

Electric Vehicle Charger Selection Guide



1 Background

The Redwood Coast Energy Authority (RCEA) developed this guide as the result of an Electric Vehicle (EV) Readiness Implementation grant funded by the California Energy Commission (CEC). The goal of this guide is to help site hosts and others learn about, evaluate and compare the features of EV charging equipment (available as of November 2016) to assist them in selecting the charger for their application.

In a prior project, RCEA conducted an Electric Vehicle Charger (EVC) selection process in partnership with the CEC's Alternative and Renewable Fuels and Vehicle Technology Program. The project team identified EV chargers available on the market and developed a rubric to objectively compare cost, performance and design metrics. The team then contacted manufacturers and obtained product information, evaluated criteria, and assessed available EV charger models.

The first section in this guide provides an overview of EVC equipment, how it works, and considerations in making a purchase. The next section includes a table of EVC features available from domestic manufacturers. To gather this information, RCEA sent out specification sheets of predetermined criteria to EVC manufacturers and requested an email response with completed specifications for current 208/240 V charger models. Additional information, including 480 V chargers, was collected using publically available technical specifications. As funding allows, the table will be updated periodically to include new models and specifications as product offerings evolve.

1.1 Selecting an EVC: Making Choices

While there are many different chargers to choose from, answering a few questions about what you need in an EVC can make the decision easier:

1. What type of charging do you want to provide?
2. Do you want a networked charger or a stand-alone charger?
3. Do you wish to charge for access to an EVC? What costs are you willing to incur?

This section will provide some background information to help answer these questions, as well as providing some approximate costs associated with installing EVCs.

1.2 Types of EV Charging

Chargers are generally classified in terms of the power they can provide, designated as "levels":

- A Level 1 EVC uses a standard 120 volt outlet, usually taking between 8-20 hours to fully charge a PEV.
- A Level 2 EVC uses a 208/240 volt electric circuit, usually taking 4-8 hours to fully charge a PEV.

There are several names to describe equipment that charges electric vehicles. Most literature uses the term "Electric Vehicle Supply Equipment," or EVSE.

This guide uses "Electric Vehicle Charger," or EVC, as it describes the function more clearly: a device providing power to charge an electric vehicle.

See the end of this guide for a glossary of common electric vehicle charging terms.

- A Level 3 EVC uses a 480 volt electric circuit, usually taking 20 minutes to reach 80% charge. Once at 80% charge, Level 3 chargers reduce power to supply the remaining charge in order to prevent damage to the battery.

The charge times will vary depending on the PEV and the battery capacity. More information is provided in the Glossary section of this guide. The different charging levels serve different consumer needs: fast chargers best suit long-distance trips where time is a premium, while slower chargers work best at locations where people will be parked for long periods. The charging pyramid (Figure 1) illustrates charging levels, their typical charge time, and approximate cost.

Chargers are also classified by the kind of connector on the charging cord. There are currently two competing standards: J1772, developed by SAE International, and CHAdeMO, developed by an organization of the same name. The connector inlets can be seen in Figure 2. Tesla also has a proprietary connector for their charging stations, exclusively available to Tesla drivers. In the US, CHAdeMO charging comprises the largest share of Level 3 stations, while J1772 is the main standard for Level 1 and Level 2 charging, with a smaller share of Level 3 charging.

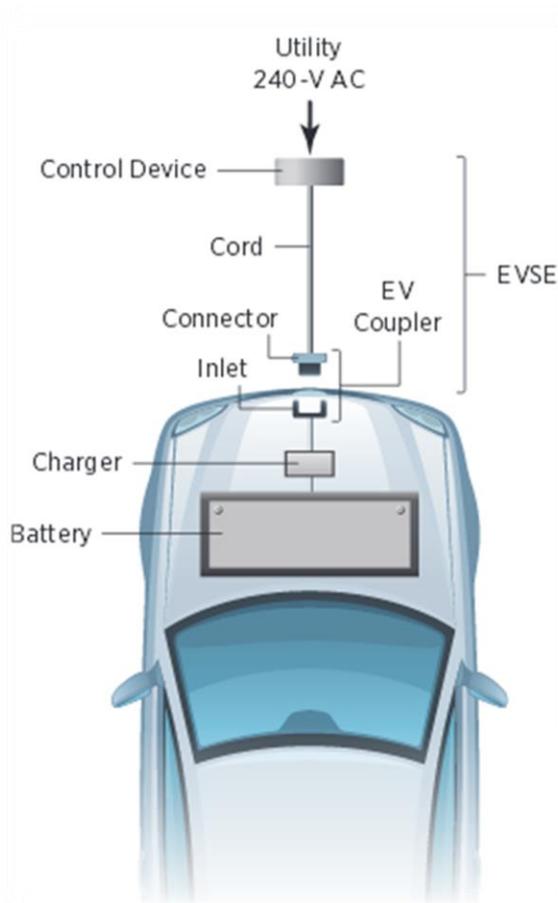
It is important to note that not every car will be able to take advantage of an EVC's full power. While external charging devices are commonly called "chargers" (including in this guide), they merely provide an electric current – the actual "charger" managing energy flow into the battery is inside the electric vehicle, as shown in Figure 2. Different vehicles will have different charging rates depending on the internal charger; some will not support Level 3 charging, and other chargers (particularly in older vehicle models) will have charging rates below the standard Level 2 rate.

The Charging Pyramid		
Level	Charge Time	Cost to Charge
L3	<i>Travel</i> 20 min	\$\$\$\$
L2/L3	<i>Public</i> 0.5 - 3 hours	\$\$\$
L1/L2	<i>Workplace</i> 4 - 8 hours	\$\$
L1/L2	<i>Residential</i> 8 - 10 hours	\$

Level 1	Level 2	Level 3
		
<ul style="list-style-type: none"> • 120 Volts, 12-16 A • 2-5 miles of range per hour of charge • Plug in to any standard outlet 	<ul style="list-style-type: none"> • 208/240 Volts, up to 80 Amps • 10-20 miles of range per hour of charge • Typical equipment cost \$1,000 - \$7,000 	<ul style="list-style-type: none"> • 208-600 VDC, up to 200 A • 60-80 miles of range per hour of charge • Typical installed cost \$20,000 - \$100,000

Charging pyramid courtesy of: Zero-Emission Vehicles in California: COMMUNITY READINESS GUIDEBOOK, accessible at http://opr.ca.gov/docs/ZEV_Guidebook.pdf. Photo credits for Level 1, Level 2, and Level 3 are P1, P2, and P3, in section 6.1, respectively.

Figure 1: Comparison of charging levels, time, and typical installation cost



CHAdeMO Level 3 receptacle (left) and Level 1 and Level 2 J1772 standard receptacle (right). Source used with permission from: <http://www.afdc.energy.gov/pdfs/51227.pdf>

Level 2 charging schematic. In this diagram, EVSE means the same as EVC. Source used with permission from: <http://www.afdc.energy.gov/pdfs/51227.pdf>

Figure 2: EVC schematic and connector inlet image

One of the largest factors in determining the type of charging to provide is cost. While maintenance and accessory costs can be significant (and will be explored in more detail in Section 1.4), equipment and installation are the largest cost components, and vary the most between different level chargers. Level 2 charging equipment, the most common for public charging, ranges from \$1,000 to \$7,000, depending on features. Incentives can help reduce the upfront cost; for example, the EV infrastructure tax credit for an EVC in 2016 is 30% up to \$1,000 for consumers, and 30% up to \$30,000 for businesses. Some states provide EVC and battery-only electric vehicle (BEV) incentives: Oregon has an EVC tax credit for 50% of the project cost up to \$750. Other options include credits or incentives for organizations, alternative energy sources, and leased facilities.

Installation costs are highly variable: the type of site host, wiring, number of circuits and EVC units being installed, and trenching are all key factors unique to each installation. The cost for other components, such as EVC parking spot signs and wheel stops, will also vary depending on state requirements and shipping costs. Overall, the installation, maintenance, and equipment costs for a Level 2 station could range from \$12,000 - \$20,000. With more expensive equipment and more demanding electric service, Level 3 charging stations are typically at least 2-3 times the cost of a Level 2 station.

1.3 Stand-Alone vs. Networked Chargers

A service network provides oversight and services to support a system of EVCs. Services are available to EV drivers as well as site hosts or network administrators, with different fee structures aimed at each. The simplest EVCs, frequently referred to as stand-alone or “dumb” chargers, do not have network access – they are essentially electrical outlets with circuitry to enable communication and safe charging with the vehicle, as outlined in Figure 3. Without network access, stand-alone chargers cannot process payment, and are generally reserved for residential or fleet applications.

An EVC network adds a variety of capabilities. For drivers, services may include payment options, station location and availability, and options such as reservations, messaging, and summary reports. Site host services include payment management, customer support, station status, data reporting, and typically access to a network “dashboard”.

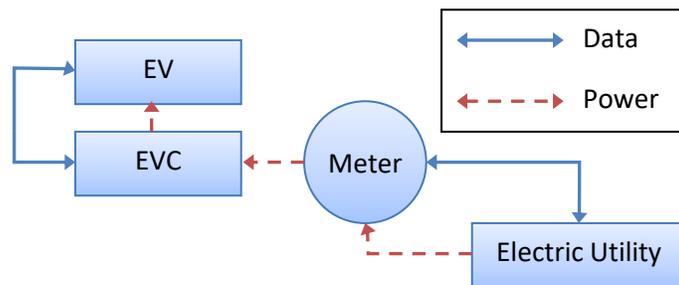


Figure 3: EVC Stand-alone ("dumb-charger") configuration

EVC selection is a balance between the preferred ownership model and realistic availability of services at the desired location. Stand-alone chargers

have lower installation costs, simpler designs, and no recurring fees for features such as payment processing and cloud connectivity. They may also be the only viable option in locations with poor cell reception, or at low-use sites where network fees would likely exceed the cost of allowing free access. Conversely, networked EVCs allow for payment options, notification of charging station status, and provide remote diagnostic capabilities.

For those who wish to install a networked charger, service networks generally fall into two categories:

- Subscription access: users subscribe to the service network, which typically establishes an initial deposit and either manual or automatic deposits to keep a payment account active. Users then connect their vehicles and use a dedicated RFID card or smart phone app to initiate a charging session and have fees deducted from their account. These models may include a subscription fee, charging session fees, incremental fee based on the amount of electricity consumed, or some combination of fees.
- Open access: these service networks provide a dedicated subscription, but also accept universal payment methods such as credit cards. **In California, all publically available charging stations must be open access:** California Health and Safety Code Section 44268.2 states that public charging station customers “shall not be required to pay a subscription fee in order to use the station, and shall not be required to obtain membership in any club, association, or organization as a condition of using the station.” The specification tables in Section 2 of this guide explicitly state which charging stations are open access.

Networked chargers include several components beyond conventional charging hardware to enable the interchange of money and data, as well as data connections beyond the utility (Figure 4). These additional components/connections include:

- Communication: cell service or Internet connection to provide access to the cloud for data exchange.
- Network administrator: dedicated staff to routinely monitor station status, issue repair requests, track station usage, and maintain onsite hardware and software.
- Manufacturer or Network Service Center: central hub or operations center for all networked charging stations to provide customer support, manage data communication and reporting, monitor station status, and perform remote diagnosis and system updates.
- Transaction processor: Third-party group to manage financial transactions between EVC customers and financial institutions.
- Bank: financial institute that manages customer funds and releases payment for charging sessions and subscription account deposits.

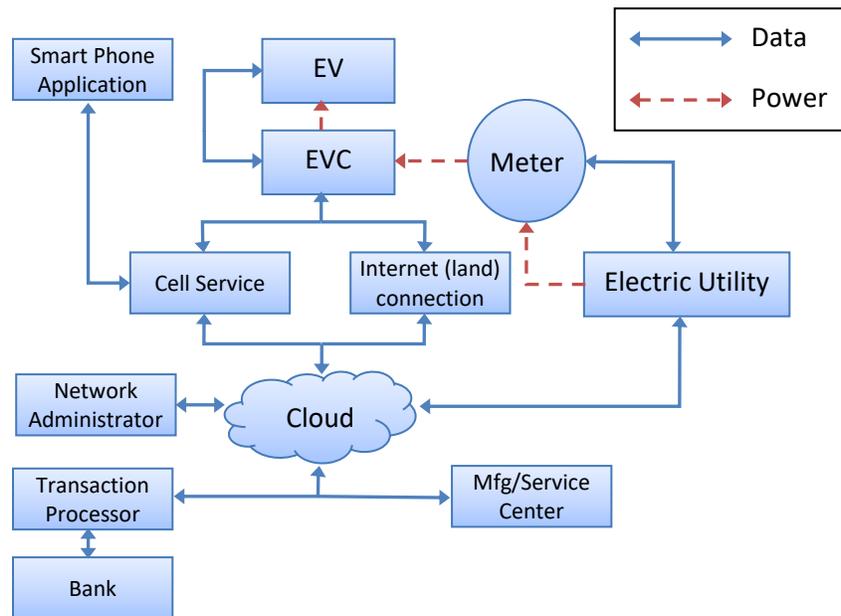


Figure 4: EVC Network with payment capability

Networks also provide a variety of customer dashboards for site hosts to monitor their site and obtain information about station status, usage patterns, revenue, greenhouse gas savings, and other details, as illustrated in Figure 5.

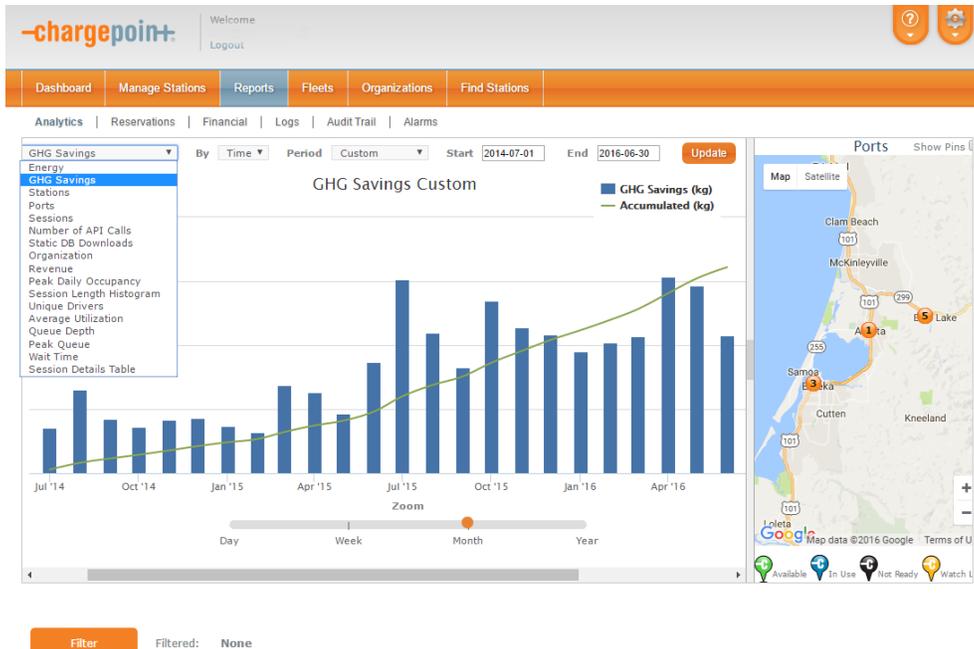


Figure 5: Example of a network dashboard

To reduce inconvenience for drivers, various manufacturers are working to create ways to allow drivers to use a single service to access other “out of network” EVCs. One such system is called the Open Charge Point Protocol (OCPP). When it is fully implemented, it is expected to operate similarly to the way that banks provide access to each other’s customers with automatic teller machines (ATMs).

From a site host point of view, unless it is a workplace installation or similar ownership model, a charging station is primarily operated through a network management team and associated software. Most EVCs are connected by default to a service network by manufacturers to support their own diagnostic and customer support requirements. The site offerings and user experience will vary depending on location, cell or network access, and more. There are also cases in which the service network and site host both manage and maintain the charging station network.

1.4 Owner and Customer Payment

For many, the most important criterion in selecting an EVC is cost. While the equipment costs are generally straightforward, ongoing operational costs can be more complicated. Depending on the complexity of the network and business model, site owners may face multiple fees for different network components. For example, a location may include a monthly cell service fee, monthly utility meter fee, electric bill, and service network subscription. Some networks may bundle these fees into a per-charging session fee, either as a flat rate or as a portion of the total session cost. While not every charger will have the same fees, any installation will incur some of the costs below:

Energy price

All chargers will require the station owner to purchase energy. This includes both the per-kWh charge for electricity directly used by the charger, and potential demand charges if the charger increases your peak demand.

High-cost scenario: The lowest power chargers draw approximately 2 kW of power – unlikely to increase a demand charge, but could potentially use 48 kWh (about 2 full vehicle charges) per day. DC fast chargers require 50 kW of power, potentially using 1200 kWh (about 48 full vehicle charges) and are more likely to incur demand charges.

Networking fees

If you wish to purchase a smart charger, most will require subscription fees to access the network. Network subscriptions are typically on an annual or multi-year basis.

High-cost scenario: While prices will vary depending on the network, typical charges are between \$250-300/charging port/year. A bank of 5 dual-port chargers would cost approximately \$3,000/ year.

Credit card processing fees

While most charger networks include a network-only payment card free of fees, most smart chargers will still accept credit cards (and the subsequent processing fees) in order to be accessible to the largest portion of the market. Some networks will handle all financial transaction for you, paying the processing fees themselves – and generally offsetting the cost in the network fee structure. If the network does not cover processing fees, you will be responsible – such fees are typically a small percentage of the total transaction value.

High-cost scenario: Profits from charger transactions will be a few percentage points less

Maintenance costs

Though actual charger upkeep can be minimal depending on the complexity of the equipment, repairing broken chargers could prove costly if not under warranty. For most, the warranty price will be the majority of the maintenance cost. Warranty pricing will differ based on the equipment and terms of coverage - some provide renewable warranties, others are fixed-term. Some manufacturers will include the warranty price in the equipment cost.

High-cost scenario: Annual extended warranties for DC fast chargers can cost over \$800/charger/year. Less powerful chargers may have a fixed length warranty for half as much, but will leave you responsible for repair charges after the term is over.

For those looking to generate revenue from an EVC, most networks allow site owners to set their own pricing scales. Pricing is typically based on the amount of energy charged (similar to a utility bill), the time spent using the charger (similar to a parking meter), or as a flat per-charging-session fee. The fee structure you choose will have consequences for the driver. For example, a flat per-session fee will benefit those who can charge the most energy per session – either with longer charge sessions or with

fast charger capability. Time-based fees benefit those who charge at a fast rate. Service networks may also support custom pricing strategies, such as including a time-based “parking meter” rates in addition to the charging fees to encourage people to move their vehicles once charging is complete. Customer payment typically involves using an RFID card obtained through registering with a network, or a credit card.

2 EV Charger Specifications

Once you’ve determined your specific EVC needs, you need to investigate the available options. Based on the EVC selection process finalized by RCEA and the CEC’s Alternative and Renewable Fuels and Vehicle Technology Program for a previous grant, the most important criteria to consider are:

1. Theft deterrence features
2. Credit card reader type
3. Commercial maturity
4. Standard warranty length
5. Highest rating (in kW) available per plug
6. Dual plug with high power capability option

Prioritization of equipment features will also differ from site host to site host, and these criteria are not the only important criteria. The specifications table in Section 2.1 of this guide breaks down different categories based on Hardware (electrical and mechanical), Management Software, Payment System, and Manufacturer Information:

- Hardware - Electrical
 - *Number Charging Ports/Type*: The number of EVs that can charge simultaneously, and the connector type (e.g. J1772, CHAdeMO, see Figure 2 for examples)
 - *Input Power*: Power circuit required to support the charger
 - *Output Power*: Maximum power deliverable to an electric vehicle. Given as a kW rating, and as an estimated miles of range added per hour of charging time.
 - *Cross Vendor Software Compatibility*: Can this charger use other manufacturer’s software?
 - *Operating Conditions*: Temperature and humidity operating limits¹
- Hardware - Mechanical
 - *Mounting*: Either pedestal or wall.

¹ Not usually an issue outside of extreme climates.

- *Pedestal*: Hard-wired to a permanent pole or box. Typically mounted on a sidewalk or a concrete base.
 - *Wall*: Either hard-wired or temporarily wired to an existing wall. Typically includes a mounting plate.
 - *Cable*: Cable management strategy (e.g. coil, retractable, etc.)
 - *Number of Charging Ports/Type*: The number of EVs that can charge simultaneously, and the connector type (e.g. J1772, CHAdeMO)
 - *Theft*: Systems available to prevent theft or vandalism
 - *Power Input Ratings*: Power circuit required to support charger
 - *Operating Conditions*: Temperature and humidity operating limits
- Management software:
 - *Network capable*: Can utilize networked management software.
 - *Remote management*: Can charger information and settings be accessed remotely?
 - *Cross Vendor Hardware Compatibility*: Can other chargers use this software?
 - *Network protocol*: Protocol for communication between EVC site host and an EVC network
 - *Demand Response Capability*: Ability to adjust power output in response to grid demand.
 - *Data reporting*: Available data generated by charger.
- Payment System:
 - *Open Access*: Can any customer charge (yes) or is a service subscription required (no)?
 - *Customer payment*: Possible customer payment methods.
 - *Price Setting Option*: Potential fee structures the owner can set.
 - *Owner payment*: Expected network and maintenance fees paid by station owner.
- Manufacturer/Certification Information:
 - *Listings*: Product testing certifications (e.g. UL, ETL, etc.).
 - *Accessibility Features*: Device features intended to increase access for handicapped users.
 - *First Entry to EVSE Market*: Date of first product the manufacturer released to the EVSE market.
 - *Installation Rating*: Product installation certifications (e.g. NEMA).

2.1 EVC Specification Tables

These tables give an overview of the various charging station equipment available as of November, 2016. Exact pricing and warranty will differ depending on the exact submodel and accessories included. While we have made every effort to ensure the information in these tables is accurate, they should not be considered a final authority on EVC specifications. For pricing and other detailed information, contact a sales representative. For images of the chargers, see Section 6.

Hardware - Electrical							
Manufacturer	Model	# Charging Ports/Type	Input Power	Output Power		Cross Vendor Software Compatibility	Operating conditions
				kW	miles range / hrs charging		
<i>Level 2 EVC</i>							
AeroVironment	TurboDock	1/J1772	208/240VAC; 16A	3.8 kW	13 miles range/hour	N/A	-40°F to 122°F
Blink	PE-30Kice	1/J1772	208/240VAC; 30A	7.2 kW	24 miles range/hour	No	-22°F to 122°F
BTC Power	Chargion	1-2/J1772	208/240VAC; 16A, 30A, 40A options	3.3 – 9.6 kW	11-32 miles range/hour	Greenlots SKY/OCPP compliant	-22°F to 122°F 90% RH non-condensing
ChargePoint	CT4000	1-2/J1772	208/240VAC; 40A circuit	7.2 kW (max)	24 miles range/hour	No	-22°F to 122°F 95% RH non-condensing
Clipper Creek	LCS / HCS / CS	1/J1772	208/240 VAC	2.88 – 19.2 kW	9.6-64 miles range/hour	CS models can use Liberty Plugins control system	Unknown
Efacec	Public	2/J1772	208/240 VAC 30 A / each output	7.2 kW	24 miles range/hour	Greenlots SKY OCPPv1.2, 1.5 and 1.6 compliant	-13°F to 122°F or -31°F to 122°F
EV Box	BusinessLine	1-2/J1772	1- or 3-phase, 230V – 400V, 16A and 32A	3.7 – 22 kW	12-73 miles range/hour	Greenlots SKY OCPPv1.2, 1.5 and 1.6 compliant	-22°F to 122°F 95% RH non-condensing
EVoCharge	30A EVoReel EVSE/iEVSE	1-2/J1772	208/240VAC; 40A	7.2 kW	24 miles range/hour	Customer can configure with any OCPP network	-22°F to 122°F 95% RH non-condensing
EVSE LLC	AutoCoil	1-2/J1772	208/240VAC; 30A	7.2 kW	24 miles range/hour	Greenlots SKY/OCPP compliant	-22°F to 122°F 95% RH non-condensing
GE	Durastation	1-2/J1772	208/240VAC; 40A	7.2 kW	24 miles range/hour	Not Specified	-22°F to 122°F 95% RH non-condensing
Juice Bar	Mini Bar	1-2/J1772, 1-2/120V connections	208/240VAC; 40A	7.2 kW	24 miles range/hour	Uses Greenlots SKY software	-22°F to 122°F
Millbank	PowerGen	1/J1772	208/240VAC	7.2 kW	24 miles range/hour	N/A	-22°F to 122°F
OPConnect	Mark II	1-2/J1772	208/240VAC; 30A per port	7.2 kW	24 miles range/hour	Yes	-22°F to 140°F 95% RH non-condensing
Schneider	EVlink Level 2	1-2/J1772	208/240VAC, 40A, 2 Pole Circuit Breaker	7.2 kW	24 miles range/hour	Chargepoint network (Level 2)/ Greenlots (DC Fast)	-22°F to 122°F 95% RH non-condensing

Hardware – Electrical, continued

Manufacturer	Model	# Charging Ports/Type	Input Power	Output Power		Cross Vendor Software Compatibility	Operating conditions
				kW	miles range / hrs charging		
Level 2 EVC							
SemaConnect	ChargePro™	1/J1772	208/240VAC; 30A	7.2 kW	24 miles range/hour	No	-22°F to 122°F 95% RH non-condensing
Shorepower Technologies	ePump	1-4/J1772	240VAC per connection port; up to 30A	7.2 kW	24 miles range/hour	Not Specified	-4°F to 140°F
Siemens	VersiCharge	1/J1772	208/240VAC; 40A circuit	1.8 – 7.2 kW	6-24 miles range/hour	Greenlots SKY OCPPv1.2, 1.5 and 1.6 compliant	-22°F to 122°F 95% RH non-condensing
Level 3 EVC							
ChargePoint	CPE200	1/CHAdEMO + 1/SAE CCS	480 VAC, 63A	50 kW	167 miles range/hour	No	-35°F to 120°F 95% RH non-condensing
EV Box	BusinessLine	1-2/J1772	3-phase, 400V, 32A	3.7 – 22 kW	12-73 miles range/hour	Greenlots SKY OCPPv1.2, 1.5 and 1.6 compliant	-22°F to 122°F 95% RH non-condensing
Schneider	EVlink DC Fast	1/CHAdEMO or 1/CHAdEMO + 1/SAE CCS	480VAC, 79A	50 kW max	167 miles range/hour	Chargepoint network (Level 2)/ Greenlots (DC Fast)	-22°F to 122°F 95% RH non-condensing

* - based on 30 kWh/100 mile fuel efficiency for standard 2016 Nissan Leaf, as reported at www.fueleconomy.gov. Reflects optimal driving conditions.

Hardware - Mechanical							
Manufacturer	Model	Mounting	Cable Management	# Charging Ports/Type	Theft Deterrence	Power Rating input(s)	Operating conditions
<i>Level 2 EVC</i>							
AeroVironment	TuboDock	Wall or Pedestal	Coil Rack	1/J1772	Not specified	208/240VAC; 16A	-40°F to 122°F
Blink	PE-30Kice	Wall or Pedestal	Coil Rack	1/J1772	Not specified	208/240VAC; 30A	-22°F to 122°F
BTC Power	Chargion	Wall or Pedestal	Coil Rack or Cord Retractor	1-2/J1772	Not specified	208/240VAC; 16A, 30A, 40A options	-22°F to 122°F 90% RH non-condensing
ChargePoint (charger by Leviton)	CT4000	Wall or Pedestal	Cable Hanger	1-2/J1772	Locking charger holster	208/240VAC; 40A circuit	-22°F to 122°F 95% RH non-condensing
Clipper Creek	LCS / HCS / CS	Wall or Pedestal	Cable Wrap	1/J1772	Lockable connector, HCS allows key-based access	208/240 VAC	Unknown
Efacec	Public	Wall or Pedestal	Coil Rack	2/J1772	Bolted to wall or pole mount	208/240 Vac 30 A / each output	-13°F to 122°F or -31°F to 122°F
EV Box	BusinessLine	Wall or Pedestal	Cable Hanger	1-2/J1772	Bolted to wall or pole mount	1-phase, 230V, 16A	-22°F to 122°F 95% RH non-condensing
EVoCharge	30A EVoReel EVSE/iEVSE	Wall or Pedestal	Retractable Reel with auto-rewind & lock features. Wall or Ceiling Mounted.	1-2/J1772	Tamper proof mounting fasteners	208/240VAC; 40A	-22°F to 122°F 95% RH non-condensing
EVSE LLC	AutoCoil	Wall or Pedestal	Retractable cable	1-2/J1772	Not specified	208/240VAC; 30A	-22°F to 122°F 95% RH non-condensing
GE	Durastation	Pedestal	Coil Rack	1-2/J1772	Not specified	208/240VAC; 40A	-22°F to 122°F 95% RH non-condensing
Juice Bar	Mini Bar	Wall or Pedestal	Coil and optional over head cord management system	1-2/J1772, 1-2/120 V connections	2 key secure lock for internal components	208/240VAC; 40A	-22°F to 122°F
Millbank	PowerGen	Wall or Pedestal	Cable wrap (wall) or storage (pedestal)	1/J1772	Pedestal has lockable component cabinet	208/240VAC	-22°F to 122°F
OPConnect	Mark II	Wall or Pedestal	Coil Rack	1-2/J1772	Integrated surveillance camera	208/240VAC; 30A per port	-22°F to 140°F 95% RH non-condensing

Hardware – Mechanical, continued

Manufacturer	Model	Mounting	Cable Management	# Charging Ports/Type	Theft Deterrence	Power Rating input(s)	Operating conditions
<i>Level 2 EVC</i>							
Schneider	EVlink Level 2	Wall or Pedestal	Coil Rack	1-2/J1772	Not specified	208/240VAC, 40A, 2 Pole Circuit Breaker	-22°F to 122°F 95% RH non-condensing
SemaConnect	ChargePro™	Wall or Pedestal	Coil Rack	1/J1772	Not specified	208/240VAC; 30A	-22°F to 122°F 95% RH non-condensing
Shorepower Technologies	ePump	Pedestal	Coil rack	1-4/J1772	Overcurrent & GFCI protection; car-to-cord safety detection; locking cord and access doors (optional)	240VAC per connection port; up to 30A	-4°F to 140°F
Siemens	VersiCharge	Pedestal	Cable Wrap	1/J1772	Charger locks to pedestal mount	208/240VAC; 40A circuit	-22°F to 122°F 95% RH non-condensing
<i>Level 3 EVC</i>							
ChargePoint	CPE200	Pedestal	Cable Hanger	1/CHAdEMO + 1/SAE CCS	Not specified	480 VAC, 63A	-35°F to 120°F 95% RH non-condensing
EV Box	BusinessLine	Wall or Pedestal	Cable Hanger	1-2/J1772	Bolted to wall or pole mount	3-phase, 400V, 32A	-22°F to 122°F 95% RH non-condensing
Schneider	EVlink DC Fast	Pedestal	Coil Rack	1/CHAdEMO or 1/CHAdEMO + 1/SAE CCS	Not specified	480VAC, 79A	-22°F to 122°F 95% RH non-condensing

Management Software							
Manufacturer	Model	Network-capable	Remote Management	Cross Vendor Hardware Compatibility	Network Protocol	Demand response capability	Data Reporting
Level 2 EVC							
AeroVironment	TurboDock	No	Yes; Bluetooth enabled	N/A	N/A	N/A	N/A
Blink	PE-30Kice	Yes	Yes	No	Proprietary	Yes	Yes
BTC Power	Chargion	Yes	Yes	Yes	OCPP	Yes	Yes
ChargePoint	CT4000	Yes	Yes	Yes	3G GSM, 3G CDMA	Not specified	Included
Clipper Creek	LCS / HCS / CS	CS only	CS only	N/A	N/A	N/A	N/A
Efacec	Public	Yes	Yes	N/A	OCPP	Yes, automated through OpenADR	Yes
EV Box	BusinessLine	Yes	Yes	N/A	OCPP	Yes, automated through OpenADR	Yes
EVoCharge	30A EVoReel EVSE/iEVSE	Yes, not mandatory	Yes via OCPP Network	N/A	OCPP via Cellular or CAT5	Capable (Optional)	Yes via OCPP Network
EVSE LLC	AutoCoil	Yes	Yes	N/A	OCPP	Yes	Yes
GE	Durastation	Yes, not mandatory	Yes	Not Specified	Not Specified	Not Specified	Yes
Juice Bar	Mini Bar	Yes, not mandatory	Yes	N/A	OCPP	Not specified	Usage data by session
Millbank	PowerGen	No	N/A	N/A	N/A	N/A	N/A
OPConnect	Mark II	Yes	Yes	Yes	OCPP/ApenADR	Yes	Yes
Schneider	EVlink Level 2	Yes, not mandatory	Yes	N/A	OCPP	Yes	Included
SemaConnect	ChargePro™	Yes, not mandatory	Yes	Not Specified	CDMA or GPRS cellular	Yes	Yes
Shorepower Technologies	ePump	Yes, not mandatory	Yes	Yes	OpenADR 2.0b	Yes, OpenADR 2.0b	Energy use data online
Siemens	VersiCharge	Yes	Yes	N/A	OCPP	Yes, automated through OpenADR	Yes
Level 3 EVC							
ChargePoint	CPE200	Yes	Yes	Yes	3G GSM, 3G CDMA	Not specified	Included
EV Box	BusinessLine	Yes	Yes	N/A	OCPP	Yes, automated through OpenADR	Yes
Schneider	EVlink DC Fast	Yes, not mandatory	Yes	N/A	OCPP	Yes	Included

Payment System					
Manufacturer	Model	Open Access	Customer Payment	Price Setting Option	Owner Payment
<i>Level 2 EVC</i>					
AeroVironment	TurboDock	Yes	N/A	N/A	N/A
Blink	PE-30Kice	Yes	Blink InCard, mobile app, and “800” number	Set by Blink network	Not Specified
BTC Power	Chargion	Yes	RFID or credit card	Price by duration, energy, or session. Time-variable pricing available.	Network fees, subscription plans available
ChargePoint	CT4000	Yes	Chargepoint or RFID card, “800” number	Price by duration, energy, or session. Time and user-variable pricing available.	Chargepoint network plan, fees by port. Various subscriptions lengths.
Clipper Creek	LCS / HCS / CS	Yes	Requires external device	N/A	CS may require Liberty Plugin subscription
Efacec	Public	Yes	RFID, mobile app, and call center	Price by duration, energy, or session. Time and user-variable pricing available.	Hardware maintenance and warranty bundled pricing available
EV Box	BusinessLine	Yes	RFID, mobile app, and call center	Price by duration, energy, or session. Time and user-variable pricing available.	Hardware maintenance and warranty bundled pricing available
EVoCharge	30A EVoReel EVSE/iEVSE	Yes	RFID and mobile app, optional magnetic stripe/chip based card, Google Wallet/Apple Pay	Price by duration, energy, or session. Time and user-variable pricing available.	Monthly and annual network options
EVSE LLC	AutoCoil	Yes	RFID and mobile app, optional magnetic stripe/chip based card	Price by duration, energy, or session. Time and user-variable pricing available.	Network fees, subscription plans available
GE	Durastation	Yes	Credit card, mobile app and PayPal.	Price by duration, energy, or session. Time and user-variable pricing available.	Choice of free network and yearly subscription
Juice Bar	Mini Bar	Yes	QR scan, mobile app, and “800” number available 24/7	Price by duration, energy, or session. Time and user-variable pricing available.	Some network fees, multi-year subscription discounts available
Millbank	PowerGen	Yes	N/A	N/A	N/A
OPConnect	Mark II	Yes	Major credit cards, OPConnect card, Wright Express Fleet Card®, phone number or email based PIN, mobile app	Flexible	Network fees will vary
Schneider	EVlink Level 2	Yes	RFID, PayPal	Price by duration, energy, or session. Time and user-variable pricing available.	1, 2, and 3 year subscription plans

Payment System, continued					
Manufacturer	Model	Open Access	Customer Payment	Price Setting Option	Owner Payment
<i>Level 2 EVC</i>					
SemaConnect	ChargePro™	Yes	SemaConnect Pass, mobile app, and “800” number	Price by energy or duration. Time and user-variable pricing available.	Monthly network fee, available in multi-year packages
Shorepower Technologies	ePump	Yes	Major credit cards, user cards, and RFIDs	Price by duration	Annual network fee, 15% transaction fee
Siemens	VersiCharge	Yes	Mobile app and call center	Price by duration, energy, or session. Time and user-variable pricing available.	Hardware maintenance and warranty bundled pricing available
<i>Level 3 EVC</i>					
ChargePoint	CT4000, CPE200	Yes	Chargepoint or RFID card, “800” number	Price by duration, energy, or session. Time and user-variable pricing available.	Chargepoint network plan; \$280/port/year, various subscriptions lengths.
EV Box	BusinessLine	Yes	RFID, mobile app, and call center	Price by duration, energy, or session. Time and user-variable pricing available.	Hardware maintenance and warranty bundled pricing available
Schneider	EVlink DC Fast	Yes	RFID, PayPal	Price by duration, energy, or session. Time and user-variable pricing available.	1, 2, and 3 year subscription plans

Manufacturer/Certification Information					
Manufacturer	Model	Listings	Accessibility Features	First Entry to EVSE Market	Installation Rating
<i>Level 2 EVC</i>					
AeroVironment	TurboDock	UL and cUL	Insertion force: Not listed Control height: 48"	2011	NEMA 3R
Blink	PE-30Kice	NEC 625, UL and ULc to 2594	Insertion force: 45N<F<80N Control height: 48" – 60"	2012	Outdoor Rated, NEMA 3R
BTC Power	Chargion	NEC 625 UL 2231, UL2594	Insertion force: 45N<F<80N Control height: < 54"	2013	NEMA 3R
ChargePoint	CT4000	UL, cUL, NEC Article 625	Insertion force: Not listed Control height: < 48"	2009	Not Specified
Clipper Creek	LCS / HCS / CS	UL, cUL, ETL, cETL	Insertion force: 45N<F<80N Control height: Variable	2006	NEMA 4R
Efacec	Public	UL, SAE 1772	Insertion force: 45N<F<80N Control height: < 54"	2011	Not Specified
EV Box	BusinessLine	SAE 1772	Insertion force: 45N<F<80N Control height: Variable	2010	Not Specified
EVoCharge	30A EVoReel EVSE/iEVSE	UL/cUL & ETL/cETL	Insertion force: 45N<F<80N Control height: > 54"	2009	Outdoor Rated, NEMA 3R
EVSE LLC	AutoCoil	NEC 625, UL 2231&2594, CAN/CSA 22.2	Insertion force: 45N<F<80N Control height: < 54"	2009	NEMA 3R
GE	Durastation	NEC 625, UL and cUL, SAE J1772	Insertion force: 45N<F<80N Control height: < 48"	2011	NEMA 3R
Juice Bar	Mini Bar	ETL, UL 2231, UL2594, CSA C22.2 No. 280-13	Insertion force: 45N<F<80N Control height: < 54"	2009	Not Specified
Millbank	PowerGen	Unknown	Insertion force: Unknown Control height: < 48"	2011	NEMA 3R (pedestal) or NEMA 4R (wall mount)
OPConnect	Mark II	UL 2594, 2231	Insertion force: 45N<F<80N Control height: <54"	2009	NEMA 3S per 250-1997
Schneider	EVlink	NEC 625, SAE J1772, UL, CSA 22.2	Insertion force: 45N<F<80N Control height: < 54"	2011	NEMA 3R
SemaConnect	ChargePro™	NEC 625 UL 2231, UL2594	Insertion force: 45N<F<80N Control height: < 54"	2008	NEMA 3R
Shorepower Technologies	ePump	ETL & ETI	Insertion force: Unknown Control height: < 48"	2004	Not Specified
Siemens	VersiCharge	UL, SAE J1772, NEC 625	Insertion force: 45N<F<80N Control height: Variable	2011	NEMA 4R

Manufacturer/Certification Information, continued					
Manufacturer	Model	Listings	Accessibility Features	First Entry to EVSE Market	Installation Rating
<i>Level 3 EVC</i>					
ChargePoint	CPE200	UL, cUL, NEC Article 625	Insertion force: 45N<F<80N Control height: < 54"	2009	Not Specified
EV Box	BusinessLine	SAE 1772	Insertion force: Unknown Control height: Variable	2010	Not Specified
Schneider	EVlink	cULus, CHAdeMO, SAEJ1772 (DC Fast)	Insertion force: Unknown Control height: < 54"	2011	NEMA 3R

2.2 Manufacturer Information Gaps

We have endeavored to include as many EVC manufacturers and network providers as possible in this guide. When available technical specifications were insufficient, we contacted the manufacturer to request additional information. The following manufacturers have not responded to our requests for information as of January 2017:

- General Electric

3 Glossary

Charging Ports/Type: The number of cars that can charge simultaneously on a single charger, and the type of connector(s) (e.g. CHAdeMO, J1772) available.

Accessibility Features: Charger features to facilitate greater access to potential users. As standards for electric vehicle chargers under the ADA do not extend beyond the height of operable parts, we focus on the operable part (control) height, and the insertion force required to insert a charger connector.

ADA title 24 2017 compliance (ADA): Americans with Disabilities Act EVC regulations. New scoping provisions in effect January 2017 ensures requirements such as van and general accessibility dimensions, parking designation, and path of travel are in accordance with the 2016 California Building Code. (2)

BEV: Battery-only electric vehicle. A vehicle whose only power source is an onboard battery.

Cable management: Method to physically store charging cable, typically a rack for cable coils or a retractable cable device.

Cable Hangar: A cable management method that anchors the cable to the charger such that the cable hangs above the ground.

Cable Wrap: A cable management method where the charging cord is intended to wrap around the physical charger.

CAT5: Common computer networking cable, typically used to connect internet-based devices.

CEC: [California Energy Commission](#), a California State agency.

CHAdeMO: CHArge de MOve (CHAdeMO). An association as well as the eponymous level 3 EV fast charging process that requires a CHAdeMO charging socket on the EV. This is different from the level 2 SAE J1772 charging sockets common to most public chargers in the US.

Charging ports: Number of charging plugs, or ports, per EVC. Multiple ports per station allows for more charging ability with adjacent parking spots. EVCs may be wall-mounted, pedestal, or overhead, supporting different configurations and access. “Dual head” refers to two charging ports per EVC.

Coil Rack: A cable management method where a physical rack is provided to coil the cable.

Commercial maturity: Hardware or software manufacturer is a major market participant with an established customer base and several product releases. This is a qualitative metric for general consideration and subject to interpretation. The specification tables attempt to capture this with the date of entry into the EVSE market.

Connector: PEV input receptacle for charging. Level 1 and Level 2 charging is based the Society of Automotive Engineers (SAE) International standard, or SAE J1772 standard. PEVs equipped with Level 3 charging may use the CHAdeMO connector, developed in coordination with Tokyo Electric Power Company, or the CSS Combo.

Cross vendor compatibility: The ability for EVC hardware to operate using networks from a different manufacturer (cross vendor software compatibility) or the ability for network software to operate on hardware produced by a different manufacturer (cross vendor hardware compatibility).

Customer payment methods (Customer Payment): Payment and subscription methods for customers. Magnetic strip: located on the back of a credit or debit card and can be swiped through a reader. RFID: Radio Frequency Identification device uses a copper coil antenna and a chip to store small amounts of data that can be accessed by a reader within close proximity using radio waves. Club card: existing EVC manufacturer or network RFID card. Mobile device: smartphone may contain wireless RFID chips, which allows a smartphone or plastic key ring to communicate with nearby devices without a cable.

Data reporting: Usage and service data recorded by networked EVSE.

Demand Charges: A charge levied by utility companies based upon the customer's maximum power draw during a given period. Typically only applies to large electricity consumers.

Demand Response Capability: The ability of EVCs to adjust power output based on local grid demand. Exact implementation will vary, but is typically coordinated between a service network provider and electric utility.

Energy use and data reporting (Data Reporting): Method for recording EVC energy usage and data.

EVC: Electric vehicle charger. Generally referred to outside of this guide as EVSE.

EVSE: Electric vehicle supply equipment. The common literature acronym for electric vehicle chargers.

First Entry to EVSE Market: The year in which a manufacturer first released an EVSE product.

Input Power: Power input, in voltage and amperage.

Installation Rating: Installation certifications. NEMA: National Electrical Manufacturers Association; ratings typically establish durability of outdoor installations.

J1772: An electric vehicle charging standard established by SAE International (formerly the Society of Automotive Engineers). Establishes charger connector shape, standard for Level 2 chargers in the US.

kWh: kilowatt per hour.

Level 1: A charging process using a cord that plugs into a standard 120 volt outlet, usually taking between 8-20 hours to fully charge a PEV with a standard battery capacity.

Level 2: A charging process using a 240 volt electric circuit, which usually takes 4-8 hours to fully charge a PEV with a standard battery capacity. Level 2 is the most common type of public charging in California.

Level 3: A charging process that uses a 480 volt electric circuit, that will quickly charge a battery to 80% (usually taking 20 minutes for a PEV with a standard battery capacity), before reducing power to Level 2 charge capacity to fully replenish the battery.

Listings: Manufacturer certifications by either independent safety certification laboratories (such as UL or ETL) or national standards (such as the National Electric Code [NEC]).

Manufacturer: The company responsible for manufacturing the charger or network software described in the specification tables.

Model: The specific model of charger examined in the specification tables. For this guide, models have been selected to give a general idea of the capabilities of the chargers produced by that manufacturer.

Mounting: The physical mounting for the charger unit, i.e. wall-mounted or pedestal-mounted.

Network-capable: An infrastructure system of public EVCs. There are a variety of providers, administrators, and manufacturers who offer services.

Network protocol: Protocol for communication between EVC site host and an EVC network, such as the Open Charge Point Protocol (OCPP)

Network Service: An infrastructure system of public EVCs. There are a variety of providers, administrators, and manufacturers who offer services.

OCPP: Open Charge Point Protocol (OCPP), an international open communication standard. OCPP-compliant hardware and software is designed to function together regardless of manufacturer. (3)

Open Access: A charger that can be available for any customer to use, with or without a network subscription

Operating Conditions: The temperature and humidity requirements for a charger to operate normally.

Output Power: Power output provided to vehicle from the charger.

Owner Payment: Payment and subscription methods for site owners/ operators.

Pedestal: Pedestal EVCs include a pole, box, or similar structure to provide free-standing installation. These typically are mounted on a sidewalk or small concrete foundation, similar to other street-based utility equipment. Pedestal EVCs are hard-wired.

PEV: Plug-in electric vehicle. A vehicle requiring battery electric power to operate that can be externally

charged. Both battery-only (BEV) and plug-in hybrid (PHEV) vehicles available.

PHEV: Plug-in hybrid electric vehicle. A plug-in electric vehicle that also carries a backup gasoline generator.

Power rating input(s): Power input, in voltage and amperage.

Pricing schedules: Pricing schedule for EVCs. Variable pricing: site host offers varying price points at different locations or points-of-sale.

Price Setting Option: The different price schemes a charger is capable of supporting, i.e. dollars/kWh, dollars/hour, etc.

Range/Hours: A measurement of charger power specifying the amount of driving range added per hour of time spent charging.

RCEA: Redwood Coast Energy Authority.

Remote Management Capability: EVC can be controlled through a device not physically attached to the station. It is important for communication and control, and can be implemented to improve safety and productivity.

ROEV Compliant: Meets standards currently in development by Roaming for EV Charging (ROEV) association to allow drivers to access multiple network services with a single account. The association represents ChargePoint, Blink, and NRG EVgo networks and works with Nissan, BMW, Audi, and Honda. (4)

SAE CCS: Society of Automotive Engineers Combined Charging System. It is a fast charging method for EVs delivering high-voltage current via a specific combination plug. The plug socket is an AC connector with a DC option.

Session fees: EVC charging fees for customer. Typically determined by site host. Important to consider surcharges and commissions.

Theft Deterrence: Features to prevent EVC theft and vandalism.

4 References

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6 Product Photos

This section shows the general appearance of some of the EVC models described in this guide.

<p>AeroVironment TurboDock (P4)</p> 	<p>Blink, single port (P5)</p> 	<p>BTC Power Chargion EVP, single port (P6)</p> 	<p>BTC Power Chargion EVP, dual port (P7)</p> 	<p>ChargePoint CT 4000 (P8P8)</p> 
<p>ChargePoint CPE200 (P9P9)</p> 	<p>ClipperCreek LCS (P10)</p> 	<p>ClipperCreek HCS (P11)</p> 	<p>ClipperCreek CS (P12)</p> 	<p>Efacec Public Charger (P13)</p> 
<p>EV Box Business (P14)</p> 	<p>EVSE LLC AutoCoil (P15)</p> 	<p>EvoCharge, EVoReel (P16)</p> 	<p>EvoCharge, single port (P17)</p> 	<p>EvoCharge, dual port (P17)</p> 

<p>GE DuraStation Double Pedestal (P18)</p> 	<p>JuiceBar LLC, Minibar double port (P19)</p> 	<p>Millbank PowerGen (P20)</p> 	<p>OPConnect Mark II (P21)</p> 	<p>Schneider EV Link Level 2 (P22)</p> 
<p>Schneider EV Link DC Fast (P23)</p> 	<p>SemaConnect ChargePro (P24)</p> 	<p>Shorepower Technologies, ePump (P25)</p> 	<p>Siemens VersiCharger (P26)</p> 	

Stations not to scale: please see manufacturing specifications for physical dimensions. Image credits are given in section 6.1. Current models may vary from those shown here.

6.1 Photo credits

- P1. PCS-15 by ClipperCreek. <https://store.clippercreek.com/level1/pcs-15-portable-ev-charging-station>.
- P2. Image by Chargepoint. <http://strattonreport.com/news/chargepoint-invest-20-million-national-network-high-speed-ev-chargers/>.
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- P6. Level 2 Commercial EV Charging Station by BTCPower. <http://www.btcpower.com/products-and-applications/Level-2-Commercial-EV-Charging-Station/>.
- P7. BTCPower Dual Pedestal by BTCPower. http://www.thebluebook.com/iProView/813090/national-car-charging-llc/subcontractors//images/564078_-electric-vehicle-charging-stations/866745_btcpower-dual-pedestal.html.
- P8. CT4000 Family by ChargePoint. <https://www.chargepoint.com/products/commercial/ct4000/>.
- P9. ChargePoint Express 200 by ChargePoint. <http://www.chargepoint.com/products/commercial/cpe200/>.
- P10. LCS-30 by ClipperCreek. <https://store.clippercreek.com/all-products/lcs-30-24-amp-ev-charging-station>.
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- P16. EVoReel Charging Station by EVOCharge. https://www.evcharge.com/uploaded/Product_Page_1.jpg.
- P17. Pedestal Mount – EVoReel Charging Station by EVOCharge. https://www.evcharge.com/uploaded/Product_Page_2.jpg.
- P18. Double Pedestal by GE Industrial Solutions. <http://apps.geindustrial.com/publibrary/checkout/DET-834?TNR=Cross%20Reference%7CDET-834%7CPDF&filename=DET-834.pdf>.
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- P21. Mark II, by OPConnect. <http://www.opconnect.com/press/ev-charging-stations-solutions/>.
- P22. EV230PDRR by Schneider Electric. http://download.schneider-electric.com/files?p_Reference=0100CT1501_SEC-05&p_EnDocType=Catalog&p_File_Id=5024286529&p_File_Name=0100CT1501_SEC-05.pdf.
- P23. DC Quick Charging by Schneider Electric. http://download.schneider-electric.com/files?p_Reference=0100CT1501_SEC-05&p_EnDocType=Catalog&p_File_Id=5024286529&p_File_Name=0100CT1501_SEC-05.pdf.
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