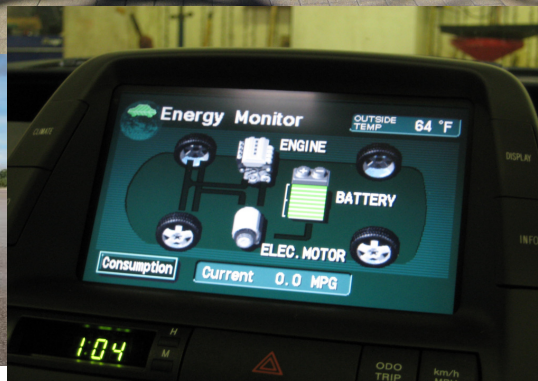
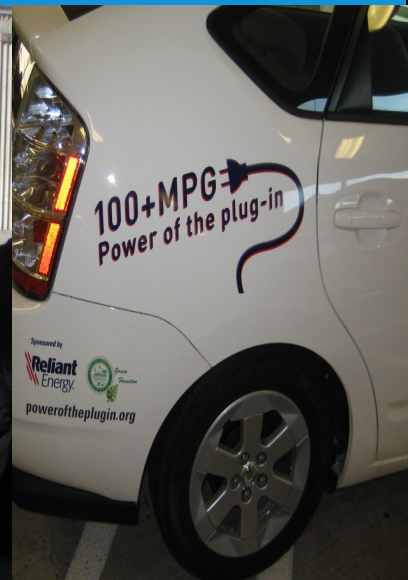
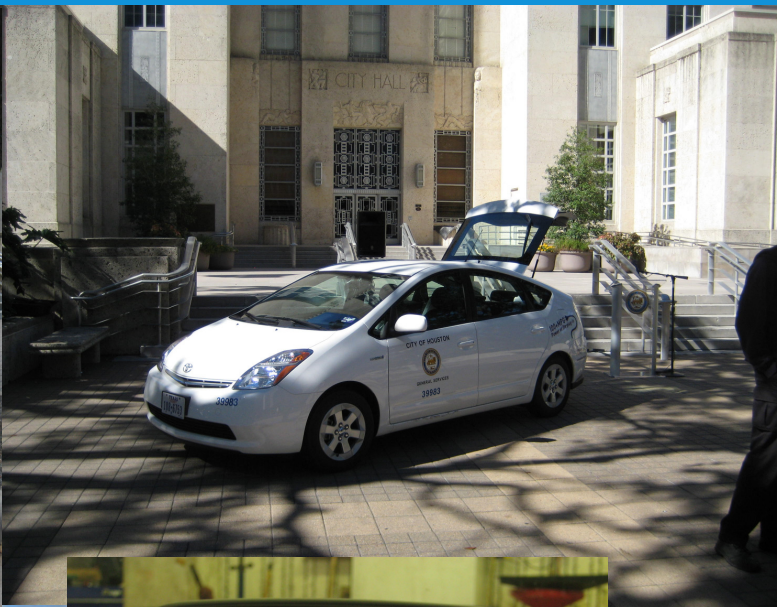




Recommended Electric Vehicle Charging Infrastructure Deployment Guidelines for the Greater Houston Area



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Acronyms

BEV	Battery Electric Vehicle—Vehicle powered 100% by the battery energy storage system available on-board the vehicle.
CCID	Charge Current Interrupting Device—A device within EVSE to shut off the electricity supply if it senses a potential problem that could result in electrical shock to the user.
EV	Electric Vehicle
EREV	Extended Range Electric Vehicle—see <i>PHEV</i>
EVSE	Electric Vehicle Supply Equipment—Equipment that provides for the transfer of energy between electric utility power and the electric vehicle.
ICE	Internal Combustion Engine
kW	Kilowatts—A measurement of electric power. Used to denote the power an electrical circuit can deliver to a battery.
kWh	Kilowatt Hours—A measurement of total electrical energy used over time. Used to denote the capacity of an EV battery.
NEC	National Electric Code—Part of the National Fire Code series established by the National Fire Protection Association (NFPA) as NFPA 70. The NEC codifies the requirements for safe electrical installations into a single, standardized source.
NEMA	National Electrical Manufacturers Association—Group that develops standards for electrical products.
PHEV	Plug-in Hybrid Electric Vehicle—Vehicles utilizing a battery and an internal combustion engine (ICE) powered by gasoline, diesel, or other liquid or gaseous fuels.
REEV	Range Extended Electric Vehicle—see <i>PHEV</i>
RTP	Real Time Pricing—a concept for future use whereby utility pricing is provided to assist a customer in selecting the lowest cost charge.
SAE	Society of Automotive Engineers—standards development organization for the engineering of powered vehicles.
TOU	Time of Use—an incentive-based electrical rate established by an electric utility that bases price of electricity on the time of day.
V2G	Vehicle to Grid—a concept of using battery storage on electric vehicles to supply power to the electrical grid.
VAC	Voltage Alternating Current. Often referred to as AC.

1. Executive Summary

The following *Recommended Electric Vehicle Charging Infrastructure Deployment Guidelines* (Guidelines) document has been prepared by The City of Houston, The Clinton Foundation, ECOtality North America, and the Houston EV Project Advisory Team. This document not only serves to provide focus for the stakeholders in the process, but also provides the foundation for future endeavors. Several local decisions must be made for the successful deployment of EVSE, which we believe then encourages further adoption of EVs in the Houston community. The comments that have been received on the draft guidelines by the advisory team and local stakeholders have been incorporated into this final document. It is a public document to which any additional stakeholders and enthusiasts can refer to understand the local deployment of electric vehicles and charging stations in the Houston area.

This is the first document for the City of Houston EV Project Community Plan, providing the foundation upon which the EV Micro-Climate™ program builds in order to provide the optimum infrastructure to support and encourage the adoption of EVs in the Houston area.

The Guidelines document starts in Section 2 by introducing the Roadmap for the City of Houston's development of an EV charging infrastructure.

Section 3 describing electric vehicle technology, including EVSE, battery technologies that are either available in the marketplace or coming in the near future, an auto manufacturers' future plans.

Section 4 discusses the terminology and general requirements of EVSE, which provides the safe transfer of energy between the electric utility power and the electric vehicle. Level 1, Level 2, and DC Fast charging levels and components are discussed, as well.

Section 5 gives an in-depth description of the single-family residence, carport, multi-family, commercial fleet, and publicly-available EVSE installation processes. The commercial fleet and publicly-available scenarios discuss the options for both Level 2 and DC Fast charging for those locations. In addition, such issues as power and siting requirements are discussed.

EV Signage will be very important in the overall experience for widespread adoption of EV use. Section 6, *Additional Charging Considerations*, identifies the two main signage purposes, keeping non-EV vehicles from parking in charging station stalls and helping EV drivers find charging stations. In addition, this section discusses lighting, shelter, accessibility requirements, point of sale considerations and other safety issues regarding EVSE.

Section 7 is devoted to the Codes and Standards that are designed to protect the public and make EVSE accessible for use, including Regulatory agencies, National Electric Code, SAE, UL and OSHA. The City of Houston Engineering, Permitting and Construction process is discussed in detail with accompanying Flow Chart.

Section 8 concentrates on Utility Integration and their effort to evaluate and implement Smart-Grid technologies. This allows them to control various electrical loads on their systems. Through these Smart-Grid technologies, utilities can minimize new power plant and electrical distribution and transmission investment by shifting and controlling load while minimizing the impact to the customer.

2. Roadmap Introduction

The City of Houston (City) is the fourth largest city in the nation, with an estimated 2009 population of 2.26 million¹. At 5.9 million people, the Houston metropolitan area is the sixth largest in the U.S. and in the last ten years has grown by more than 1.1 million people. The Houston area is home to the country's largest petrochemical and refining complex, the country's second-largest port, and on-road travel that exceeded 140 million vehicle miles traveled per day. Consequently, Houston faces significant challenges in air quality, including emissions of greenhouse gases (GHG). In response, the City has been a leader in addressing these challenges. In August of 2008, the City issued an Emissions Reduction Plan (ERP) setting forth actions on three key sources of GHG emissions: buildings and structures, waste, and mobile sources. The City has implemented and continues to implement numerous other actions to improve air quality and reduce GHG emissions.

Vehicle electrification is a key action that Houston has instituted working with the Clinton Climate Initiative, the Houston Advanced Research Center, ECOtality North America, the Rocky Mountain Institute, Texas A & M University, and the University of Texas at Austin. The Houston Electric Vehicle Initiative is building capacity within communities and working through partnerships across multiple stakeholder groups to create ongoing air quality improvements and GHG reductions. These efforts support the achievement of the City's broader environmental, economic, health, and social co-benefits.

As part of this initiative, the City has asked ECOtality North America to work with its partners and stakeholders to develop an EV Micro-Climate™ program that will help ensure that Houston is well prepared to support the consumer adoption of electric transportation. Beginning with extensive feasibility and infrastructure planning studies, the program provides a blueprint that will create a rich EV charging infrastructure in the Houston area. The program is being developed with all pertinent stakeholders, including governmental organizations, utilities, private-sector businesses, and automotive manufacturers.

Electric vehicles have unique requirements that differ from internal combustion engine vehicles, and many stakeholders currently are not familiar with these requirements. Therefore, the first step in the EV Micro-Climate program is the creation of *Electric Vehicle Charging Infrastructure Deployment Guidelines* that provide the background information for understanding EV requirements. These guidelines serve as the foundation for building an optimal EV charging infrastructure that supports and encourages EV adoption.

These Deployment Guidelines are not intended to be used as an installation manual or a replacement for approved codes and standards, but to create a common knowledge base of EV requirements for stakeholders involved in the development and approval of EV charging infrastructure.

¹ U.S. Census Bureau, <http://factfinder.census.gov>

3. Electric Vehicle Technology

This section describes the basic electric vehicle technologies that are either available in the marketplace or coming to market in the near future. The focus of this section is on street-legal vehicles that incorporate a battery energy storage device with the ability to connect to the electrical grid for the supply of some or all of its fuel energy requirements. Two main vehicle configurations are described, along with the four main categories of vehicle applications. Vehicle categories and the relative size of their battery packs are discussed in relationship to recommended charging infrastructure.

A. Electric Vehicle Configurations

There are two basic EV configurations at this point in time: battery electric vehicles (BEVs) powered exclusively by batteries, and plug-in hybrid electric vehicles (PHEVs), powered by a combination of batteries and another power source, such as an internal combustion engine.

- **Battery Electric Vehicle (BEV)**

Battery Electric Vehicles (BEVs) are powered only by the battery energy storage system available onboard the vehicle. The Nissan LEAF is an example of a BEV. A BEV is refueled by connecting it to the electrical grid via a connector system that is designed specifically for this purpose. Most advanced BEVs and PHEVs recapture some of the energy used through regenerative braking (essentially, using the electric motor as a generator during braking). When regenerative braking is applied, BEVs can typically recover 5 to 15 percent of the energy used to propel the vehicle to the vehicle speed prior to braking. Solar photovoltaic (PV) panels on vehicle roofs can also provide power to operate some small accessory loads (such as the radio) and help charge the battery.

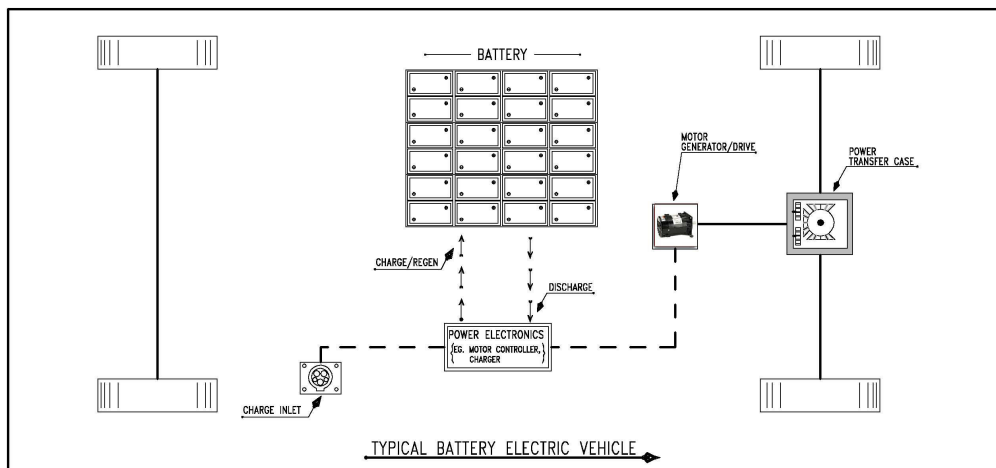


Figure 3-1: Battery Electric Vehicle

A typical BEV is shown in the block diagram in Figure 3-1. Since the BEV has no other significant energy source, the battery must be selected to meet the BEV range and power requirements. These EV batteries are typically more than ten times as powerful as batteries on conventional internal combustion engine (ICE) vehicles.

- **Plug-in Hybrid Electric Vehicle (PHEV)**

Like a typical hybrid vehicle (HEV), the PHEV configuration utilizes a battery and an ICE powered by gasoline, diesel, or other liquid or gaseous fuels. The PHEV has much greater battery capacity than today's typical HEV. PHEVs and HEVs have two main design configurations, a *Series Hybrid* as depicted in Figure 3-2 below, and a *Parallel Hybrid* as depicted in Figure 3-3. The Series Hybrid is propelled solely by the electric drive system, whereas the Parallel Hybrid vehicle is propelled by both the ICE and the electric drive system. A Series Hybrid typically requires a larger and more powerful battery than a Parallel Hybrid vehicle to meet the performance requirements for operating solely on battery power.

A PHEV has all of the abilities of an HEV, except that a PHEV has the ability to plug in and use grid-powered electricity to charge the battery. The PHEV is able to run for an increased distance strictly on the electric motor without having to use the ICE, thus increasing fuel efficiency.

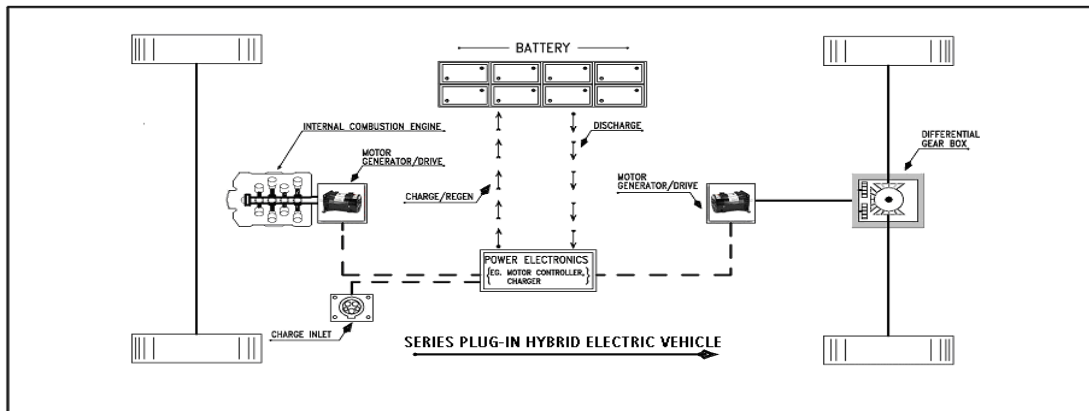


Figure 3-2: Series Plug-In Hybrid Vehicle Block Diagram

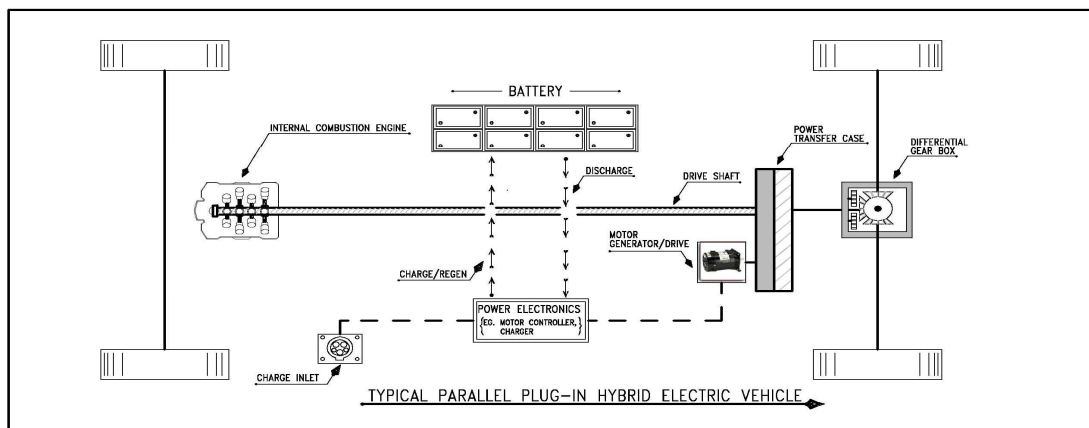


Figure 3-3: Parallel Plug-In Hybrid Vehicle Block Diagram

Manufacturers of PHEVs use different strategies in combining the battery and ICE and may utilize the battery only for the first several miles; an example of this strategy is the Chevrolet Volt, which has an ICE providing generating power for the duration of the vehicle range. Others may use the battery power for sustaining motion and the ICE for acceleration or higher-energy demands at highway speeds. Frequently, the vehicles employing the former strategy gain a

designation such as *PHEV-20* to indicate that the first 20 miles are battery only. Other terms related to PHEVs may include *Range Extended Electric Vehicle* (REEV) or *Extended Range Electric Vehicle* (EREV).

B. Electric Vehicle Categories

EVs can also be categorized by size, speed, and operating characteristics.

- **On-Road Highway Speed Vehicles**

An *On-Road Highway Speed Vehicle* is an EV capable of driving on all public roads and highways. Performance of these on-road vehicles is similar to conventional light-duty ICE vehicles.

- **Commercial On-Road Highway Speed Vehicles**

There are a number of commercial electric vehicles, including trucks and buses. These vehicles are found as both BEVs and PHEVs. Performance and capabilities of these vehicles are specific to their applications.

The EV Micro-Climate program is currently focused on only these on-road vehicles that operate in a manner similar to conventional ICE vehicles. Specialty vehicles such as electric motorcycles and bicycles require a different planning process.

Other lower-speed vehicles that can operate on local roadways include City and Neighborhood Electric Vehicles. These are also available in the market in the Houston area and may use EVSE technologies set forth in this document.

- **City Electric Vehicles**

Traditionally, *City Electric Vehicles* have been BEVs that are capable of driving on most public roads, but generally are not driven on highways. Top speed is typically limited to 55 mph.

- **Neighborhood Electric Vehicles (NEVs)**

Neighborhood Electric Vehicles (NEVs), also known as *Low-Speed Vehicles* (LSVs), are BEVs that are limited to operating at lower speed limits. In Texas, these vehicles may operate at maximum speeds of 35 mph on roadways with posted speed limits of 45 mph or less.

C. Batteries

- **Battery Technology**

Recent advancements in battery technologies will allow EVs to compete with ICE vehicles in performance, convenience, and cost. Today, most major car companies utilize nickel-metal-hydrate or various lithium-based technologies for their EVs. Lithium provides four times the energy of lead-acid and two times that of nickel-metal-hydrate. The materials for lithium-based batteries are generally considered abundant, non-hazardous, and lower cost than nickel-based technologies. The current challenge with lithium-based technologies is increasing battery capacity while maintaining quality and cycle life and lowering production costs.

From an infrastructure standpoint, it is important to consider that, as battery costs are driven down over time, the auto companies will increase the size of battery packs and thus increase the range of electric vehicles.

- **Relative Battery Capacity**

Battery size or capacity is measured in kilowatt hours (kWh). Battery capacity for EVs currently will range from as little as 3 kWh to as large as 40 kWh or more. Typically, PHEVs will have smaller battery packs because they have more than one power source, such as an internal combustion engine. BEVs rely completely on the energy stored from their battery pack for both range and acceleration, and therefore require a much larger battery pack than a PHEV for the same size vehicle.

- **Battery Charging Time**

The amount of time to fully charge an EV battery is a function of the battery size and the amount of electric power (measured in kilowatts (kW)) that an electrical circuit can deliver to the battery. Larger circuits, as measured by voltage and amperage, will deliver larger amounts of kW. The common 110-120 volts AC (VAC), 15 amp circuit will deliver at least 1.1 kW to a battery. A 220-240 VAC, 40 amp circuit (similar to the circuit used for household appliances like dryers and ovens) will deliver at minimum 6 kW to a battery. Table 3-1 below shows several different on-road highway speed electric vehicles, battery pack size, and charge times at different power levels to replenish a depleted battery.

Table 3-1: EV Charge Times with Depleted Battery²

EV Configuration	Typical Battery Size (kWh)	Circuit Size and Power in kW Delivered to Battery			
		120 VAC, 15 amp 1.2 kW	120 VAC, 20 amp 1.6 kW	240 VAC, 40 amp 6.5 kW	480 VAC, 85 amp 60 kW
PHEV-10	4	3 h 20 m	2 h 30 m	35 m	n/a
PHEV-20	8	6 h 40 m	5 h	1 h 15m	n/a
PHEV-40	16	13 h 20 m	10 h	2 h 30 m	16 m
BEV	24	20 h	15 h	3 h 40 m	24 m
BEV	35	29 h 10 m	21 h 50 m	5 h 20 m	35 m
PHEV Bus	50	n/a	n/a	7 h 40 m	50 m

Note: Power delivered to battery calculated as follows: 120VAC x 12 amps x .85 eff.; 120VAC x 16 amps x .85 eff.; 240VAC x 32 amps x .85 eff.; 480VAC x $\sqrt{3}$ x 85 amps x .85 eff.

² Consumers will likely choose to recharge vehicles at regular intervals to avoid complete depletion of batteries; for example, plugging in vehicles each evening. As such, the charge times shown here should be near the maximum.

D. Automaker Plans

Many automakers have announced plans for the introduction of on-road highway speed EVs in the near future. A summary of these plans is shown in Table 3-2 below.

Table 3-2: Automaker PHEV and BEV Plans³

Make	Model	All Electric Range (mi)	Battery Size (kWh)	U.S. Target Intro. Date
Plug In Hybrid Electric Vehicles				
Audi	A1 Sportback	31-62		2011
BYD Auto	F3DM	60		2010
Fisker	Karma	50		2010
Ford	Escape	40	10	2012
General Motors	Chevrolet Volt	40	16	2010
Hyundai	Blue-Will	38		2012
Toyota	Prius Plug-in	12.4-18.6		2012
Volvo	V70	31		2012
Battery Electric Vehicles				
BMW	ActiveE	100		2011
BYD Auto	e6	205		2010
Chrysler/Fiat	Fiat 500	100		2012
Coda Automotive	Coda Sedan	90-120		2010
Daimler	Smart fortwo	82	16	For sale now
	Mercedes Benz BlueZero	120	35	2010 low volume
	Mercedes Benz SLS AMG E-Cell	90-130	48-60	2013
Ford	Focus	100		2011
	Transit Connect	100		2010
	Tourneo Connect	100	21	2011
Hyundai	i10 Electric	100	16	2012
Mitsubishi	iMiEV	100	16	2010

³ Credit Suisse "Electric Vehicles," Equity Research, *Energy Technology/Auto Parts & Equipment*, October 1, 2009.

Make	Model	All Electric Range (mi)	Battery Size (kWh)	U.S. Target Intro. Date
Nissan	LEAF	100	24	2010
Rolls Royce	Electric Phantom			2010
SAIC	Roewe 750	125		2012
Tesla Motors	Roadster	245	56	For sale now
	Model S	160, 230, 300		2011
Th!nk	City	113		2010
Toyota	RAV4 EV	100		2011

4. Charging Requirements

This section covers the terminology and general requirements of Electric Vehicle Supply Equipment (EVSE). EVSE provides for the safe transfer of energy between the electric utility power and the electric vehicle.

A. Charging Components

The terms used to identify the components in the delivery of power to the vehicle are shown in Figure 4-1 and defined below.

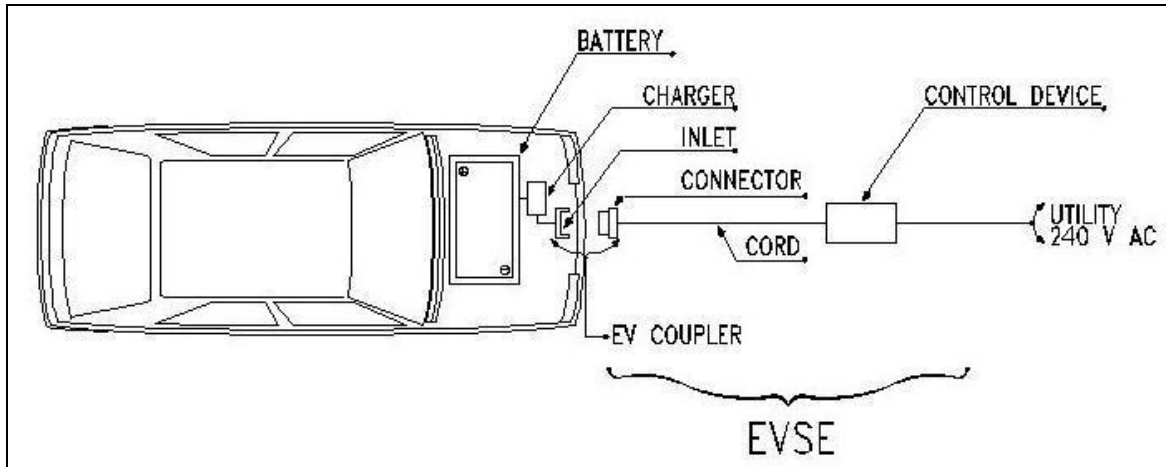


Figure 4-1: Level 2 Charging Diagram

Power is delivered to the EV's onboard battery through the *EV inlet* to the charger. The *charger* converts Alternating Current (AC) to the Direct Current (DC) required to charge the battery. The charger and EV inlet are considered part of the EV. A *connector* is a device that, by insertion into an EV inlet, establishes an electrical connection to the electric vehicle for the purpose of charging and information exchange. The EV inlet and connector together are referred to as the *coupler*. The EVSE consists of the connector, cord, and interface to utility power. The interface between the EVSE and utility power will be directly "hardwired" to a control device, as illustrated in Figure 4-1, or a plug and receptacle, as illustrated in Figure 4-3.

During the 1990s, there was no consensus on EV inlet and connector design. Both conductive and inductive types of couplers were designed and in both cases, different designs of each type were provided by automakers. At the present time, however, the Society of Automotive Engineers (SAE) has agreed that all vehicles produced by automakers in the United States will conform to a single design, known as the *J1772 Standard*.⁴

⁴ While the J1772 Standard will be utilized by all automakers in the United States, it may not be the standard that is adopted in other countries. This is the subject of a harmonization project with the Canadian Codes. A common connector is also the goal of European, Asian, and North American designers.



J1772 Connector



J1772 Inlet (right side)

Figure 4-2 J1772 Connector and Inlet (Preliminary)

The J1772 Standard EV coupler is designed for 10,000 connections and disconnections with exposure to dust, salt, and water; is able to withstand a vehicle driving over it; and is corrosion resistant.

The J1772 Standard and National Electrical Code (NEC) requirements create multiple safety layers for EV components, including:

- The EV coupler -
 - must be engineered to prevent inadvertent disconnection.
 - must have a grounded pole that is the first to make contact and the last to break contact.
 - must contain an interlock device that prevents vehicle startup while connected.
 - must be unique to EV charging and cannot be used for other purposes.
- The EV inlet -
 - must be de-energized until it is attached to the EVSE.
 - must de-energize prior to removal of the connector.
- The EVSE -
 - must be tested and approved for use by Underwriters Laboratory (UL), or a similar nationally-recognized, independent testing lab.
 - must be able to initiate area ventilation for those specific batteries that may emit potentially explosive gases.
 - must have a charge current interrupting device (CCID) that will shut off the electricity supply if it senses a potential problem that could result in electrical shock to the user.

In addition, when connected, the vehicle charger will communicate with the EVSE to identify the circuit rating (voltage and amperage) and adjust the charge to the battery accordingly. Thus, an EVSE that is capable of delivering 20 amps will deliver that current, even if connected to a 40 amp rated circuit.

The J1772 coupler and EV inlet will be used for both Level 1 and Level 2 charging, which are described below.

B. Charging Levels

In 1991, the Infrastructure Working Council (IWC) was formed by the Electric Power Research Institute (EPRI) to establish a consensus on several aspects of EV charging. Level 1, Level 2, and DC Fast Charging levels (sometimes referred to as Level 3) were defined by the IWC, along with the corresponding functionality requirements and safety systems. EPRI published a document in 1994 that describes the consensus items of the IWC.⁵

For Levels 1 and 2, the conversion of the utility AC power to the DC power required for battery charging occurs in the vehicle's on-board charger. In DC Fast Charging, the conversion from AC to DC power typically occurs off-board so that DC power is delivered directly to the vehicle.⁶

Level 1 – 120 volt AC

The Level 1 method uses a standard 120 volts AC (VAC) branch circuit, which is the lowest common voltage level found in both residential and commercial buildings. Typical voltage ratings can be from 110 – 120 volts AC. Typical amp ratings for these receptacles are 15 or 20 amps.

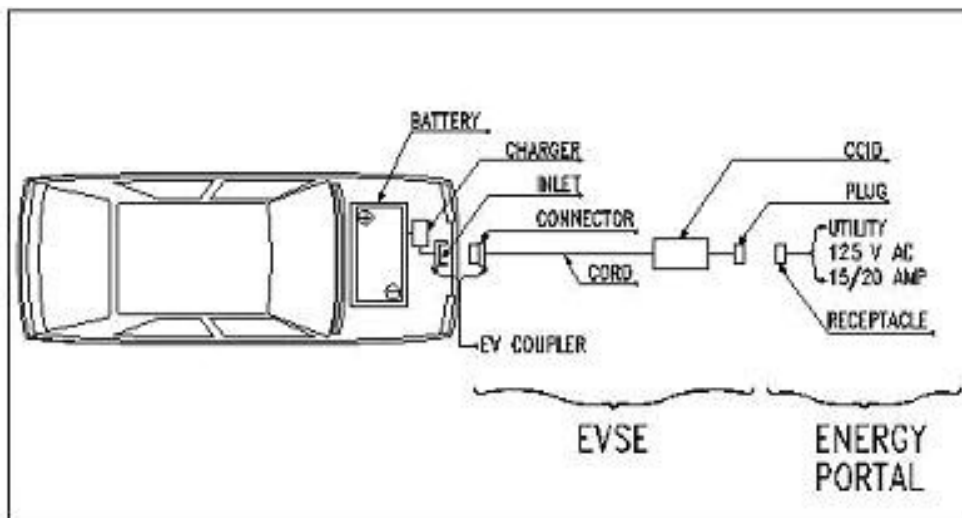


Figure 4-3 Level 1 Charging Diagram

⁵ "Electric Vehicle Charging Systems: Volume 2." *Report of the Connector and Connecting Station Committee*, EPRI, December 1994.

⁶ AC DC Fast Charging (delivering high-power AC directly to the vehicle) is defined within the SAE J1772 document, but this approach has not been implemented yet.

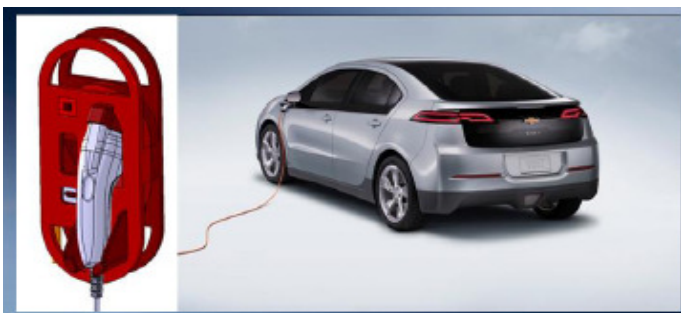


Figure 4-4 Level 1 Cord Set⁷

Level 1 charging typically uses a standard 3-prong electrical outlet (NEMA 5-15R/20R) to connect to premises wiring.

EV suppliers typically will provide a Level 1 Cord Set (125 VAC, 15 or 20 amps) with the vehicle. This cord set will use a standard 3-prong plug (NEMA 5-15P/20P), with a charge current interrupting device (CCID) located in the power supply cable within 12 inches of the plug. The vehicle connector at the other end of the cord will be the design identified in the J1772 Standard. This connector will mate properly with the vehicle inlet, also approved by J1772.

Because Level 1 charge times can be several hours with a depleted battery (see Table 3-1), this technology will mainly be used at the owner's home. Consequently, many EV owners are expected to choose Level 2 charging at home and in publicly available locations. Some EV manufacturers suggest that their Level 1 cord set should be used only when Level 2 EVSE is not available, such as when parked overnight at a non-owner's home.

Kits are available to convert ICE and hybrid vehicles to plug-in electric vehicles. Many of these conversions use a standard prong electrical plug and outlet to provide Level 1 charging. With the standardization of EVs on the J1772 Standard and the higher level of safety afforded by a J1772-compliant charging station, existing vehicles may need to be retrofitted to accommodate a J1772 inlet in order to take advantage of the deployment of EVSE infrastructure.

Level 2 – 240 volt AC

Level 2 is typically described as the “primary” and “preferred” method for the EVSE for both private and publicly-available facilities, and specifies a single-phase branch circuit with typical voltage ratings from 220 – 240 volts AC. The J1772-approved connector allows for current as high as 80 amps AC (100 amp rated circuit). However, current levels that high are rare; a more typical rating would be 40 amps AC, which allows a maximum current of 32 amps. This provides approximately 7.7 kW with a 240 VAC circuit.

⁷ Conceptual Design for Chevrolet Volt, *Electrifying the Nation*, PHEV Summit, Tony Posawatz, January 2009.

The higher voltage of Level 2 allows a much faster battery charge. Because of the higher voltage, Level 2 has a higher level of safety requirements than Level 1 under the National Electric Code (NEC), including the requirement that the connector and cord be hardwired to the control device and premises wiring, as illustrated in Figure 4-1 and Figure 4-3.



Figure 4-5 Level 2 Charging

DC Fast Charging (Level 3)

DC Fast Charging (sometimes referred to as Level 3) is planned for commercial and public applications and is intended to perform a rapid recharge, giving the consumer an experience similar to conventional gasoline fueling. Typically, DC Fast Charging would provide a 50% recharge in 10 to 15 minutes. DC Fast Charging generally uses an off-board charger to provide the AC to DC conversion. The vehicle's on-board battery management system controls the off-board charger to deliver DC directly to the battery.⁸

⁸ Note: Although it will be uncommon, a vehicle manufacturer may choose not to incorporate an on-board charger for Level 1 and 2, and instead utilize an off-board DC charger for all power levels. In this case, the electric vehicle would have only a DC charge port. Another potential configuration that may be found, particularly with commercial vehicles, is providing 3-phase power directly to the vehicle. This configuration requires dedicated charging equipment that will be incompatible with typical publicly available infrastructure.

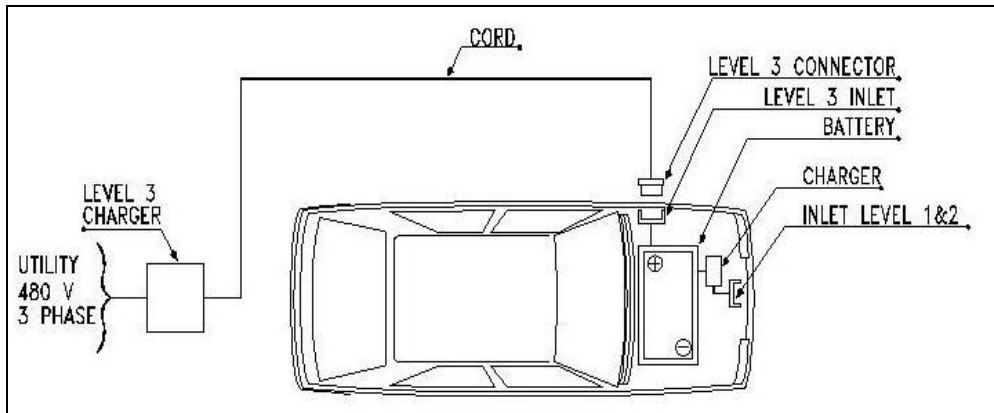


Figure 4-6 DC Fast Charging

This off-board charger is serviced by a three-phase circuit at 208, 480, or 600VAC. The SAE standards committee is working on a DC Fast Charging connector, but has placed the highest priority in getting the Level 1 and 2 connector approved first. The DC Fast Charger connector standard is expected to be approved in 2011.



Figure 4-7 DC Fast Charging (80kW) circa 2010

Note: Although it will be uncommon, a vehicle manufacturer may choose not to incorporate an on-board charger for Levels 1 and 2, and instead utilize an off-board DC charger for all power levels. In this case, the electric vehicle would have only a DC charge port. Another potential configuration that may be found, particularly with commercial vehicles, is providing 3-phase power directly to the vehicle. This configuration requires dedicated charging equipment that will be non-compatible with typical publicly available infrastructure.

C. Level 1 versus Level 2 Considerations

For a BEV owner (and some PHEV owners), the preferred method of residential charging may be Level 2 (240VAC/single-phase power), providing a faster charging time. For others, a dedicated Level 1 circuit may meet their needs; for example, if Level 2 charging were available at work or in public areas, home charging time would be reduced. Table 3-1 shows relative battery sizes and estimated recharge times.

D. General Guidelines

This section identifies general guidelines for EVSE.

- **Certification:** EVSE will meet the appropriate codes and standards and will be certified and so marked by a Nationally Recognized Testing Laboratory (e.g., Underwriters Laboratories). Owners should be cautioned against using equipment that has not been certified for EV use.
- **Cord Length:** The EVSE will provide a maximum of 25 feet of flexibility from a wall location to the EV Inlet. This length was derived by adding the typical 15-foot car length and adding the 7-foot car width plus 3 feet to the EVSE's permanent location. The EV inlet location on each EV model will vary by manufacturer; however, this standard length should be sufficient to reach from a reasonably positioned EVSE to the inlet. (as illustrated further in this document).
- **Tripping Hazard:** An extended EV cord may present a tripping hazard, so the EVSE should be located away from potential foot traffic, if possible. An alternative might be an overhead support or trolley system to allow the cord to hang above the vehicle and above head height near the EV inlet.
- **Ventilation Requirements:** Automobile manufacturers are expected to use non-gassing batteries. If used, gassing batteries may have ventilation requirements associated with them. While this may be rare, EVSE should be capable of energizing a properly-sized ventilation system. The EVSE would communicate with the vehicle before charging, and if ventilation is required but no ventilation system exists, the EVSE would not charge the vehicle. Those chargers intended for non-gassing batteries only should be clearly labeled as such.
- **Energized Equipment:** Unless de-energized by the local disconnect, the EVSE is considered to be electrically energized equipment. Because it operates above 50 volts, Part 19 Electrical Safety of the Occupational Health and Safety (OHS) Regulation requires guarding of live parts. EVSE should be positioned in a way that avoids vehicle contact. Wheel stops are one method suggested for preventing a vehicle from contacting the EVSE. They also help position the EV in the optimum location for charging.



Figure 4-6 Wheel Stop⁹



Figure 4-7 Garage Wheel Stop¹⁰

- **Shortest Run:** In addition to the above, the lowest-cost EVSE installation will generally be the location closest to the electrical supply breaker. This minimizes the conduit run to the charger.
- **Ergonomics/Ease of Use:** Most EV owners will find it convenient for them to have the EVSE located near the EV inlet. In some cases, this may require backing into the garage, which will minimize the tripping hazards and reduce the electrical circuit length to the EVSE. The EV inlet location on the vehicle varies, and may be in the rear, the front, or on either side. For this reason, it is not practical to design the EVSE's permanent location for a specific vehicle, although this is probably what will be done.

⁹ Rubberform Recycled Products LLC, www.rubberform.com

¹⁰ ProPark Garage Wheel Stop, www.organizeit.com

5. Charging Scenarios

A. Single Attached/Detached Garages

Power Requirements

- **Level 1:** Dedicated branch circuit with NEMA 5-15R or 5-20R Receptacle.
- **Level 2:** Dedicated branch circuit hardwired to a permanently-mounted EVSE with the following specifications: 240VAC/single phase, 4-wire (2 hot, GND, and neutral), 40 amp breaker.

Cost Estimates

Costs will vary based on the length of the circuit run, electrical service and/or electrical panel upgrades, and other factors.

Level 2 Notes

The breaker size recommended will meet the requirements of almost all BEVs and PHEVs. Some PHEVs with small battery packs (see Table 3-1) may only require a 20 or 30 amp breaker for their recommended EVSE, in which case the breaker can be easily changed.

For new construction, bring the circuit to a dual gang box with a cover plate for future installation of EVSE.

For new construction that is incorporating an advanced internet network within the home, an internet connection at the EVSE location would be advisable. For existing homes, the value of providing an internet connection at the EVSE location is unknown at this time and is left up to the individual homeowner. It is likely that wireless methods will be available where a hard connection is not available.

Many Level 2 EVSE suppliers will provide controls in the EVSE to enable charging at programmable times to take advantage of any future off-peak electric power pricing options. If not, homeowners may desire to install a timing device in this circuit to control charging times.

Siting Requirements Guidelines

An indoor-rated EVSE is preferred for an enclosed garage. The EV should be positioned so that the general requirements described previously are considered.

Often the EVSE will be placed on an exterior wall to shorten the distance from the electrical service panel while positioning the EVSE out of the way.

If the EVSE is to be installed after the EV has been purchased, the location of the EV inlet can play a part in the location of the EVSE. It is best to keep the EVSE as close to the inlet as possible to minimize how much the cord is extended across the floor. If the branch circuit is installed prior to the EV purchase, the garage junction box should be on the wall closest to the utility service connection, consistent with the general requirements for EVSE. Preferred and non-preferred locations are shown in Figure 5-1 below.

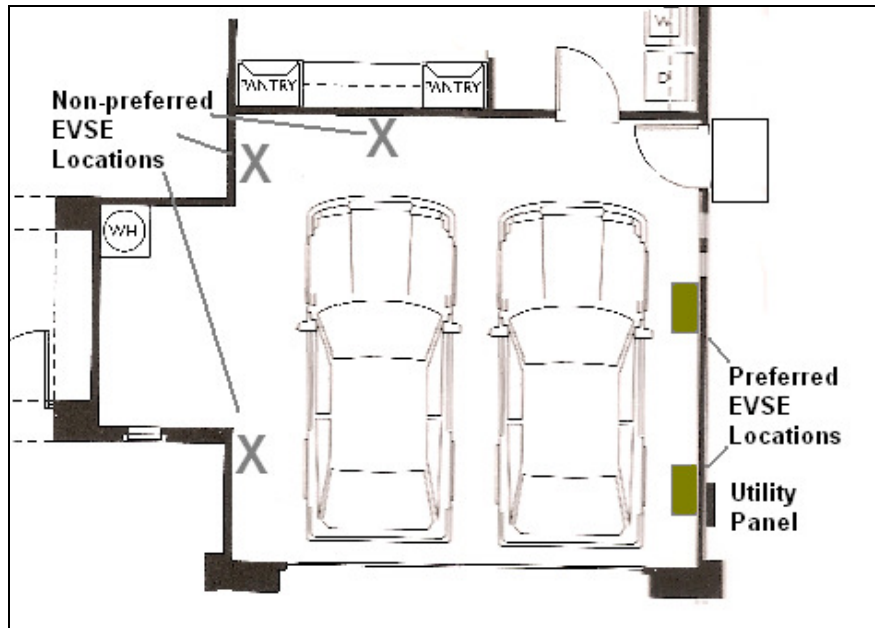


Figure 5-1: Double Garage Location for EVSE

In the above figure, the best location would be with the EV parked on the right. The non-preferred EVSE locations are in typical walking areas that would present a tripping hazard from the cord. In addition, these locations are further from the utility panel, increasing the cost of installation. If the EV owner wishes to place the EVSE in these locations, one option would be an overhead support for the charge cable and connector. If the EV inlet is on the left side of the vehicle, the owner could back into the garage for easier access.

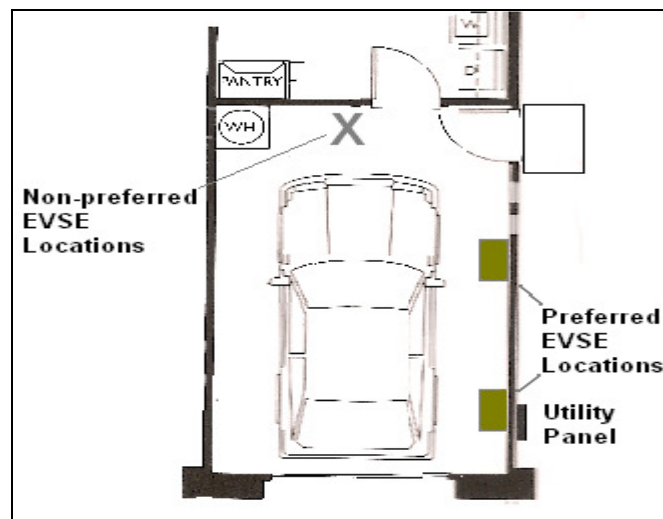


Figure 5-2: Typical Single Garage Location for EVSE

In the single garage, most locations will be acceptable for placement, except perhaps at the head of the vehicle, because of tripping concerns. The preferred locations are closer to the utility panel, reducing installation costs. Again, the option of using overhead support for the EVSE cable would allow EVSE installation where the owner prefers.

The National Electrical Code (NEC) provides additional requirements should the EVSE be located in a hazardous area. Any other materials stored in the garage also should be considered when placing the EVSE, particularly if they are hazardous.

Detached garages add additional considerations for routing the electrical supply to the garage. Landscaping may be affected during the installation process, which may be important to the owner and require thorough advanced planning.

Installation Process

Installing an EVSE in a residential garage typically consists of installing a dedicated branch circuit from an existing house distribution panel to an EV outlet receptacle (125 VAC, 15/20 A) for Level 1 or an EVSE (operating at 240 VAC, 40 A) for Level 2. If the garage is built with the conduit or raceway already installed from the panel to the garage, this task is simplified.

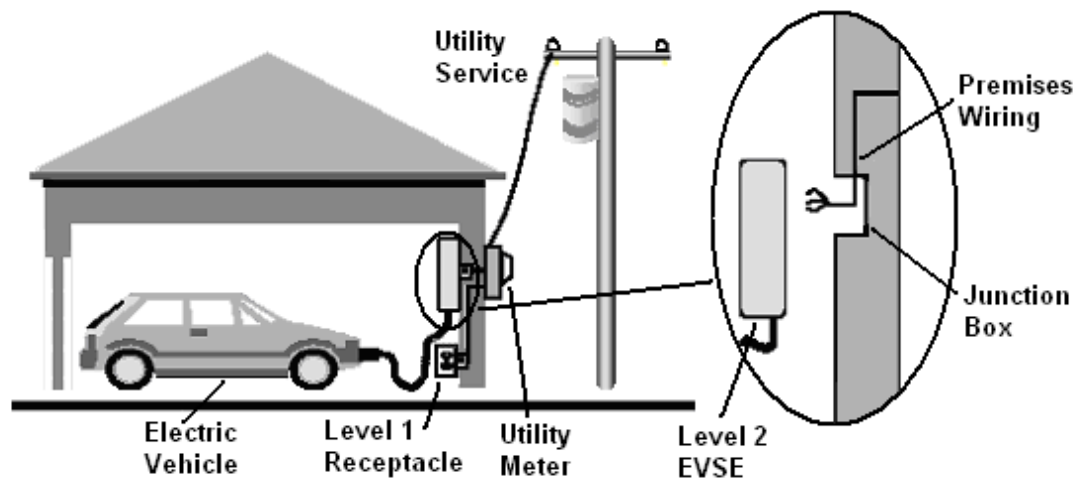


Figure 5-3: Typical Level 1 and Level 2 Installations for a Residential Garage

The steps involved in the installation process are shown in the flowchart in Figure 5-4. They include:

- Consultation with the EV dealer to choose Level 1 or Level 2 EVSE, determine whether ventilation will be required, and decide which EVSE to purchase
- Consultation with the retail electric provider to determine rate structure, as well as the electric transmission and distribution provider regarding any requirements for a special or second meter
- Consultation with a licensed electrical contractor to plan the installation effort, including location of the EVSE, routing the raceway from the utility service panel to the EVSE, Level 1 or Level 2 requirements, ventilation requirements, adequacy of current utility service, and preparing an installation quote
- Electrical contractor submission of required permitting documents and plans

- Completion of EVSE installation and utility service components, if required
- Inspection of final installation.

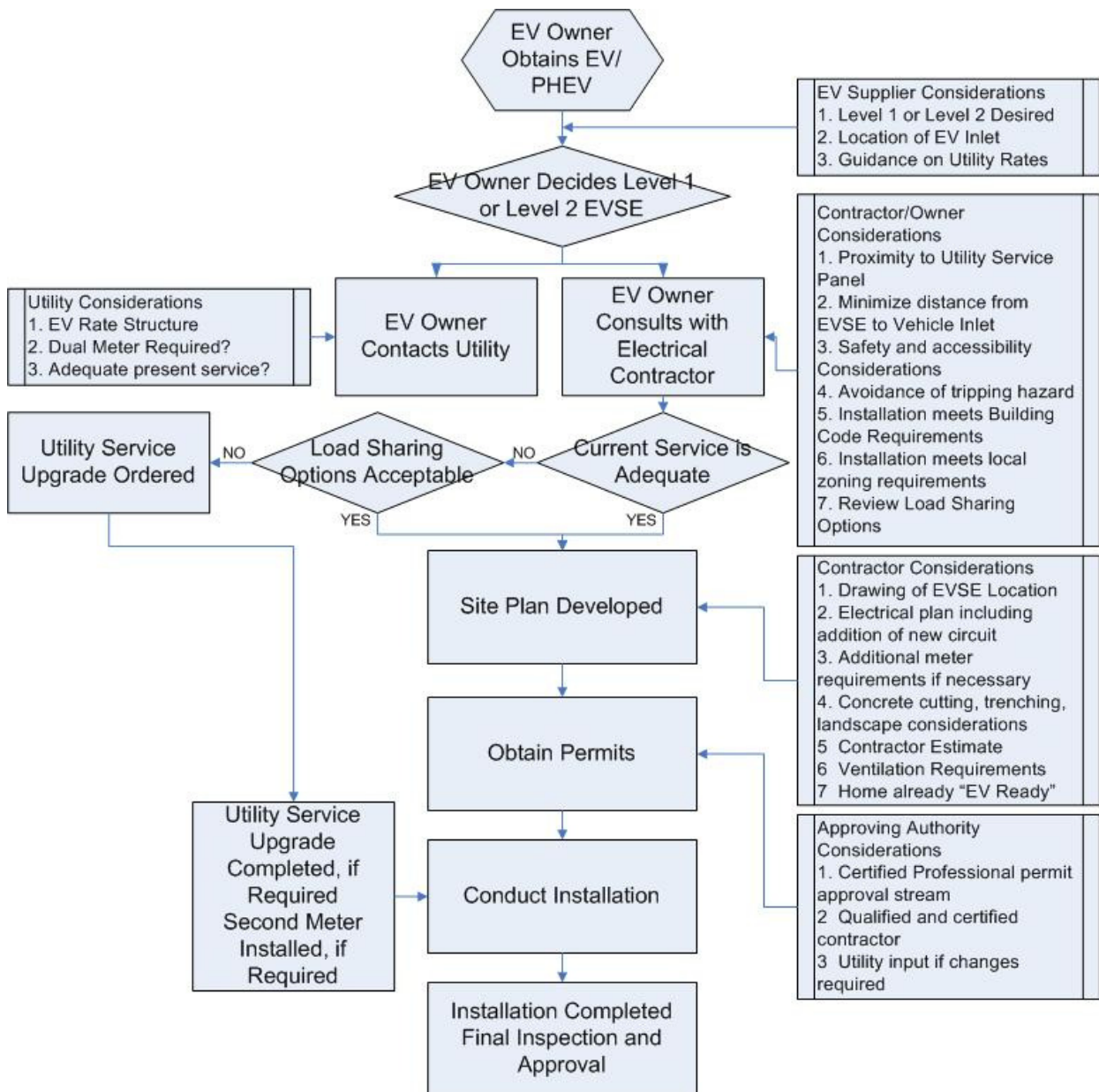


Figure 5-4 Installation Process for a Residential Garage/Carport

If the garage has a pre-existing raceway, a 120 VAC, 15/20 amp circuit or a 240 VAC, a 40 amp circuit can be installed. Some homes may not have sufficient utility electrical service to install this circuit. In that case, either a new service must be added, or a load control device must be installed so the home's electrical system is not overloaded (for example, by recharging at the same time that an electric dryer is in use).

Although a new home may already have the raceway installed, a permit for the service is required. Increasingly, standards are directing that a raceway for an electric vehicle will be included in new home construction. The conductors may or may not be included. If included, consideration should be given to sizing the conductors for the 240 VAC, 40 amp circuit required for Level 2 charging, but installing the 125 VAC, 20 amp Level 1 breaker and receptacle. The homeowner would then have a functional circuit that could be upgraded easily to Level 2.

The homeowner should contact an electrical contractor to evaluate the options for adding a new service versus upgrading the existing service. Utility fees may apply.

B. Carport

Power Requirements

Power requirements are the same as garage scenario above.

Cost Estimates

Costs will vary based on the length of the circuit run, electrical panel upgrades, and other factors specific to the building.

Siting Guidelines

The siting for a carport will include those identified for the garage. Some owners may elect to place the EVSE in the garage, but charge a vehicle outdoors. Since a carport is considered an outdoor area, the EVSE should be properly designed for exterior use. Consideration must be given to precipitation and temperature extremes. In Houston areas that experience high levels of precipitation, pooling of water in the carport or driveway may be a concern. While the EVSE is safe for use, owners may have a concern about standing in pooled water while connecting the EVSE. These concerns need to be addressed with owner when locating the EVSE.

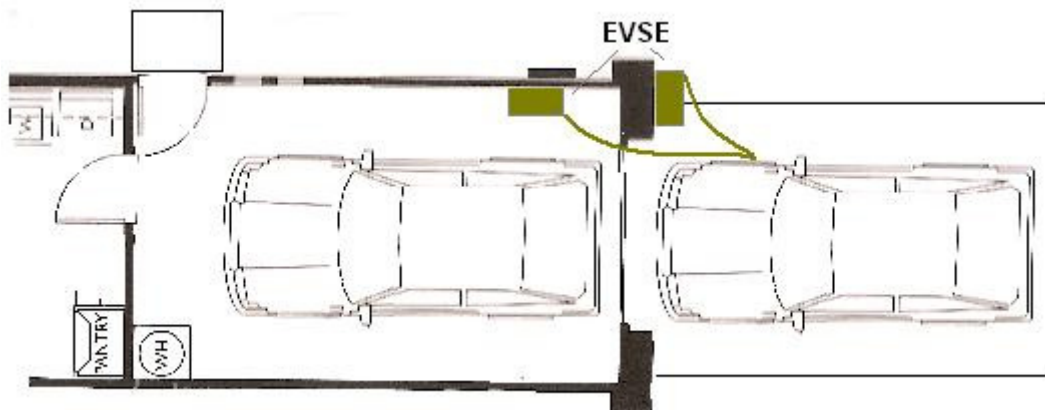


Figure 5-5 Installation Considerations for Outdoor Parking

Although occurring infrequently in the Houston area, freezing temperatures can cause cords to freeze to the parking surface, which is another reason to consider overhead cord support. Adequate lighting should be considered to mitigate concerns for vandalism, as noted in Section 6. The carport installation process is similar to the garage installation process previously outlined.

Consultation with Landlord or Homeowner's Association (HOA)

An installation in a multi-family location may involve a more lengthy approval process for zoning considerations. The local zoning requirements may require a public hearing or pre-approval by a Design Review Committee.

C. Multi-Family Dwellings

Power Requirements

Power requirements are the same as the garage scenario.

Cost Estimates

Costs will vary based on length of the circuit run, trenching, electrical panel upgrades, and other factors.

Siting Guidelines

Multi-family dwellings have additional considerations, because the apartment or condominium owner must be involved in any siting decisions. The EV owner will prefer a site close to the dwelling, but this may not be in the best interest of the apartment owner. Special flooding or drainage conditions may apply. Lighting and vandalism concerns will exist. Payment methods for the electrical usage will need to be identified. There may be insurance and liability questions. All of these concerns should be discussed with the property owner prior to the EV purchase.

If and when the EV owner later relocates, the electrical installation raceway and panel upgrades, if any, will be retained at the multi-family location. Ownership of the EVSE needs to be identified clearly. If the EV owner wants to take the EVSE when they relocate, site restoration may be required. Circuit removal or de-energizing methods should be settled. Discussion with the utility also is required, since there may be metering questions or issues to be resolved. Also, in condominiums, the HOA may be involved in approving EVSE additions and removals.

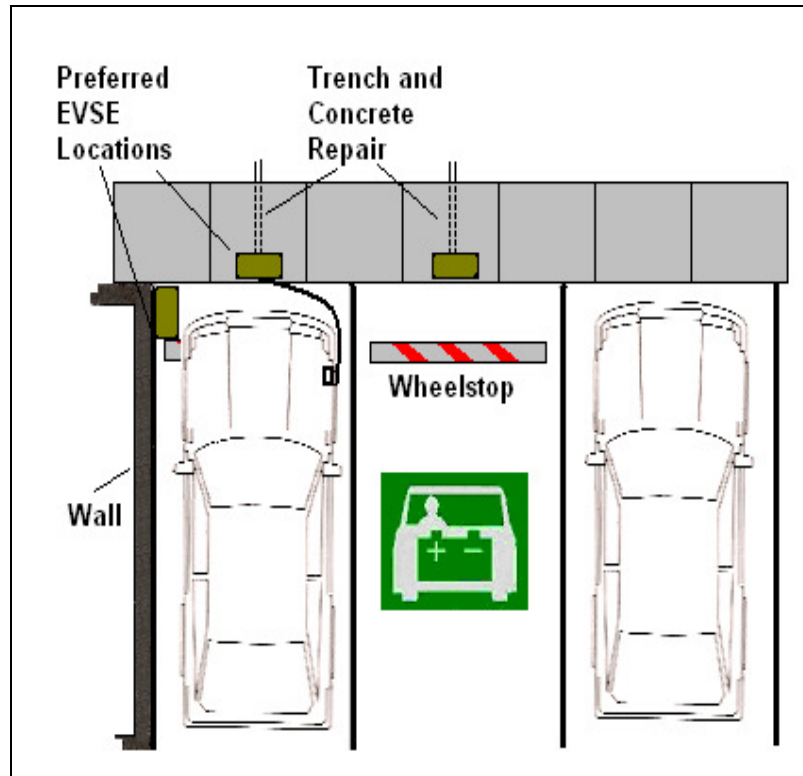


Figure 5-6: Typical EVSE Installation in Multi-Family Lot

In general, unless the location is well protected from the environment, the EVSE will need to be outdoor rated. Unless an adjacent wall is available, installation of the EVSE at the front of the vehicle may be the only choice. If located at the front of the parking stall, the EVSE should be installed on the vehicle side of any walkway to minimize the cord becoming a tripping hazard. If there is a walkway for pedestrians located as shown in the figure, the EVSE should be located so that the back of the EVSE faces the walkway. Because a wheel stop will be needed, EV parking should not be in an area of normal pedestrian traffic, to avoid creating a tripping hazard for pedestrians when no vehicle is present.

Trenching and concrete work and repairs are likely. Consideration must be given to maintaining a safe and secure area around the parking stall to avoid tripping hazards or EVSE interference with other operations.

Installation Process

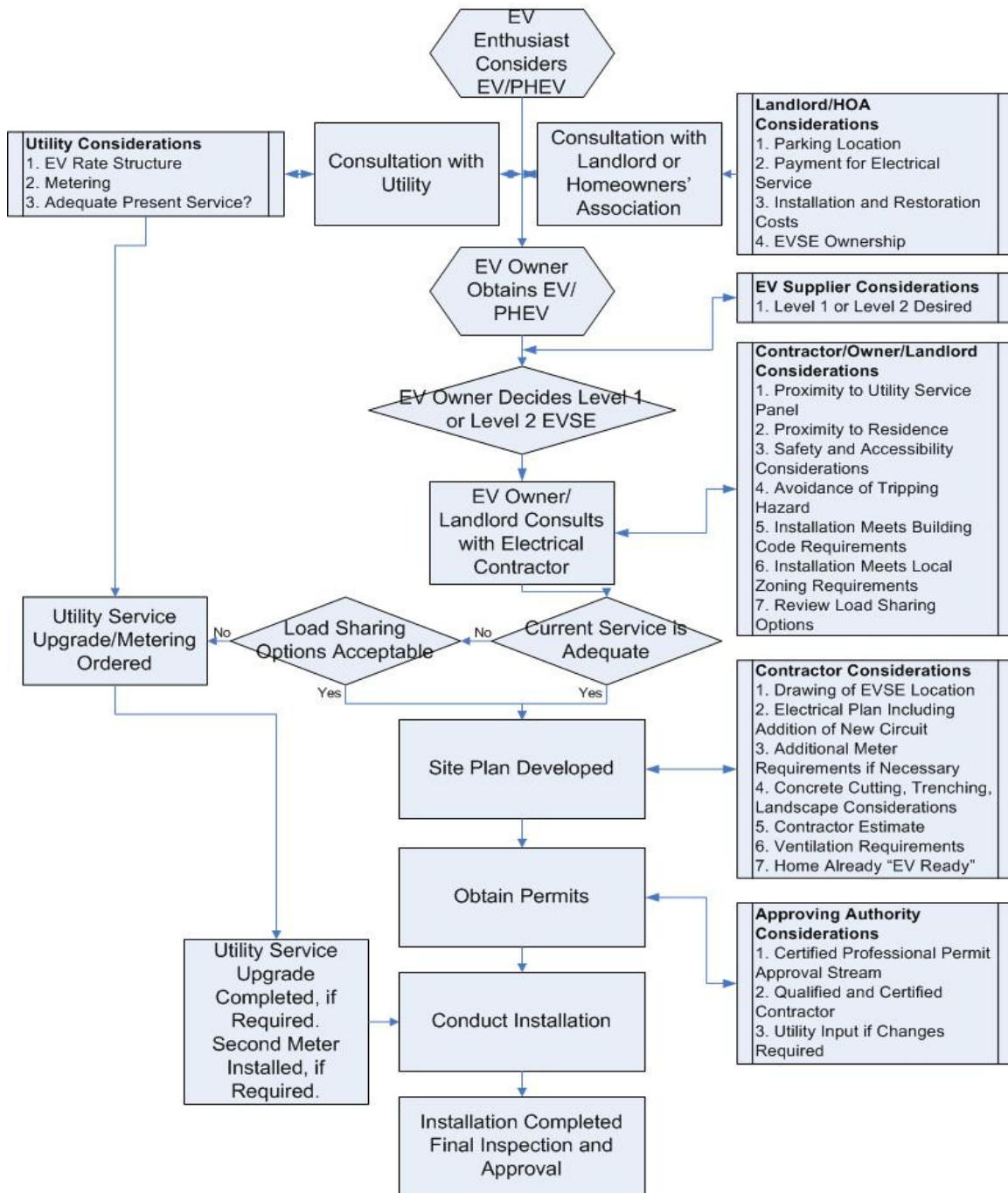


Figure 5-7: Installation Process for Multi-Family

If the parking area has a pre-existing raceway, the EV owner and property owner can determine if this will be a 120 VAC, 15/20 amp circuit or a 240 VAC, 40 amp circuit. This will require review by an electrical contractor to make sure the service panel is sufficient to support the choice. Although a raceway may have been installed previously, a permit for the service will be required.

Multiple Parking Stall Installation

In a new construction or retrofit situation, broad charging infrastructure installation in a multi-residential building will require the services of an electrical consultant to determine the best approach. For example, the EVSE owner may consider a load control strategy to manage the charging load within the capacity of the electrical service to the building, rather than upgrading the service size to accommodate increased building load from electric vehicle charging.

D. Commercial Fleets

Power Requirements

Commercial fleets will need dedicated branch circuits hardwired to permanently-mounted EVSE with the following specifications: 208VAC or 240VAC / single-phase, 4-wire (2 hot, GND, neutral), 40 amp breaker.

Commercial fleet charge stations generally will include multiple charging station locations, and therefore with new construction, these additional locations will need to be accounted for when sizing the electrical service. Since it is likely that most of the charging will occur during working hours, for existing buildings, the additional load may require an upgrade or a new electrical service.

Because of the potentially large electrical load, it is recommended that a network connection be provided in close proximity to the charge stations. This connection may be required for interface with the building energy management system or to implement local utility load control strategies.

Cost Estimates

Costs will vary based on length of the circuit run, trenching, electrical service upgrades, and other factors specific to the building or site.

Siting Guidelines

Presently, commercial fleets make up the highest population of EVs. A significant amount of planning is required to correctly size an EV parking and charging area. Consideration must be given to current requirements, as well as anticipated future requirements. Electrical service requirements will be much higher than residential or multi-family installations, and can have a significant impact on electrical usage and the utility. For that reason, electrical utility planners need to be involved early on in the fleet planning process.

Flood-prone area restrictions must be considered, as well as issues of standing water. Large parking lots may have low spots where water accumulates. Although a Level 2 EVSE contains the proper protection device for this issue, employees may not be comfortable operating the EVSE in standing water.

Installation of an EVSE unit in a commercial facility typically consists of installing new dedicated branch circuits from the electrical distribution panel to a Level 2 EVSE. In a commercial fleet, there are typically many such EVSE units in adjacent parking stalls. Proximity to the electrical service is an important factor in locating this parking area. The length of the circuit run and the number of units will have a significant impact on the cost.

Because these EVSE units are in a designated area, the potential for pedestrian traffic is less and more consideration can be given to the most economical installation methods. In addition, the commercial nature of the site will allow greater overall security, such as fences and gates, so the threat of vandalism is minimized.

Fleet managers must also be aware of other equipment that will be stored in the vicinity of the EVSE. It is important that a hazardous environment does not already exist in the area planned.

Fleet manager interests and priorities can also stimulate the development of DC Fast Charging. The higher recharge rate means a shorter turnaround for each vehicle and maximizes on-road time. The 480/600 VAC required for DC Fast Charging is generally available in commercial facilities.



Figure 5-8: Level 2 Commercial EV Charging Location

Installation Process

The commercial installation process is similar to the processes described previously, except that much more detailed planning is involved prior to the owner making the final decision and obtaining permits.

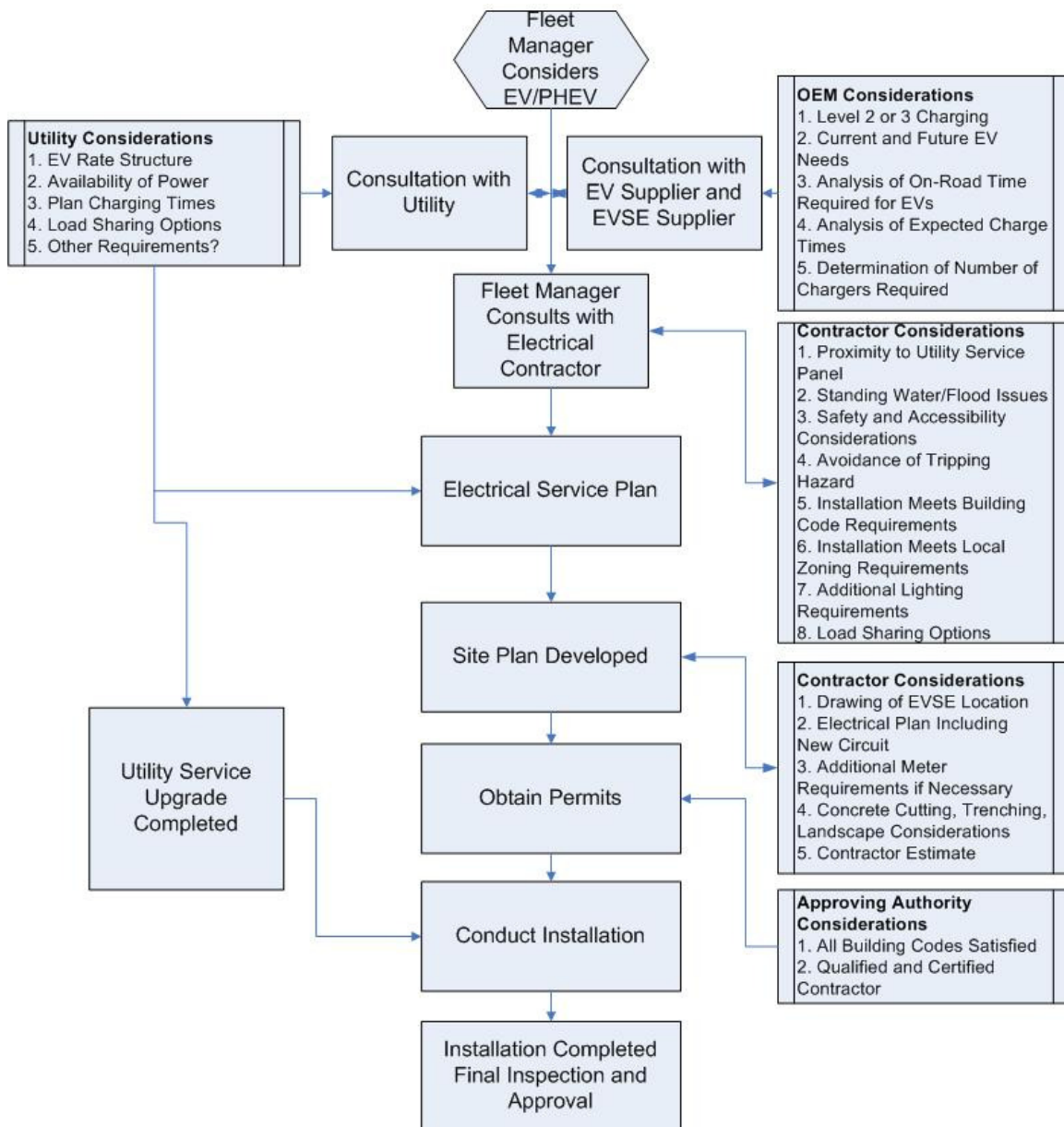


Figure 5-9: Installation Process for Commercial Fleet Operations

E. Publicly Available Charging Stations

Consumers will expect to be able to recharge at locations other than at their homes. This can be accomplished by the installation of publicly available charging locations. The EV Micro-Climate program and other planning efforts in the Houston area include this important consideration. As consumers become familiar with EV charging requirements and as battery technologies extend vehicle range, this consideration will change somewhat.

Publicly available charging may employ a mix of Levels 1, 2, and 3 (DC Fast) charging stations; however, the charge return generated by a dedicated Level 1 charging station would be minimal, and its use is neither recommended nor included in the EV Micro-Climate recommendations. The standard configuration for a publicly-available Level 2

charging station includes a J1772 connector. This accommodates all vehicles equipped with a J1772 inlet, including PHEVs and other EVs that require lower kW charging than a BEV.

Publicly-available charging may be served by either public or commercial charging stations. Public charging stations are those EVSE installed on publicly-owned property, such as city or county government property. Curbside chargers are another example. Commercial charging stations are EVSE stations installed on private or commercial property, such as retail locations.

The determination of publicly-available Level 2 EVSE charging sites should focus on locations where the EV owner will be parked for a significant period of time, i.e., 1 – 3 hours. An adequate level of recharge can occur during this time period. There are many types of locations where vehicle owners may park for this length of time. Examples include restaurants, theaters, shopping malls, governmental facilities, hotels, amusement parks, public parks, sports venues, arts productions, museums, libraries, outlet malls, airport visitor lots, and major retail outlets.

Businesses, such as electric utilities or others that wish to promote EV usage, may install public charging near their building entrance in highly visible areas, even though an EV owner's stay times at the building or facility may be shorter than the typical 1 – 3 hours. As noted above, these stations are recommended to be Level 2.

The site determination for publicly-available DC Fast Charging EVSE charging sites should focus on locations where the EV owner will be parked for a relatively short period of time, e.g., 15 minutes, during which an appreciable recharge can occur. Typical locations where vehicle owners might be expected to park for this amount of time include convenience stores, coffee houses, service stations, drug stores, and restaurants, among many other choices. For DC Fast Charging, the availability of 480/600 VAC is an important consideration.

Publicly-available charge stations will vary greatly in design and requirements. They also include a number of other requirements not found in residential and fleet applications, such as signage and point-of-sale systems, as described in Section 6.

LEED Building Certification

A driving force in the design, construction, and operation of facilities is the Leadership in Energy and Environmental Design (LEED) Green Building Rating System. It was developed as a voluntary program by the U.S. Green Building Council and it provides standards for environmentally sustainable construction, site location, and facility operation. It includes provisions for incorporating a CO₂ emissions reduction goal for company personnel and encouraging, through monetary incentives or preferred parking, the use of alternative fuel vehicles. It provides credits in its rating system for installing EV charging stations and suggests certain percentages of parking be devoted to alternative fuel vehicles. These locations will apply to both employees and to visitors using the facility. Companies interested in being LEED-certified are excellent sites for publicly-available charging stations.

Power Requirements

Level 2: Dedicated branch circuits hardwired to permanently-mounted EVSE with the following specifications: 208VAC or 240VAC / single-phase, 4-wire (2 hot, GND, neutral), 40 amp breaker.

DC Fast Charging: Dedicated branch circuit hardwired to permanently-mounted charger supplied with the circuit, as specified in the installation manual. DC Fast Charging chargers rated up to 30kW may require either 208VAC/3-phase or 480VAC/3-phase. DC Fast Charging chargers greater than 30kW probably will require 480VAC/3-phase.

Example Sizes

1. For 30kW output power, the typical input power requirements are:
 - 208VAC/3-phase, 4-wire (3-hot, GND), 125 amp breaker, -or-
 - 480VAC/3-phase, 4-wire (3-hot, GND), 60 amp breaker
2. For 60kW output power, the typical input power requirement is:
 - 480VAC/3-phase, 4-wire (3-hot, GND), 125 amp breaker

Communication between the vehicle and EVSE is generally preferred for any publicly-available charge station, but it is not necessarily required. Wireless methods will probably be utilized, but if a hardwired Internet connection is available, it is generally preferable to wireless.

Siting Guidelines

Siting guidelines for publicly available charging are similar to other scenarios previously discussed, but involve many additional considerations. Questions such as ownership, vandalism, payment for use, maintenance, and data collection are addressed in following sections.

Flood-prone area restrictions must be considered, as well as issues of standing water or high precipitation. As previously noted, despite the safety of the device, users may not be comfortable operating the EVSE in standing water. Unlike fleet use, an area designated for public use should be in a preferred parking area. Also unlike fleet use, the area will be available to the public, and therefore the potential for vandalism will be greater. Public chargers likely will be in a high pedestrian traffic area, so avoidance of creating tripping hazards is particularly important.

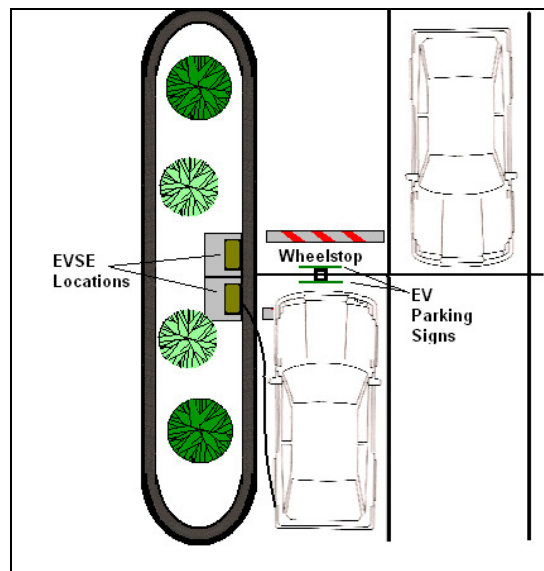


Figure 5-10: Publicly Available Charging Layout Example

There are several ways to address the protection of the equipment, shelter, signage, and pedestrian safety. The following pictures provide examples. Each graphic illustration show striped areas, bollards to protect EVSE, and paving signage denoting EV charging.



Figure 5-11: Publicly Available Charging Examples

Some publicly-available charging will be advanced by commercial businesses interested in promoting electric vehicle use through personal preference or as part of LEED certification. Commercial businesses may decide on their own to purchase and install systems or to share in these costs with other interests. Other business owners will be receptive to placement of chargers in their parking lots if incentives are available. Other public, private, and governmental agencies will install EVSE in support for EVs. Mapping these selected locations will provide input to an overall municipal or regional plan that identifies optimal sites that will help ensure sufficient publicly-available charging.

Publicly-available sites also will need to conform to accessibility requirements, as well as requirements for the number of parking stalls with EVSE that are accessible. This issue is discussed further in Section 6.

Lighting and shelter are extremely important in public sites for safety and security. The EV owner must feel safe when parking at night for charging. In addition, the EV owner must have sufficient lighting to read directions to properly locate the EV connector and insert it into the EV inlet. An indoor stall in a parking structure or a sheltered stall in the outdoor parking lot provides additional convenience for the EV owner (see Figure 6-3: *Public Charging with Shelter and Lighting*).

Installation of EVSE in a public area typically consists of installing new dedicated branch circuits from the central meter distribution panel to a Level 2 EVSE. Multiple EVSE units would be located in adjacent parking stalls for ease of charging, as well as to minimize costs. Proximity to the electrical service is an important factor in locating this parking area. The length of the circuit run and the number of units will have a significant cost impact.

The cost of providing power to the EV parking location must be balanced with the convenience of the parking location to the facilities being visited by the EV owner. It may be more convenient for the EV owner if a large shopping mall has two or three EV parking areas rather than one large area, although the cost for three areas will be greater than the cost for one.

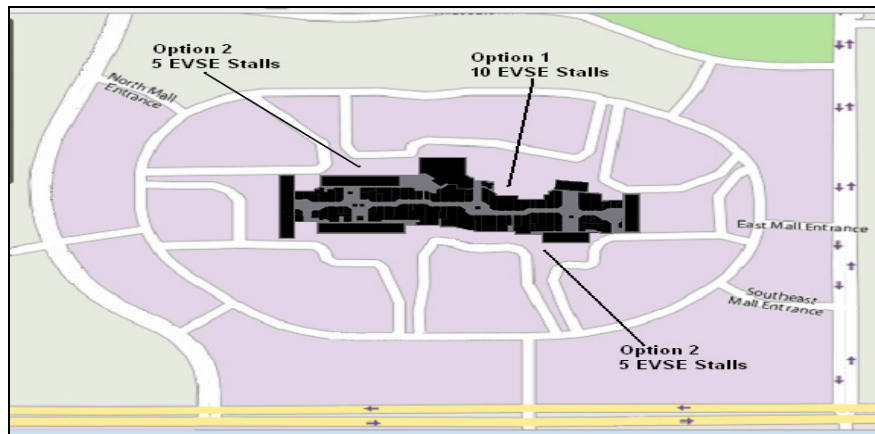


Figure 5-12 Shopping Mall EVSE Parking Example

Local concerns for area aesthetics are another consideration and may require the installation of landscaping or screening walls to shield the electrical transformer, panel, or other equipment from the public eye.

Trouble reporting is very important in public charging areas. Each publicly-available charging area should be equipped with a method whereby the EV user can easily notify the equipment owner of any equipment trouble. Public satisfaction will suffer if stations are out of service or not kept in an appealing condition. The trouble-reporting solution may be a normal business call number or a service call number that monitors many publicly-available charging locations. This requires some sort of communications line (either phone or internet). At a minimum, a sign may be posted at the EVSE location directing comments to a particular place or organization.



Figure 5-13: Indoor Charging



Figure 5-14: Outdoor Charging

Installation Process

The installation process is similar to the processes shown previously, but more detailed planning is required before submitting plans to obtain permits.

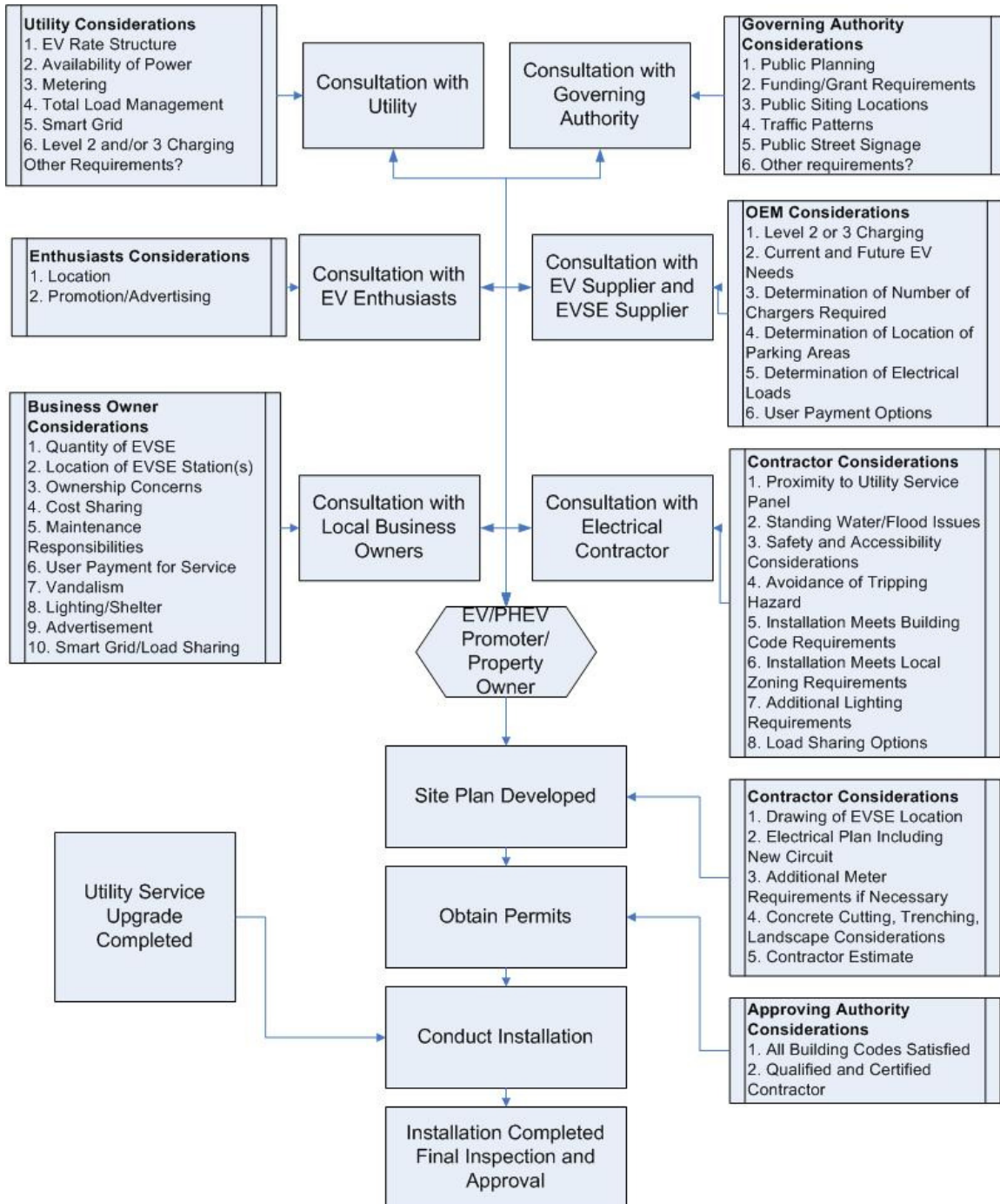


Figure 5-15: Installation Flowchart for Public Charging

The quality of the advance planning will determine the quality of the final installation and, ultimately, the EV owner's acceptance and satisfaction.

Curbside Charging

Curbside charging will normally occur in public right-of-way and is not necessarily associated with a commercial business. Generally speaking, such areas are owned by local or state governments rather than private interests. Many of the same considerations previously noted apply.



Figure 5-16: Curbside Charging

6. Additional Charging Considerations

A. Signage

In addition to the signs and warnings required by NEC, information signage is recommended for publicly available charging stations. Signage has two purposes: keeping non-EV vehicles from parking in charging station stalls, and helping EV drivers find charging stations.



Figure 6-1: MUTCD – FHWA Electric Vehicle Charging Station Sign (2009)

The *Manual on Uniform Traffic Control* (MUTCD) defines the standards used by road managers nationwide to install and maintain traffic control devices on all public streets, highways, and private roads open to the public. The example in Figure 6-1 follows MUTCD standards.



Figure 6-2: Wayfinding Sign

Maps and websites identifying charging locations are an essential part of expanded EV use. It is helpful to post EV parking area signs on adjacent streets and access points directing EV drivers to the charging locations. A wide variety of symbols for charging station wayfinding were developed in the mid-1990s. A number of designs have been suggested to update these symbols. Stakeholders have identified several criteria, including being able to symbolize the next generation of EVs that do not use lead-acid batteries, as well as modern charging stations that do not have a two-prong plug extending from the vehicle or charging station. As with other road and highway signage, a common design to indicate charging station locations will be developed for use on

federal and state highways and local streets. Standard blue highway information signs are currently used in Texas for alternative fuel station locations on limited access highways.

B. Lighting and Shelter

For commercial, apartment, condominium, and fleet charging stations, adequate lighting is recommended for convenience. Shelter is not typically required for outdoor-rated equipment. For geographic locations like the Houston area that have significant rainfall or snow, providing shelter over the charging equipment will provide added convenience for EV users. Locations within parking garages or private garages that are well protected from the environment may utilize EVSE that is not specifically outdoor rated.

Lighting should be sufficient to easily read associated signs, instructions, or controls on the EVSE and provide sufficient lighting around the vehicle for all possible EV inlet locations.



Figure 6-3: Public Charging with Shelter and Lighting

In residential garages or carports, lighting is also important, so pedestrians can avoid tripping over extended charge cords while the EV is charging.

C. Accessibility Recommendations

Current state and federal regulations do not provide design criteria that specifically address EV parking and charging; however, certain design requirements were added to the NEC for accessible EVSE, and some municipalities provide guidance for accessible EV parking locations. New standards may be developed; therefore, recommendations herein constitute the best guidance to date.

There are two possible scenarios to consider when establishing charging stations and accommodating persons with disabilities: where the primary purpose is EV charging, and where the primary purpose is accessible parking.

EV Charging is the Primary Purpose

When EV charging stations are provided at a site in addition to regular parking, EV charging is considered the primary purpose. Parking spaces with accessible EV charging stations are not reserved exclusively for the use of persons with disabilities and a disabled parking pass would not be required.

To enable persons with disabilities to have access to a charging station, EV connectors should be stored or located within accessible reach ranges. In addition, the charging station should be on a route that is accessible both between the charging station and the vehicle and all around the vehicle.

Accessible EV charging stations should be provided according to Table 6-1.

Table 6-1: Accessible Charging Station Recommendations

EV Charging Stations	Accessible EV Charging Stations
1 – 50	1
51 – 100	2

The accessible EV charging stations should be located in close proximity to major buildings and site facilities; however, these charging stations need not be located immediately adjacent to the buildings and other facilities like traditional ADA parking, since EV charging, not parking, is considered the primary purpose.

Accessible Parking is the Primary Purpose

If a charging station is placed in an existing accessible parking space, then the primary use of that space must be accessible parking; that is, a disabled parking pass would be required to park in this EV charging space.

The federal Americans with Disabilities Act, Revised Code of Texas, and Texas Administrative Code identify requirements for location, design, and number of parking spaces for persons with disabilities.

Note that it is important that the placement of the charging station in an existing accessible parking space allows adequate space (minimum of 36 inches) for a wheelchair to pass the vehicle wheel stop.

D. Safety Issues Related to Indoor Charging

The possibility of invoking the ventilation requirements or hazardous environment requirements of the NEC exists when installing indoor charging. When the EVSE connector makes contact with the EV inlet, the pilot signal from the vehicle will identify whether the battery requires ventilation. While most BEV and PHEV batteries do not require ventilation systems, some batteries, such as lead acid or zinc air batteries, emit hydrogen gas when charged. Most vehicle manufacturers will identify clearly that their batteries do or do not require ventilation. Without adequate ventilation, the hydrogen gas concentration may increase to an explosive condition. The EVSE contains controls to turn on the ventilation system when required, and also to stop charging should that ventilation system fail.

Recognizing that hydrogen is lighter than the air mixture, higher concentrations would accumulate near the ceiling. The ventilation system should take this into account by exhausting high and replenishing lower.

Indoor charging also can provide a challenge with respect to lighting, tight access, and storage of other material. Often areas in an enclosed garage can be poorly lighted, and when this is combined with tight access around the vehicle and other equipment stored in and around the vehicle parking area, the possibility of personal injury from tripping increases.

E. Installations Located in Flood Zones

Permits for constructing facilities, including EV charging stations, include reviews to determine whether the site is located in a flood-prone area. The Code of Federal Regulations, *Title 44 Emergency Management and Assistance, Part 60 Criteria for Land Management and Use*, includes the following requirement:

“If a proposed building site is in a flood-prone area, all new construction and substantial improvements shall (i) be designed (or modified) and adequately anchored to prevent flotation, collapse, or lateral movement of the structure resulting from hydrodynamic and hydrostatic loads, including the effects of buoyancy, (ii) be constructed with materials resistant to flood damage, (iii) be constructed by methods and practices that minimize flood damages, and (iv) be constructed with electrical heating, ventilation, plumbing, and air conditioning equipment and other service facilities that are designed and/or located so as to prevent water from entering or accumulating within the components during conditions of flooding.”¹¹

For EVSE components, elevation and component protection are the two primary methods for minimizing flood damage, preventing water from entering or accumulating, and resisting flood damages. These measures are required by the National Flood Insurance Program (NFIP).

The primary protection for EVSE is elevation. *Elevation* refers to the location of a component above the Design Flood Elevation (DFE). It is preferable for EVSE installation to be above the DFE. This may require EVSE to be located outside a garage if inside would be below the DFE; lower areas of a condominium parking lot to be barred from EVSE installation; and EVSE charging stations to be installed on the third level of a parking garage, rather than the first.

Component protection refers to the implementation of design techniques that protect a component from flood damage when they are located below the DFE.

Wet flood proofing refers to the elimination or minimization of the potential of flood damage by implementing waterproofing techniques designed to keep floodwaters away from utility equipment. In this case, the rest of the structure may receive damage, but the EVSE is protected by barriers or other methods.

Dry flood proofing refers to the elimination or minimization of the potential for flood damage by implementing a combination of waterproofing features designed to keep floodwaters completely outside of a structure.¹² If the entire building is protected from flood water, the EVSE is also protected.

¹¹ 44CFR60.3(a)(3)

¹² FEMA Publication 348, *Principles and Practices for the Design and Construction of Flood Resistant Building Utility Systems*, November 1999.

F. Point of Sale Options

During the Early Adoption stage of EV ownership, owners of publicly available charging stations may choose to absorb the cost of the electricity used, since this actual cost is low per use. However, as public acceptance and ownership of EVs grow, more EV owners will favor having the option for point of sale. In Texas, only electric utilities can actually sell electricity, so a fee for convenience/ service offers one option for this, pending approval by the Pacific Utility Commission of Texas (PUCT). A credit card transaction fee may actually exceed the electricity cost of charging an EV. However, the availability and convenience of charging is a service the public will expect with EVs, just as with refueling other vehicles. A fee for service is one option for the EVSE owner to recover the costs for equipment, installation, service, and maintenance. Several options for point-of-sale services are available, including card readers, parking area meters, and RFID subscription service.

Card Readers

Several types of card readers are available that may be incorporated with the EVSE. Credit/debit card readers are simple to use and are already widely accepted by the public. The credit/debit card would record a fee each time publicly available charging is accessed and base the fee on the number of times accessed rather than the length of time on charge.

A smartcard is a card that is embedded with a microprocessor or memory chip, so that it can securely store more detailed information than a credit/debit card. A smartcard could be sold with a monthly subscription for charger use and be embedded with additional user information. That information could be captured in each transaction and used for data recording, as noted in Section G. The smartcard could be used for a pre-set number of charge opportunities or billed to a credit card for each use.

Both cases will require a communication system from the reader to a terminal for off-site approval and data recording. Upon approval, power will be supplied to the EVSE. The cost of this system and its integration into the EVSE will be a design consideration.



Figure 6-4: Smartcard Reader¹³

¹³ ACR-38 Smart Card Reader by Advanced Card Systems.

Parking Area Meters

Drivers are very familiar with the parking meters used in public parking. A simple coin-operated meter is one option for EV parking areas, and can be installed at the head of each EVSE parking stall. Another method in common use at public pay parking lots is a central kiosk for credit card purchases. The parking stall number is identified at the kiosk and a parking receipt issued that can be displayed in the vehicle. There is little cost for the meter, and a single kiosk reduces the point of service cost for the whole parking lot. This system would require an attendant to periodically monitor the area for violations. Penalties for violators would need to be established. Coin-operated meters also provide an opportunity for vandalism.

Radio-Frequency Identification (RFID) Subscription Service

Like the smartcard, an RFID fob can be programmed with user information. The RFID reader collects the information from the fob to activate the EVSE station. A monthly subscription for the user keeps the fob active and the monthly fee can be based upon number of actual uses or a set fee. The reader is programmed for the accepted RFID.



Figure 6-5: RFID Fob¹⁴

¹⁴ Texas Instruments RFID.

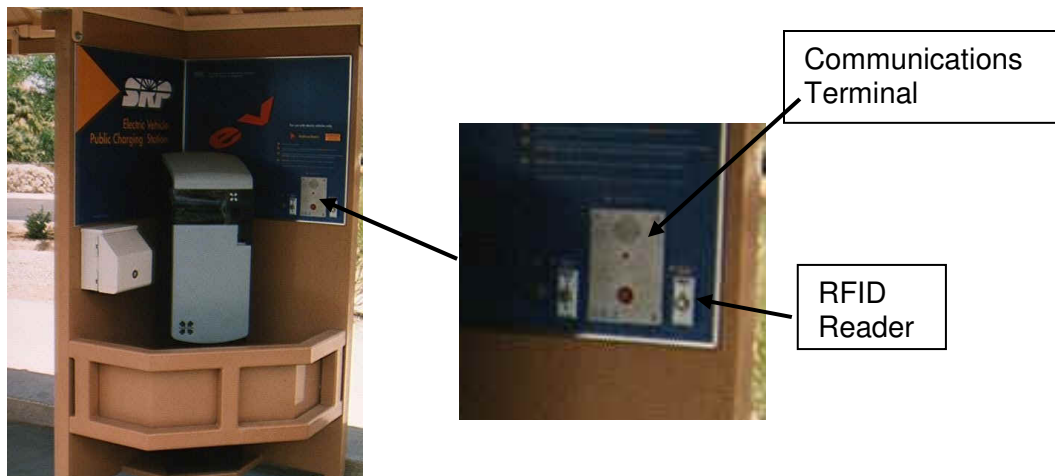


Figure 6-6: Reader and Communications Terminal

G. Data Collection

More than simply recording payment for service, the use of a smartcard or RFID can substantially increase the amount of information available at each publicly-available charging station. Data collection systems can track usage at each of the stations and provide feedback on actual EV usage. It may be found that usage at some venues is lighter than expected, whereas others may have heavier use. This information could be helpful in expanding or relocating publicly available charging locations. In addition, data for time of day usage may show peak usage at unexpected times, which may impact power utilization. Some EVSE may include features that allow a wide range of data to be collected.

H. Vandalism

Publicly available charging, like parking meters and other accessible outdoor equipment, carries the possibility of vandalism and theft. Destruction of property through purposeful defacing of equipment is a possibility; however, such destruction actually proved to be minor during EV usage in the mid-1990s. As public acceptance and the number of publicly available charging sites grow, steps are needed to minimize vandalism.

Most EVSE can be constructed of materials that will clean easily and can have graffiti removed. Careful planning for site locations to include sufficient lighting and equipment protection will discourage damage and theft. Motion sensor activated lighting may benefit users and deter abusers. EVSE with cable retractors or locking compartments for the EVSE cord and connector may be designed. Placing the EVSE in security-patrolled areas or within sight of manned centers will discourage vandalism.

EVSE owners in condominiums and apartments may wish to protect the equipment with a lockable, secure cabinet to prevent unauthorized use and for protection from vandalism.

I. Station Ownership

Ownership of the individual charging station may take several forms. A business owner may wish to host publicly available charging, but may not have the legal right to the parking lot or for making improvements. Charging stations constructed with public grants or other financing may have split ownership - one entity may own the charger and another may own the infrastructure. The sale of a business may include the EVSE or the sale of the property may include one of both components. EVSE may be rented or leased equipment. Before planning an installation, it is important to identify the entities that have legal rights with respect to the equipment and its installation. This will help determine whose approvals are required to obtain the permits and whose approvals are required to remove the equipment later?

The ownership of the EVSE will most likely reside with the owner. The management of the installation should reside with the property owner. However, both may share legal responsibilities and liabilities for the equipment and both should be protected by insurance.

For publicly available charging, there may be a combination of owners. Utilities may wish to own and manage the public charging infrastructure so that they may best manage power requirements. In a successful EV market, ownership of new public charging will likely shift to private ownership. Several businesses may join together to promote EV usage and may share in the EVSE ownership. However, there should be *one* individual business entity tasked with the responsibility of ownership, along with the proper contact information to be shared with the local utility.

J. Maintenance

The EVSE typically will not require routine maintenance. However, all usable parts can wear, and periodic inspections and testing should be conducted to ensure that all parts remain in good working order. Periodic cleaning may be required, depending on local conditions. Testing of communications systems and lighting should be conducted periodically. Repair of accidental damage or purposeful vandalism also may be required. Unless otherwise agreed, these responsibilities generally fall to the owner identified in Section I above.

7. Codes and Standards

During the 1990s, introduction of EVs, stakeholders representing the automotive companies, electric utilities, component suppliers, electric vehicle enthusiasts, equipment manufacturers, and standards and national testing organizations worked to obtain a consensus on methods and requirements for EV charging. This resulted in revisions to building codes, electric codes, first responder training, and general site design and acceptance documentation. These requirements were designed to protect the public and make EVSE accessible for use.

Equipment is designed to EVSE standards set by organizations, such as the Society of Automotive Engineers (SAE), and is tested through nationally-recognized testing laboratories, such as Underwriters Laboratories. This testing certifies that the equipment is suitable for its designed purpose. The equipment installation is required to follow the rules of the National Electric Code and Building Codes. Both of these codes can be augmented by state or local governing bodies. Frequently, the codes also affect the standards provided – as is the case for Electric Vehicles.

Nothing within these Guidelines should be construed to allow any detail of the EV charging installations to deviate from the adopted building codes and planning ordinances of each jurisdiction in which they are installed. The intent is to develop standard plans for each jurisdiction and to have those plans approved prior to requesting permits or inspection approvals from that jurisdiction. We understand that those standard plans may vary slightly from jurisdiction to jurisdiction based on their specific adopted building codes and planning ordinances.

To protect the public health and conform to safety regulations, local government regulatory agencies are responsible for monitoring the installation process to ensure that the proper codes and standards are being implemented.

A. Regulatory Agencies

The federal government, as well as state, county, and city governments, have model building codes established that provide minimum requirements for safe construction and installation processes.

For example, the City of Houston currently recognizes, among others, the International Building Code and the Texas Revised Statutes. These model codes, as well as national codes such as the NEC, are updated on a regular basis, based on industry performance and technical advances.

B. National Electric Code

The National Electric Code (NEC) is part of the National Fire Code series established by the National Fire Protection Association (NFPA) as NFPA 70. The NEC codifies the requirements for safe electrical installations into a single, standardized source. This code is adopted by state and local jurisdictions and may be augmented by those jurisdictions to be applied as the local practice. When identifying the electrical requirements for EVSE installation, it is important to work with the local jurisdiction to identify any local requirements in addition to the national code standard. The NEC is updated every three years. Although the current published, adopted edition is 2008, not all jurisdictions have approved this edition, and care should be taken to follow the electrical code currently in place for each jurisdiction. Section 625 of the NEC specifically addresses electric vehicles.

C. SAE and UL

Currently, the Society of Automotive Engineers (SAE) has determined that there will be a single conductive coupler design. The J1772 “SAE Electric Vehicle Conductive Charge Coupler” is the standard that is being used by automotive suppliers in the United States. While J1773, the Inductive Charge Coupler, is still active, none of the automakers are using this method.

Applicable SAE Standards include:

- SAE J1772
- SAE J2293
- SAE J2847
- SAE J2836
- SAE J2894
- SAE J551

SAE J2293 establishes requirements for EVs and the off-board EVSE used to transfer electrical energy to an EV from a utility source. This SAE document defines, either directly or by reference, all characteristics of the total EV Energy Transfer System (EV-ETS) necessary to ensure the functional interoperability of an EV and EVSE of the same physical system architecture. The ETS, regardless of architecture, is responsible for the conversion of AC electrical energy into DC electrical energy that can be used to charge an EV's storage battery. J2847 provides specifics on digital communications; J2836 provides a case for the use of digital communications between vehicle and EVSE; J2894 addresses on-board charger power quality; and J551 provides standards for electromagnetic compatibility.

Underwriters Laboratories (UL) provides testing and certification that equipment complies with relevant standards, especially in areas involving public safety. The following UL standards form a basis for certifying EVSE.

- **UL 2202** Electric Vehicle (EV) Charging System Equipment
- **UL 2231-1** Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits: General Requirements
- **UL 2231-2** Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits: Particular Requirements for Protection Devices for Use in Charging Systems
- **UL 2251** Plugs, Receptacles, and Couplers for Electric Vehicles

Equipment that successfully completes the testing is “certified”, “approved”, or “listed” as meeting the standard. In general, the SAE and UL requirements are more restrictive and are expected to be incorporated in harmonized standards.

D. Occupational Safety and Health

Under the Occupational Safety and Health Act (OSHA) of 1970, OSHA's role is to assure safe and healthful working conditions for working men and women by authorizing enforcement of the standards developed under the Act; assisting and encouraging the states in their efforts to assure safe and healthful working conditions; and providing for research, information, education, and training in the field of occupational safety and health.¹⁵

E. Engineering, Permitting & Construction

The process flowcharts shown in Figure 5-4, Figure 5-7, Figure 5-9, and Figure 5-15 all require permitting of the work. A typical permit application includes the name of the owner or agent; the physical address where the work will be conducted; the property's parcel number; the voltage and amperage of the system; the name, address, and license number of the qualified contractor performing the installation; whether additional trades will be involved; and other information required in that jurisdiction.

Service load calculations may be required. The electrical contractor will review the existing current service loading and consider the rating of the EVSE unit(s) to be installed. The contractor then will develop a new loading calculation to determine whether the existing service panel is adequate or new service will be required.

It is recommended that local methods be considered to streamline the permitting process for residential EVSE installations. For BEV purchasers, the Level 1 Cord Set provided with the vehicle will require a significant charge period, so in general, an EV owner will prefer a Level 2 EVSE. Keeping the time span from EV purchase to fully functional and inspected EVSE installation as short as possible will be important for customer satisfaction.

Installation drawing requirements may vary by jurisdiction, ranging from layouts for residential installations to a full set of plans for public charging. In general, an electrical contractor registered with the requirements for residential garage circuits.

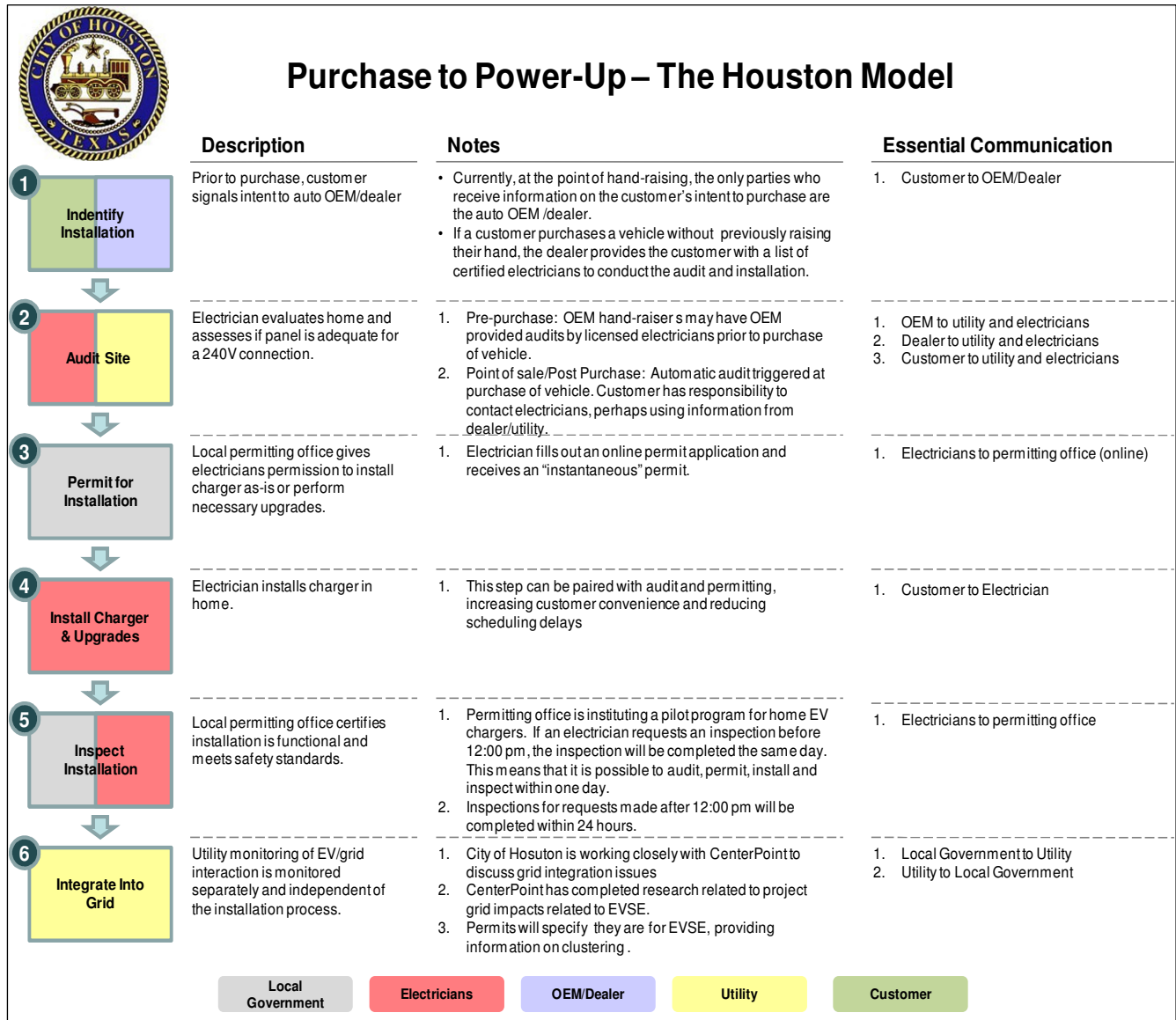
For fleet and public charging, an engineering company is recommended to prepare the detailed site plans for installation. Several trades may be involved, including general contracting, electrical, landscaping, paving, concrete, masonry, and communications systems. As noted above, careful planning is required to coordinate this effort, and an engineering company can provide the detailed set of drawings that will be required. In addition, there may be several permitting offices involved with the approval of these plans.

Commercial Electrical Contractor Participation

Local electrical contractors will be needed to help evaluate and install residential, commercial and public charging locations. It is recommended that contractors get in contact with EVSE suppliers, local government, auto dealerships and utilities to find out what programs are available for their participation. How the contractors fit into the Houston installation process is listed below in Table 7-1.

¹⁵ OSHA website www.osha.gov

Table 7-1: Purchase to Power-Up – The Houston Model



8. Utility Integration

A. Background

Electric utilities are under significant pressure to maintain a dependable, clean, low-cost electrical supply to their customer base. In order to achieve these goals, utilities are evaluating, and in some cases implementing, Smart Grid technologies that allow utilities to control various electrical loads on their systems. Through these Smart Grid technologies, utilities can minimize new power plant and electrical distribution and transmission investment by shifting and controlling load while minimizing the impact to the customer.

A retail electricity provider (REP) sells electric energy to retail customers where the sale of electricity is open to retail customers. REPs purchase wholesale electricity, delivery, and related services and seek customers to buy electricity at retail. A REP has responsibilities that include billing and collection from customers, serving as the direct contact for customers, developing an electronic interface system to communicate with market participants relating to meter information, and understanding and following the Utility Commission's rules and customer protection rules¹⁶.

Electrical transmission is the bulk transfer of electrical energy from generating power plants to substations located within populated areas. Transmission and distribution used to be owned by a single company, but numerous reforms have separated the transmission business from distribution. Power is transmitted through power lines at high voltages to reduce power loss. Energy transmission through underground means results in higher costs and causes greater operational limitations. Another limitation for distribution owners is that the energy cannot be stored, and therefore is generated on an as-needed basis. Recent developments have developed *merchant transmission*, in which a third party constructs and operates transmission lines through an unrelated utility's service area. Advocates claim that this will create competition and create low-cost additions to the transmission grids¹⁷.

Advanced Metering Infrastructure (AMI), also called *smart meters*, are being deployed by CenterPoint Energy to provide remote meter reading. Smart meters also have the ability to control various customer loads.

Electric vehicles are one of the better loads for CenterPoint to control through smart meters, because EVs have an on-board storage system. This means that delaying the charge of the battery has no noticeable impact on the customer, unlike turning off a lighting or air-conditioning load, which can have an immediate impact on the customer. Additionally, a neighborhood transformer may not be sized such that every EV-owning customer in an area can be charging at the same time. The ability to schedule the EV charging systems connected to a neighborhood transformer could significantly extend the life of that transformer, or delay and possibly eliminate the need to replace the transformer with a larger size.

¹⁶ <http://www.puc.state.tx.us/electric/business/rep/rep.cfm>

¹⁷ http://en.wikipedia.org/wiki/Electricity_transmission

As the adoption of EVs increases, load control strategies for multi-family dwellings may allow the utility to control charge times to maximize the effectiveness and utilization of existing transformers.

During residential EVSE installations, the electrical contractor will evaluate the electrical service capabilities of the existing system. If inadequate power is available at the service entrance, an electrical service upgrade shall be required.

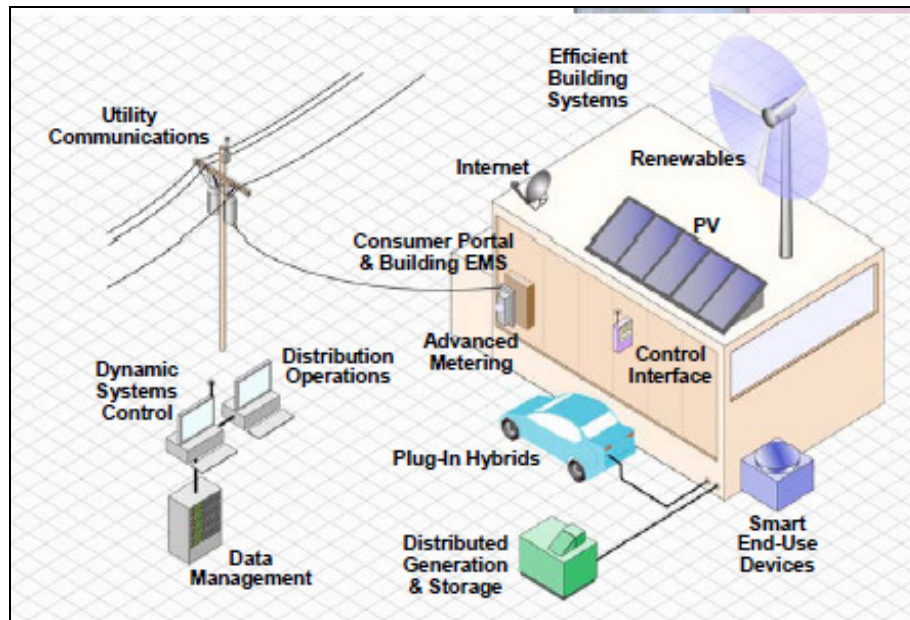


Figure 8-1: Smart Grid Infrastructure¹⁸

Figure 8-1 above incorporates many design features of a Smart Grid/distributed energy storage system. Home use of photovoltaic or wind energy can supplement the utility power. A home area network (HAN) communicating with a smart meter can control lighting, heating, cooling, and other major appliances. Given the right incentives, a home owner may elect to have the utility control total home consumption or deliver power back to the utility through the storage capability of the EV.

There are various mechanisms for utilities to control EV load, including:

- **Time-of-Use (TOU)**

TOU is an incentive-based electrical rate that allows the EV owner to save money by charging during a designated “off-peak” time frame established by the utility. Typically, these off-peak times are in the late evenings through early mornings and/or weekends, during a timeframe when demand on the utility electrical grid is at its lowest point. TOU is now being implemented by some utilities, but currently there is not a common approach. Discussion with

¹⁸ in Electric (PEV) Transportation Systems—Successful Integration of PlugSu, EPRI, *Plug-In 2009 Canada*, September 2009.

the local utility prior to installation of the charge station is recommended.

- **Dual Metering**

Some retail electric providers will provide a special rate for EV charging and will require the installation of a second meter specifically for this purpose. This will require additional installation time, since the electrical contractor shall install the meter before the EVSE is available for use. The use of a “revenue-grade” meter in the EVSE and a communications path to allow the utility control may obviate the need for the second meter.

- **Demand Response**

Demand response is a voluntary program that allows a utility to send out a signal to customers (typically large commercial customers) to cut back on loads during times the utility is experiencing a high peak on their utility grid. These customers are compensated when they participate in this program. As deployment of Smart Meters becomes more prevalent, EV owners may participate in such programs. Utilities may enter into contracts with EV owners to allow the utility to maintain more control over EV charging.

- **Real-Time Pricing (RTP)**

RTP is a concept that could be implemented in the future for EVs. In this model, pricing signals are sent to a customer through a number of communication mediums that allow the customer to charge their EV during the most cost-effective period. For example, the EVSE installed in the EV owner’s garage could be pre-programmed to ensure the car is fully charged by 6:00 am, at the lowest cost possible. RTP signals from the utility would allow this to occur without customer intervention. In order to implement RTP, smart meters would need to be in place at the charging location and the technology built in to the EVSE. These programs are under development at the time of this writing.

- **Vehicle-to-Grid (V2G)**

V2G is a concept that allows the energy storage in electric vehicles to be used to support the electrical grid during peak electrical loads, in times of emergency such as grid voltage support, or based on pricing economics. V2G could also support vehicle-to-home, where the energy stored in the vehicle battery could supplement the home’s electrical requirements. V2G requires that the on-board vehicle charger is bi-directional (energy is able to flow both in and out of the system). The EVSE at the premises must also be bi-directional and able to accommodate all of the utility requirements related to flowing energy back into the electrical grid. Although there are various development efforts in V2G, for on-road EVs, this concept probably is several years away from implementation in any commercial sense.

B. Interconnection Requirements

Although vehicle-to-grid (V2G) connections may be in the future for most applications, some infrastructure will incorporate EVSE with solar parking structures or other renewable resources. Because these systems will connect to the local grid, it will be necessary to contact the local utility to determine whether there are any interconnection requirements. These requirements are in place to protect personnel and property while feeding electricity back into the utility grid. Most utility requirements typically are already in place for solar photovoltaic and wind systems that are grid-tied to the utility.

Commercial Electrical Supply/Metering

In the Houston area, there are typically two scenarios for connection to a commercial electrical supply. The first is utilizing the existing main service entrance section (SES) or an otherwise adequate supply panel at the commercial establishment, and the second is to obtain a new service drop from CenterPoint.

The decision on which approach to take depends on a number of factors, including the ability to obtain permission from the property owner and/or tenant of the commercial business, and the location of the existing SES or adequate electrical supply from the proposed EV charging station site. If permission is granted by the property owner and/or tenant (as required), then a fairly simple analysis can be performed to compare the cost of utilizing an existing supply vs. a new service drop to determine the best approach.

A new utility service drop typically requires the establishment of a new customer account, which may include a credit evaluation of the entity applying for the meter, and a monthly meter charge in addition to the energy and demand charges. The local utility also may require an analysis of the anticipated energy consumption.

9. Summary & Conclusions

The establishment of a rich charge infrastructure environment requires significant resources. The Houston EV Project Community plan process has started with these *EV Charging Infrastructure Deployment Guidelines* to organize and drive the preparations for this infrastructure. With significant input from The Houston Advisory Team, whose membership represents a number of jurisdictions, utilities, and private sector organizations, this foundation paves the way for a long-range plan. These resulting *EV Charging Infrastructure Deployment Guidelines* should answer most questions about the deployment, provide helpful information to streamline project implementation in the coming months, and will lay out the process for planning, siting, permitting, and installing charge stations.