
- Wall-mount works best where a wall or pole exists or can be installed at reasonable cost and while maintaining site guidelines.
- Ceiling-mount is less common and works best in residential and parking garages or in any location where a sturdy overhead structure can be installed at low cost and within site guidelines.

Although there are suitable locations for EV charging along roads and highways where parallel parking exists or could be added, locating charging stations along the roadside that require parallel parking has drawbacks.

- Vehicle charging ports are in various locations and the cord may not reach the port, or the cord may not access multiple spaces.
- There are safety issues for drivers if the car port is in the side of the vehicle exposed to traffic.
- There are safety issues if the cord lies on the street.
- Highway maintenance may affect accessibility or damage the conduit.

Wall-Mount Scenario



This configuration can serve several parking spaces by allowing drivers to park in the appropriate spaces or back in as necessary to provide access to the vehicle charging port.

Image Source: "Electric Vehicle Charging Station Guidebook"
http://www.driveelectricvt.com/docs/default-source/default-document-library/electric-vehicle-charging-station-guidebook-.pdf?sfvrsn=0

Pole- or Pedestal-Mount Scenario

This configuration can serve several parking spaces depending on the length of the charging cord and the port locations.

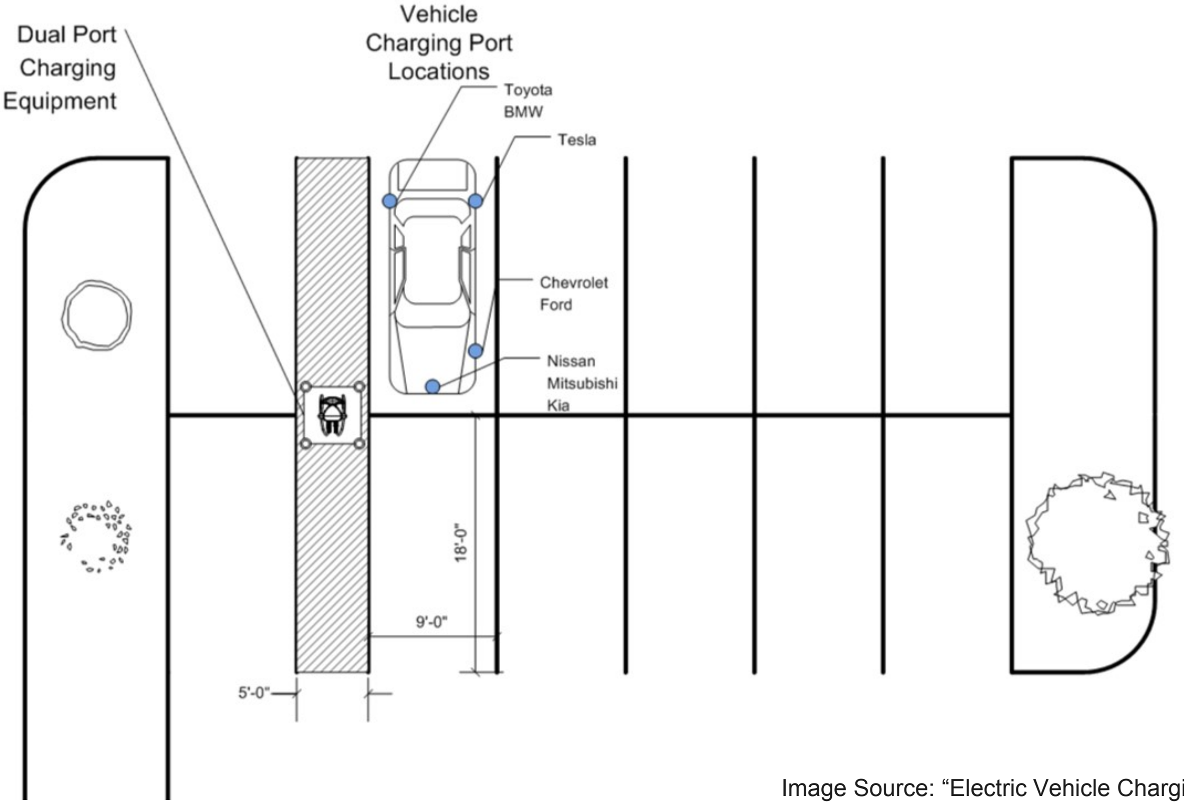


Image Source: "Electric Vehicle Charging Station Guidebook"
http://www.driveelectricvt.com/docs/default-source/default-document-library/electric-vehicle-charging-station-guidebook-.pdf?sfvrsn=0

Permitting and Inspection

Permitting costs vary by geographic location and level of government. The local AHJ requires permits and inspections for commercial electrical upgrades.

Some local governments are working to streamline the permitting process as electric vehicle adoption increases. In addition to the permit fee charged by the AHJ, there may also be a cost for the contractor's time spent to obtain the permit.

Contact and engage the AHJ (e.g., permitting agencies, fire marshals and zoning boards) at the beginning of the project to ensure that the various requirements and the relevant permitting costs are understood.

Charging Station Installation

Types of Installation Costs and Cost Drivers

According to the Department of Energy (Smith and Castellano), the most common installation costs are:

- Materials
- Labor
- Electrical service upgrades
- Trenching or boring
- Repaving/repairing parking lots and walkways
- Permits
- Signage and restriping

An installation becomes more expensive when:

- Trenching or boring a long distance from the electrical panel to the charging location
- Upgrading the electrical panel to create dedicated circuits for each EVSE unit
- Upgrading the electrical service to provide sufficient electrical capacity to the site

For Level 2 commercial EVSE, the installation cost breakdown is approximately:

- Labor: 55–60%
- Materials: 30–35%
- Permits: 1–5%
- Tax: 5%

(Alexander)

Trenching and Conduit

"Costs Associated With Non-Residential Electric Vehicle Supply Equipment" outlines electrical considerations associated with trenching and conduit. The EVSE unit is connected to the electrical service by wiring enclosed in an electrical conduit. A surface-mounted conduit can be placed along a wall or ceiling. If the conduit needs to run underground, such as in a parking lot, contractors will trench or bore a path for the conduit. When trenching is required, contractors will dig the trench, lay the conduit and then back-fill the trenched area. If a site host anticipates installing more EVSE in the future, it is more cost effective to install conduit from the electrical panel to future EVSE locations while the ground is already trenched for the initial EVSE installation. Future EVSE installations would simply require running wire through the existing conduit and setting the EVSE unit.

The total cost of trenching is affected by:

- Type of material being trenched (concrete vs. soil)
- Labor costs
- Distance traversed
- Asphalt replacement (if needed)
- Re-landscaping (if needed)
- Temporary closing of roads or parking lots

For some sites, directional boring may be a more cost effective method for installing the conduit. Whereas trenching opens the ground from above to dig a path, boring opens tunnels underneath the surface. Since boring is less invasive, there are fewer costs for disposing of removed concrete and restoring the surface to its original appearance. It also has the added benefit of not disturbing the flow of traffic above ground.

Foundations

Some pedestal mounted charging stations are directly installed on an existing hard surface such as a sidewalk. Others will require a concrete foundation as part of the installation process. Foundations range in complexity from anchors into existing concrete to pouring a base. Hole depth, and therefore the amount of concrete needed, depends on the depth to which the groundwater in soil can freeze. (Smith and Castellano)

Trenching

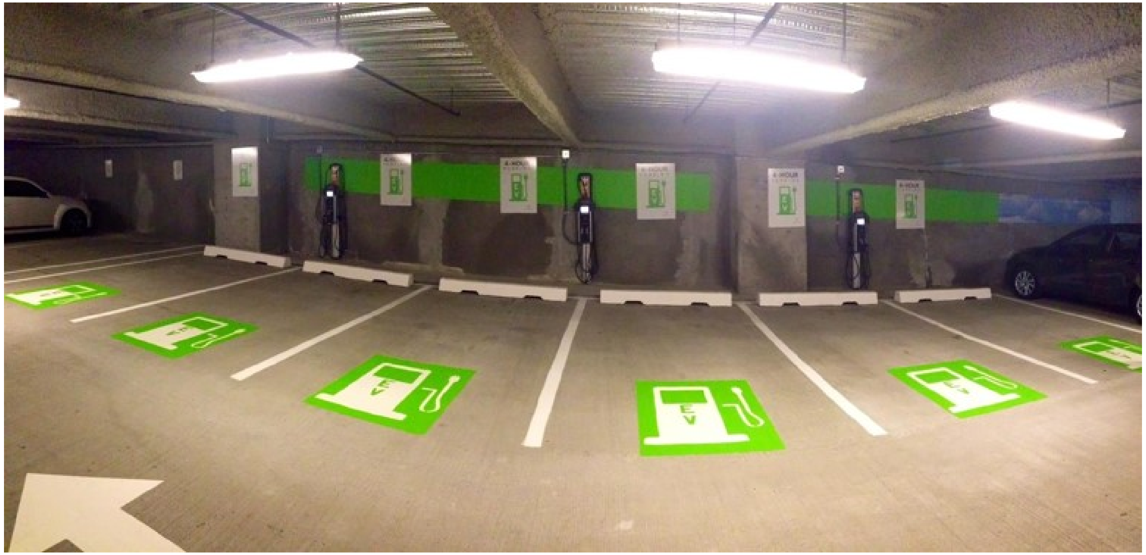
Pouring the pad

Slurry fill

Protection

It’s important to install bollards or wheel stops to protect the charging stations from damage by cars. Bollards should be installed in a way that does not interfere with station and cable operation.

Bollards



Wheel stops

Best Practices for Installation

- Locate near power source to reduce installation costs by minimizing the need and distance to trench through concrete or pavement and reduce the amount of renovation required to extend electrical conduits
- Plan for dual port stations as the installation cost is shared between both ports
- Consider a wall-mount station because surface conduit tends to be less expensive than trenched conduit
- Consider make-ready items for anticipated EV charger needs
  - Empty conduit sized for the future
  - Panel capacity
  - Upgrade electrical service
  - Trenching and laying the conduit

Don't:

- Choose a location where the cord will cross a walkway
- Choose a location where the cord will cross another parking space
- Forget about ADA compliance

Summary

Summary

- Offering EV charging is a great way to attract and retain shoppers, visitors, tenants and employees. It can also help a business stand out from the competition, while achieving sustainability goals and the potential to generate revenue.
- Consumer awareness is a driving factor in EV sales. Given that electric vehicles can help increase energy security, improve fuel economy, lower fuel costs and reduce emissions, more and more consumers will expect EV charging.
- AC Level 1 and AC Level 2 charging provide alternating current to the vehicle, with the vehicle's onboard charger converting AC to the direct current (DC) needed to charge the batteries. DC fast charging provides DC electricity directly to the vehicle battery. Charging times range from less than 20 minutes to 20 hours or more, based on the type or level of EVSE; the type of battery, its capacity and how depleted it is; and the size of the vehicle's internal charger.
- Networked stations provide enhanced services for owners and drivers by offering ports to charge EVs, controlling access, recovering costs, indicating station availability, scaling to demand and providing 24/7 driver support.
- Planning, including site assessment and selection considerations, and assessing electrical needs and availability, is critical for a functional, aesthetically pleasing and cost effective installation that can meet present and future needs.

Resources

Alexander, M., EPRI Project Manager. “Electric Vehicle Supply Equipment Installed Cost Analysis.” Electric Power Research Institute. 3002000577, Final Report, Rev. Oct. 2014.

“CALGreen (Part 11 of Title 24).” *CA.gov.* State of California, n.d. http://www.bsc.ca.gov/Home/CALGreen.aspx Accessed November 2015.

Community Energy Association. “Planning for Electric Vehicle Charging Infrastructure: A Toolkit.” *Plug-in BC.* BC Hydro, June, 2013. Web. http://pluginbc.ca/resource/planning-electric-vehicle-charging-infrastructure-toolkit/ Accessed November 2015.

“Electric Vehicle Chargers.” *City of Sunnyvale California*. City of Sunnyvale, California, April 2013. Web. http://sunnyvale.ca.gov/Portals/0/Sunnyvale/CDD/Residential/Electrical%20Car%20Chargers.pdf Accessed November 2015.

“Electric Vehicle Charging Station Guidebook: Planning for Installation and Operation.” *Drive Electric Vermont*. Chittenden County RPC. Vermont Energy Investment Corporation, June, 2014. Web. http://www.driveelectricvt.com/docs/default-source/default-document-library/electric-vehicle-charging-station-guidebook-.pdf Accessed November 2015.

“Emissions from Hybrid and Plug-In Electric Vehicles.” *Alternative Fuels Data Center.* U.S. Department of Energy, Sept. 18, 2015. Web. http://www.afdc.energy.gov/vehicles/electric_emissions.php Accessed November 2015.

“Fuel Economy.” *Fuel Economy*. U.S. Department of Energy, n.d. Web. http://fueleconomy.gov Accessed November 2015.

“Installation Guide for Electric Vehicle Supply Equipment (EVSE): An Introduction to EVSE.” *Mass.gov.* The Massachusetts Department of Energy Resources, June, 2014. Web. http://www.mass.gov/eea/docs/doer/alternative-fuels/ev-manual-mass-32011.pdf Accessed November 2015.

Resources

"LEED Credit Library." *USGBC.* U.S. Green Building Council, n.d. Web. http://www.usgbc.org/credits Accessed February 2016.

"Pasadena On-Line Zoning Code, Title 17: Article 4—Site Planning and General Development Standards." *City of Pasadena.* City of Pasadena, n.d. Web. http://ww2.cityofpasadena.net/councilagendas/2005%20agendas/Jan_10_05/9A2%20ARTICLE%204%20PART%201.pdf Accessed November 2015.

"Plug-In Electric Vehicle Handbook for Electrical Contractors." *AFDC.* DOE/GO-102012-3276. *Alternative Fuels Data Center.* U.S. Department of Energy, National Renewable Energy Laboratory (NREL), April, 2012. Web. http://www.afdc.energy.gov/pdfs/51228.pdf Accessed November 2015.

Smith, Margaret and Jonathan Castellano, New West Technologies. "Costs Associated With Non-Residential Electric Vehicle Supply Equipment." *AFDC.* DOE/EE-1289. Alternative Fuels Data Center. U.S. Department of Energy, November, 2015. Web. http://www.afdc.energy.gov/uploads/publication/evse_cost_report_2015.pdf Accessed November 2015.

Tillemann, Levi. ed. "eGallon and Electric Vehicle Sales: The Big Picture." *Energy.gov*. U.S. Department of Energy, Aug. 19, 2013. Web. http://energy.gov/articles/egallon-and-electric-vehicle-sales-big-picture Accessed November 2015.

Wilson, Matt. "Cupertino Buildings Prepare for Electric-vehicle Charging Stations." *The Mercury News.* San Jose Mercury News, Digital First Media, Mar.13, 2014. Web. http://www.mercurynews.com/my-town/ci_25331708/cupertino-buildings-prepare-electric-vehicle-charging-stations Accessed November 2015.

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