Electric Vehicle Charging Infrastructure Deployment Guidelines for the Central Puget Sound Area

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An ecotality Company

ELECTRIC TRANSPORTATION ENGINEERING CORPORATION

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Acronyms

AC	Alternating Current
ADA	Americans with Disabilities Act
AMI	Advanced Metering Infrastructure
ARRA	American Recovery and Reinvestment Act
BEV	Battery Electric Vehicle – vehicle powered 100% by the battery energy storage system available on-board the vehicle.
CCID	Charge Current Interrupting Device
DC	Direct Current
DCFC	Level 2 DC Fast Charger
DFE	Design Flood Elevation
DOE	U.S. Department of Energy
EPRI	Electric Power Research Institute
EV	Electric Vehicle
EV-ETS	Electric Vehicle-Energy Transfer System
EREV	Extended Range Electric Vehicle – see *PHEV*.
EVSE	Electric Vehicle Supply Equipment – equipment that provides for the transfer of energy between the electric utility power and the electric vehicle.
HOA	Homeowners Association
ICE	Internal Combustion Engine
IWC	Infrastructure Working Council
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
LEED	Leadership in Energy and Environmental Design
MUTCD	Manual on Uniform Traffic Control

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 – develops standards for electrical products.
NEV	Neighborhood Electric Vehicle
NFIP	National Flood Insurance Program
NFPA	National Fire Protection Association
OEM	Original Equipment Manufacturer – in this document refers to an automaker.
OHS	Occupational Health and Safety
OSHA	Occupational Safety and Health Act
PHEV	Plug-in Hybrid Electric Vehicle – vehicle utilizing a battery and an internal combustion engine (ICE) powered by either gasoline or diesel.
PV	Photovoltaic
RCW	Revised Code of Washington (State of Washington)
REEV	Range Extended Electric Vehicle – see *PHEV*.
RFID	Radio Frequency Identification
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
SES	Service Entrance Section
SBCC	Washington State Building Code Council
TOU	Time of Use – an incentive-based electrical rate established by an electric utility
UL	Underwriters Laboratory
V2G	Vehicle to Grid – a concept that allows the energy storage in electric vehicles to be used to support the electrical grid during peak electrical loads
VAC	Voltage Alternating Current

Electric Vehicle Charging Infrastructure Deployment Guidelines

1. Introduction

In 2009, the Washington State Legislature passed and Governor Gregoire signed HB 1481, which states:

> The legislature finds the development of electric vehicle infrastructure to be a critical step in creating jobs, fostering economic growth, reducing greenhouse gas emissions, reducing our reliance on foreign fuels, and reducing the pollution of Puget Sound attributable to the operation of petroleum-based vehicles on streets and highways. …it is essential that an infrastructure of convenient electric vehicle charging opportunities be developed. [1]

Concerns with global warming, oil shortages, and increasing gas prices, along with the rapid rise of more fuel-efficient vehicles, are clear indicators of changing consumer preferences and industry direction. As major automotive manufacturers plan to launch plug-in electric vehicles (EVs) in 2010, the future of transportation is being propelled by a fundamental shift to cleaner and more efficient electric drive systems.

ECOtality, Inc. (NASDAQ: ECTY), headquartered in San Francisco, California, is a leader in clean electric transportation and storage technologies. Its subsidiary, Electric Transportation Engineering Corporation (eTec) dba ECOtality North America (ECOtality), is the leading installer and provider of charging infrastructure for EVs. ECOtality has been involved in every major EV or plug-in electric vehicle (PHEV) initiative to date in North America and is currently working with major automotive manufacturers, utilities, the U.S. Department of Energy (DOE), state and municipal governments, and international research institutes to implement and expand the presence of this technology for a greener future.

ECOtality designed and currently manages the world's largest EV infrastructure demonstration - the EV Project. With a budget of over $230 million, the EV Project will deploy and study Level 2 alternating current (AC) electric vehicle supply equipment (EVSE) stations for residential use, Level 2 AC EVSE stations for commercial and Level 2 direct current (DC) fast charge (DCFC) stations representing thousands of field assets, utilized in concert with the deployment of Nissan LEAF™ vehicles and Chevrolet Volt vehicles.

The EV Project is a public-private partnership administered by the DOE through a federal stimulus grant, made possible by the American Recovery and Reinvestment Act (ARRA) and by the private investment of ECOtality and its partners.

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[1] RCW 47.80.090 [2009 c 459 § 1]

The EV Project is an infrastructure study. The EV Project will deliver to ECOtality, the Government and the general public a wealth of directly-applicable technical and professional experience for jumpstarting regional EV adoption and replicating business models that lead to sustainable, market-based charge infrastructures.

ECOtality and eTec developed the EV Micro-Climate© as an integrated turn-key program to ensure that an area is well equipped with the needed infrastructure to support the consumer adoption of electric transportation. Beginning with extensive feasibility and infrastructure planning studies, the program provides a blueprint to create a rich EV infrastructure. The program is developed with all relevant stakeholders, including governmental organizations, utilities, private-sector businesses, and automotive manufacturers.

This Guidelines document is not intended to be an installation manual or a replacement for approved codes and standards, but rather is intended to create a common knowledge base of EV requirements for stakeholders involved in the development of EV charging infrastructure. EVs have unique requirements that differ from internal combustion engine (ICE) vehicles, and many stakeholders currently are not familiar with these requirements. eTec's *Electric Vehicle Charging Infrastructure Deployment Guidelines* document provides the necessary background information for understanding EV requirements and the related codes, laws, and standards, and is 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 wherever it is directed.

2. Electric Vehicle Technology

This section describes the basic EV 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 that can 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

Battery Electric Vehicle (BEV)

Battery Electric Vehicles (BEVs) are powered 100% by the battery energy storage system available on-board the vehicle. The Nissan LEAF is an example of a BEV. A BEV is refueled by connecting it to the electrical grid through a connector system that is designed specifically for this purpose. Most advanced BEVs have the ability to recapture some of the energy storage utilized through regenerative braking (in simple terms, the propulsion motor acts 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. Sometimes manufacturers install solar photovoltaic (PV) panels on vehicle roofs. This typically provides a very small amount of energy relative to the requirements of propelling the vehicle, but integrating PV in the roof typically can provide enough power to operate some small accessory loads, such as a radio.

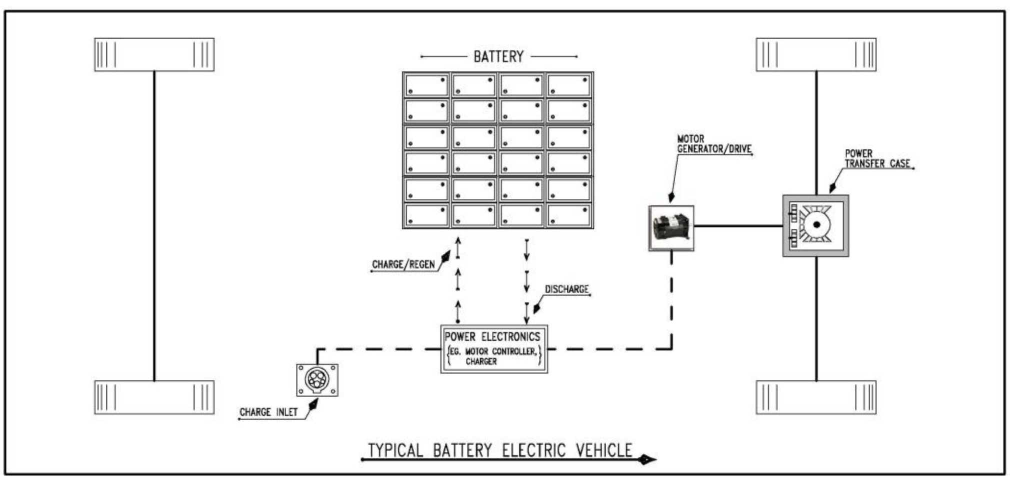

Figure 2-1 Battery Electric Vehicle

A typical BEV is shown in the block diagram in Figure 2-1. Since the BEV has no other significant energy source, a battery must be selected that meets the BEV range and power requirements. BEV batteries are typically an order of magnitude larger than the batteries in hybrid electric vehicles.

Plug-in Hybrid Electric Vehicle (PHEV)

PHEVs are powered by two energy sources. The typical PHEV configuration utilizes a battery and an ICE powered by either gasoline or diesel. Within the PHEV family, there are two main design configurations, a *Series Hybrid*, as depicted in Figure 2-2, and a *Parallel Hybrid*, as depicted in Figure 2-3. The Series Hybrid vehicle is propelled solely by the electric drive system, whereas the Parallel Hybrid vehicle is propelled by both the ICE and the electric drive system. As with a BEV, a Series Hybrid will typically require a larger and more powerful battery than a Parallel Hybrid vehicle in order to meet the performance requirements of the vehicle solely based on battery power.

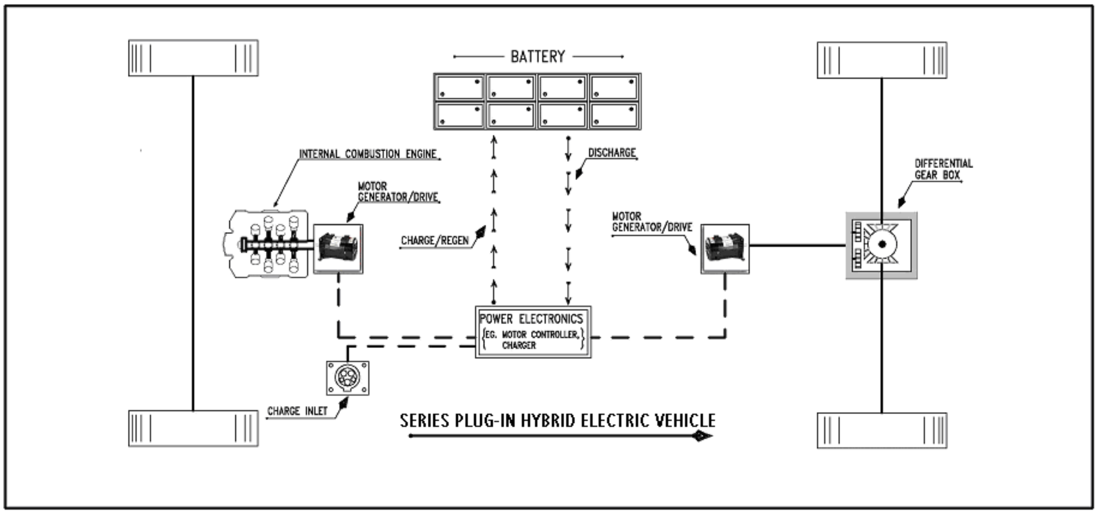

Figure 2-2 Series Plug-In Hybrid Vehicle Block Diagram

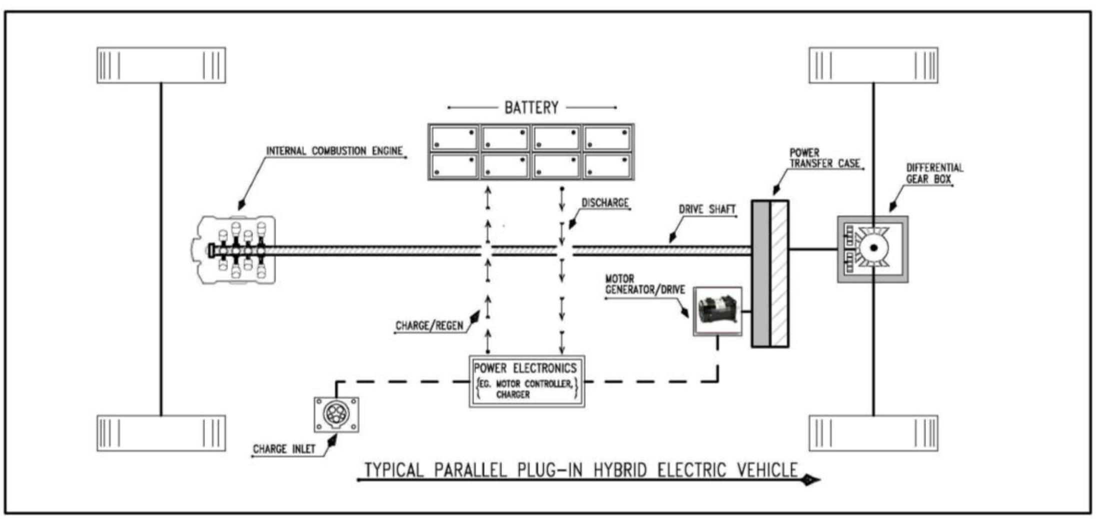

Figure 2-3 Parallel Plug-In Hybrid Vehicle Block Diagram

Manufacturers of PHEVs use different strategies in combining the battery and ICE. For example, the Chevy Volt utilizes the battery only for the first several miles, with the ICE generating electricity for the duration of the vehicle range. Other PHEVs 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 first 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 be broken down into the following categories:

- **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 ICE vehicles.
- **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 (NEV)**
  Neighborhood Electric Vehicles (NEVs), also known as *Low Speed Vehicles* (LSVs), are BEVs that are limited to 25 mph and are allowed in certain jurisdictions to operate on public streets posted at 35 mph or less.
- **Commercial On-Road Highway Speed Vehicles**
  There are a number of commercial EVs, including commercial trucks and buses. These vehicles are found as both BEVs and PHEVs. The performance and capabilities of these vehicles are specific to their applications.

The focus of the EV Micro-Climate program is on the first and last bulleted items above. Specialty vehicles such as electric motorcycles and bicycles require a different planning process.

C. Batteries

- **Battery Technology**
  Recent advancements in battery technologies will allow EVs to compete with ICE vehicles in performance, convenience, and cost. Although lead-acid technology serves many EV applications like forklifts and airport ground support equipment very cost-effectively, the limitations on energy density and repeated cycles of charging and discharging make its application to on-road highway speed EVs less practical.

  Today, most major car companies utilize nickel-metal-hydride or various lithium-based technologies for their EVs. Lithium provides four times the energy of lead-acid and two times that of nickel-metal-hydride. 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, auto manufacturers will increase the size of the lithium-based battery packs, and thus extend the range of electric vehicles.

- **Relative Battery Capacity**
  Battery size, or *capacity*, is measured in kilowatt hours (kWh). Battery capacity for electric vehicles 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 fuel source. BEVs rely completely on the storage 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 or 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 120 volts AC (VAC), 15 amp circuit will deliver at minimum 1.2 kW to a battery. A 240 VAC, 40 amp circuit (similar to the circuit used for household appliances like dryers and ovens) will deliver at minimum 6.5 kW to a battery. Table 2-1 provides information on several different on-road highway speed electric vehicles, their battery pack size, and charge times at different power levels to replenish a depleted battery.

Table 2-1 EV Charge Times

		Circuit Size and Power in kW Delivered to Battery			
EV Configuration	**Battery Size (kWh)**	**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 15 m	n/a
PHEV-40	16	13 h 20 m	10 h	2 h 28 m	16 m
BEV	24	20 h	15 h	3 h 41 m	24 m
BEV	35	29 h 10 m	21 h 50 m	5 h 23 m	35 m
PHEV Bus	50	n/a	n/a	7 h 41 m	50 m

Note: Power delivered to battery calculated as follows: 120VAC x 12Amps x.85 eff.; 120VAC x 16Amps x .85 eff.; 240VAC x 32 Amps x.85 eff.; 480VAC x √3 x 85 Amps x .85 eff.

D. Automaker Plans

Many automakers have announced plans for the introduction of on-road highway speed EVs in the near future. Figure 2-4 summarizes of these plans.

Plug-In Hybrid Electric Vehicles

Company	Model	Price	Battery Type	Battery Size	EV Range (miles)	PHEV Type	Market launch	Production Capacity
BYD	F3DM	$21,915	Lithium-ion	-	62	-	2008	
BYD	F6DM	~$22,000	Lithium-ion	-	62	-	2008	
Fisker	Karma	$87,900	Lithium-ion	22 KWh	50	Series	2010	15k
Ford	Escape PHEV	-	Lithium-ion	10 KWh	30-40	-	2012	
GM	Chevrolet Volt	~$40,000+	Lithium-ion	16 KWh	40	Series	2010	60k by 2012
Opel	Ampera	-	Lithium-ion	16 KWh	40	Series	2012	
Toyota	Prius	~$48,000	Lithium-ion	-	12-18	Parallel	2010	20k-30k
Volkswagen	Golf Twin Drive	-	Lithium-ion	12 KWh	30	-	2010	20 car pilot

Electric Vehicles

Company	Model	Price	Battery Type	Battery Size	EV Range (miles)	Latest Model	Market launch	Production Capacity
BMW	Mini E	-	Lithium-ion	35 KWh	~100+	2009	n.d.	500 pilot
BYD	E6 EV	-	Lithium-ion	18 KWh	249	2009	2009	
Chery Auto.	S18 EV	~$15,000	Lithium-ion	13 KWh	93	2009	2009	
Chrysler	Dodge circuit	-	Lithium-ion	26 KWh	150-200	2010	2010	
Coda	EV Sedan	$45,000	Lithium-ion	34 KWh	90-120	2010	2010	
Ford	Focus EV	-	Lithium-ion	-	100	2011	2011	
Mitsubishi	iMiEV	~$46,000	Lithium-ion	16 KWh	100	2009	2009	20,000
Nissan	EV LEAF	~$24k to ~$34k*	Lithium-ion	24 KWh	100	2010	2010	150,000+
Renault	Fluence ZE (Better Place)	-	Lithium-ion	-	100	2011	2011	100,000
Smart	EV	-	Lithium-ion	-	70	2010	2010	
Subaru	Stella	$47,900	Lithium-ion	9 KWh	55	2009	2009	~170 in 2009
Tesla	Model S	$57,400	Lithium-ion	-	160-300	2011	2011	
Tesla	Roadster EV	$109,000	Lithium-ion	53 KWh	244	2009	2009	
Th!nk	City	$28,000	Sodium or Li	-	110	2010	2010	2,500 (US)

Source: Company data, Credit Suisse estimates

Figure 2-4 Automaker PHEV and BEV Plans[2]

[2] Source: pluginamerica.org, cars.com, allcarselectric.com, wired.com

3. Charging Requirements

This section covers the terminology and general requirements of EVSE, which provide for the safe transfer of energy between electric utility power and an electric vehicle.

A. Charging Components

The terms used to identify the components in the delivery of power to the vehicle are defined first.

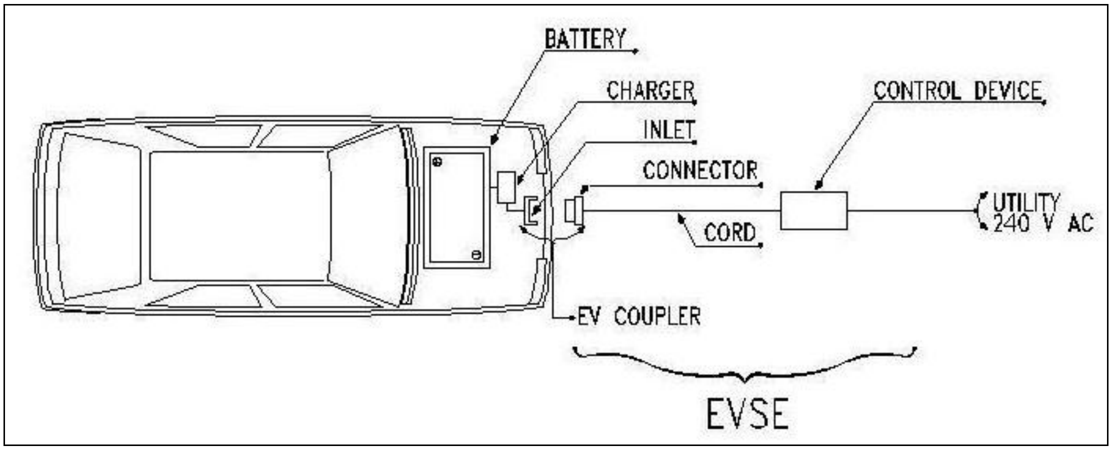

Figure 3-1 Level 2 Charging Diagram

Power is delivered to the EV's onboard battery through the *EV inlet* to the charger. The *charger* converts AC to the 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 3-1, or a plug and receptacle, as illustrated in Figure 3-3.

During the 1990's, 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*.[3]

J1772 Connector

J1772 Inlet (right side)

Figure 3-2 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.

[3] 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.

- 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 consensus on several aspects of EV charging. Charging levels 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[4].

Note: 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.[5]

Level 1 – 120 VAC

The Level 1 method uses a standard 120 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 VAC. Typical amp ratings for these receptacles are 15 or 20 amps.

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

[5] AC Level 3 (delivering high-power AC directly to the vehicle) is defined within the SAE J1772 document, but this approach has not been implemented as yet.

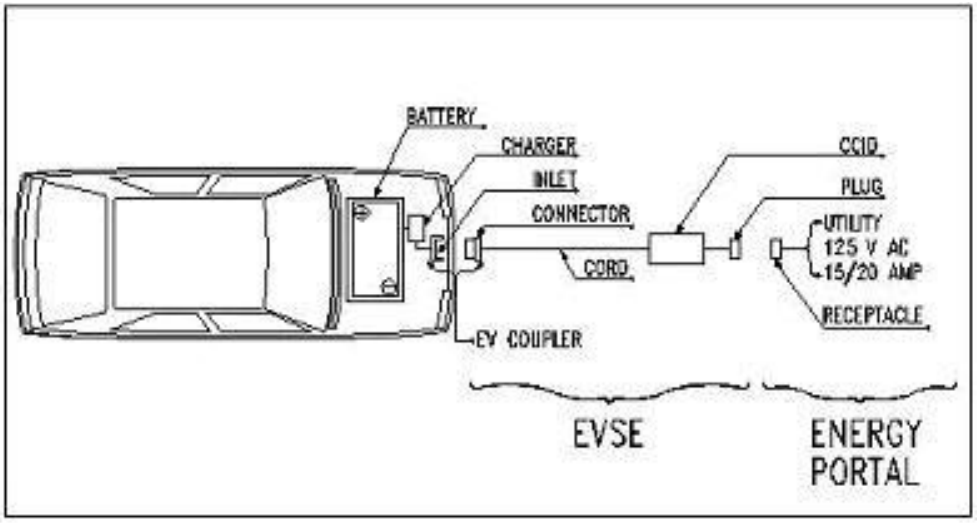

Figure 3-3 Level 1 Charging Diagram

Figure 3-4 Level 1 Cord Set[6]

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

Future EV suppliers probably will provide a Level 1 Cord Set (120 VAC, 15 or 20 amp) with the vehicle. The Cord Set will use a standard 3-prong plug (NEMA 5-15P/20P) with a charge 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.

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[6] Conceptual Design for Chevy Volt, *Electrifying the Nation, PHEV Summit*, Tony Posawatz, January 2009

Because charge times can be very long at Level 1 (see Table 2-1), many EV owners will be more interested in Level 2 charging at home and in publicly available locations. Some EV manufacturers suggest their Level 1 Cord Set should be used only during unusual circumstances when Level 2 EVSE is not available, such as when parked overnight at a non-owner's home.

Several companies provide kits to convert ICE and hybrid vehicles to plug-in vehicles. Many of these conversions use a standard 3-prong electrical plug and outlet to provide Level 1 charging to their vehicles. With the standardization of EVs on the J1772 Standard and the higher level of safety afforded by a J1772-compliant charging station, existing vehicles will need to be retrofitted to accommodate a J1772 inlet in order to take advantage of the deployment of EVSE infrastructure.

Level 2 – 240 VAC

Level 2 is typically described as the "primary" and "standard" method for the EVSE for both private and publicly available facilities. This method specifies a single-phase branch circuit with typical voltage ratings from 220 – 240 VAC. The J1772-approved connector allows current as high as 80 amps AC (100 amp rated circuit). However, current levels that high are rare, and 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.

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 NEC, including the requirement that the connector and cord be hardwired to the control device and premises wiring, as illustrated in Figures 3-1 and 3-5.

Figure 3-5 Level 2 Charging

Level 2 DCFC

DCFC was developed for commercial and public applications, and is intended to perform in a manner similar to a commercial gasoline service station in that recharge is rapid. Typically, DCFC would provide a 50% recharge in 10 to 15 minutes. DCFC typically 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. The off-board charger is serviced by a three-phase circuit at 208, 480, or 600VAC.

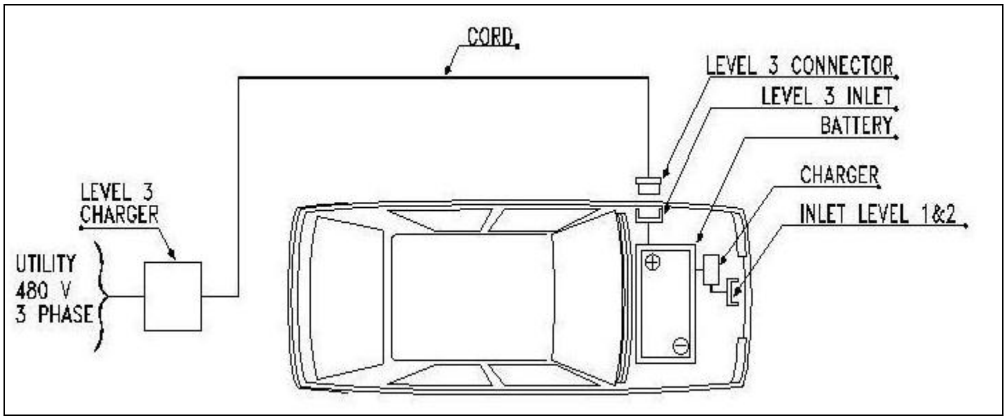

Figure 3-6 DCFC

The SAE standards committee is working on a higher-powered J1772 Level 3 method, but placed the highest priority on approving the J1772 Level 1 and 2 connector first. The Level 3 standard is expected to be approved in 2011 – 2012.

In 2010, eTec will be manufacturing DCFC equipment that uses a standard developed in Japan and approved by the Underwriters Laboratory (UL) (DC fast charging was accomplished by eTec for the Chrysler EPIC in the 1990s and for industrial applications since 1998).

Note: Although it is 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 EV would only have 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 not be compatible with typical publicly available infrastructure.

C. Level 1 versus Level 2 Considerations

For a BEV owner (and some PHEV owners who choose the utility time of use rates), the preferred method of residential charging will be Level 2 (240VAC/single phase power) in order to provide a reasonable charge time and to also allow the local utility the ability to shift load as necessary while not impacting the customer's desire to obtain a full charge by morning. For other PHEV owners, a dedicated Level 1 circuit may adequately meet the owner's charging needs.

Level 1 will suffice for some BEV owners who have the opportunity for Level 2 charging at work or in public areas, as they may find the vehicle battery remains at a higher charge and thus home charging time is not a concern. See Figure 2-1 for relative battery sizes and estimated recharge times.

D. General Requirements

This section identifies general requirements of 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., UL). 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 the wall location to the EV inlet. This figure was obtained by starting with the typical 15-foot car length, adding that to a 7-foot car width, plus 3 feet to the EVSE's permanent location. The EV inlet location on the EVs will vary by manufacturer; however, this standard length should be sufficient to reach from a reasonably-positioned EVSE station to the inlet.
- **Tripping hazard**: An extended EV cord may present a tripping hazard, so the EVSE should be located in an area of minimum pedestrian traffic. An alternative would be to consider installation of an overhead support or trolley system to allow the cord to hang above the vehicle in the location of the EV inlet.

- **Ventilation Requirements:** If there are ventilation requirements, the EVSE will be required to energize a properly-sized ventilation system. This requirement is expected to be rare, since automobile manufacturers are expected to use non-gassing batteries. An approved EVSE will communicate with the vehicle, and if ventilation is required but no ventilation system exists, the EVSE will not charge the vehicle. In multi-family or parking garage situations that already may have ventilation systems for exhaust of normal vehicle emissions, that system typically would be expected to be sufficient; however, this should be verified. It also may be impractical to wire the charger to the ventilation controls or too costly to run the system for a single vehicle charging. In these cases, it may be prudent to specify that the chargers are intended for non-gassing batteries only.
- **Energized Equipment:** Unless de-energized by the local disconnect, the EVSE is considered 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 may be positioned in a way that requires a physical barrier for its protection. Wheel stops are recommended to prevent a vehicle from contacting the EVSE. They also help position the EV in the optimum location for charging.

Figure 3-7 Wheel Stop[7]

Figure 3-8 Garage Wheel Stop[8]

- **Shortest Run**: In addition to the above requirements, the lowest-cost installation generally is the location closest to the electrical supply breaker, because it minimizes the conduit run to the charger.
- **Ergonomics/Ease of Use:** Most EV owners will find it most convenient to have the EVSE located near the EV inlet. In some cases, it may be desirable to back into the garage, which helps reduce the tripping hazard while at the same time reducing the electrical circuit run to the EVSE.

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[7] Rubberform Recycled Products LLC, www.rubberform.com

[8] ProPark Garage Wheel Stop, www.organizeit.com

4. 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, Neutral), 40Amp Breaker.

  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 30Amp breaker for their recommended EVSE, in which case the breaker can be easily changed.
  - The Neutral may not be required by some EVSE, but since it is inexpensive to include and may be required in the future if a different vehicle is purchased, it is recommended.
  - 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, it is likely that a wireless connection will be available if a hardwired connection is not present.
  - Many Level 2 EVSE suppliers will provide controls in the EVSE to allow charging at programmable times to take advantage of off-peak power pricing. If not, homeowners may wish to install a timer device in this circuit to control charging times.

Cost Estimates

$2,000 - $2,500 for a generic installation. Costs will vary based on length of the circuit run, electrical panel upgrades, and other factors.

Siting Requirements

An indoor-rated EVSE is acceptable for an enclosed garage. The EV owner probably will prefer a particular location for the EV. However, the EV should be positioned so that the above general requirements are considered. This often means that the EV will be positioned at the furthest point from the residence entry into the garage.

The installation of the EVSE at the front of the vehicle may be acceptable unless the cord becomes a tripping hazard. Often the EVSE will be placed on an exterior wall to shorten the distance from the electrical box, and at the same time position 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 will 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 spread out on 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 above. Typical locations are shown in the figure below.

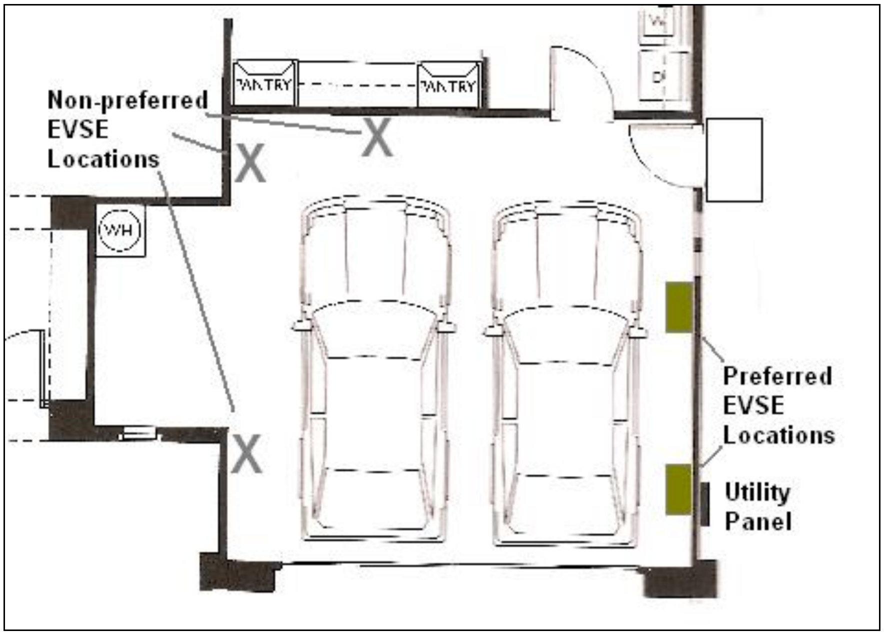

Figure 4-1 Double Garage Location for EVSE

In the above figure, the best location would be for the EV on the right. The non-preferred EVSE locations are in typical walking areas and could present a tripping hazard. In addition, these are further away from the utility panel. An option for the EV owner who wishes to place the EVSE in these locations could be to use an overhead support for the charge cable and connector. If the EV inlet is on the left side of the vehicle, the owner could consider backing into the garage.

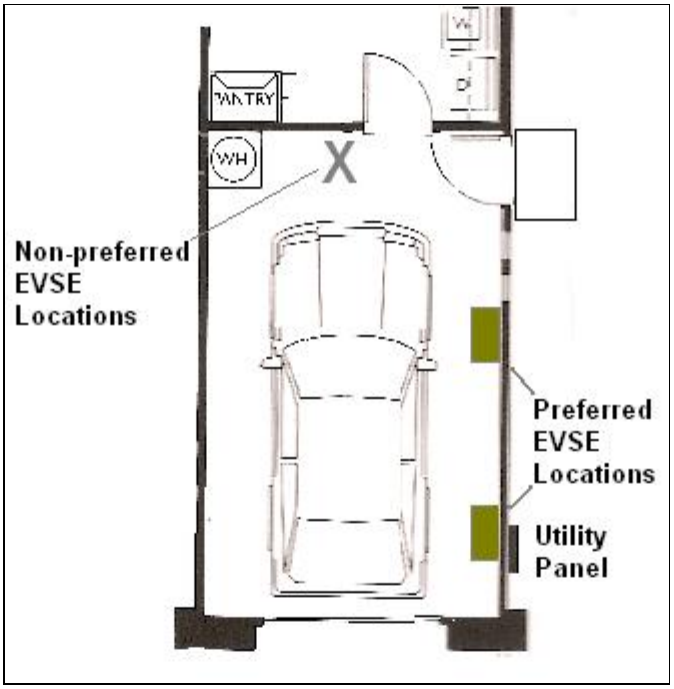

Figure 4-2 Typical Single Garage Location for EVSE

In the single garage environment, most locations will be acceptable for locating the EVSE, except perhaps at the head of the vehicle because of tripping concerns. The preferred locations were selected due to their proximity to the utility panel. Again, overhead support of the EVSE cable would allow EVSE installation where the owner prefers.

The NEC provides additional requirements should the EVSE be located in a hazardous area. If other materials stored in the garage are determined to be of a hazardous nature, they also should be considered when locating the EVSE.

Detached garages will involve additional considerations when routing the electrical supply to the garage. Landscaping could be disrupted during the installation process, and installation should be planned thoroughly in advance.

Installation Process

Installation of the EVSE in a residential garage typically consists of installing a dedicated branch circuit from an existing house distribution panel to an EV outlet receptacle (120 VAC, 15/20 A) in the case of Level 1 charging, or to an EVSE (operating at 240 VAC, 40 A) for Level 2 charging. If the garage is built with the conduit or raceway already installed from the panel to the garage, the task is greatly simplified.

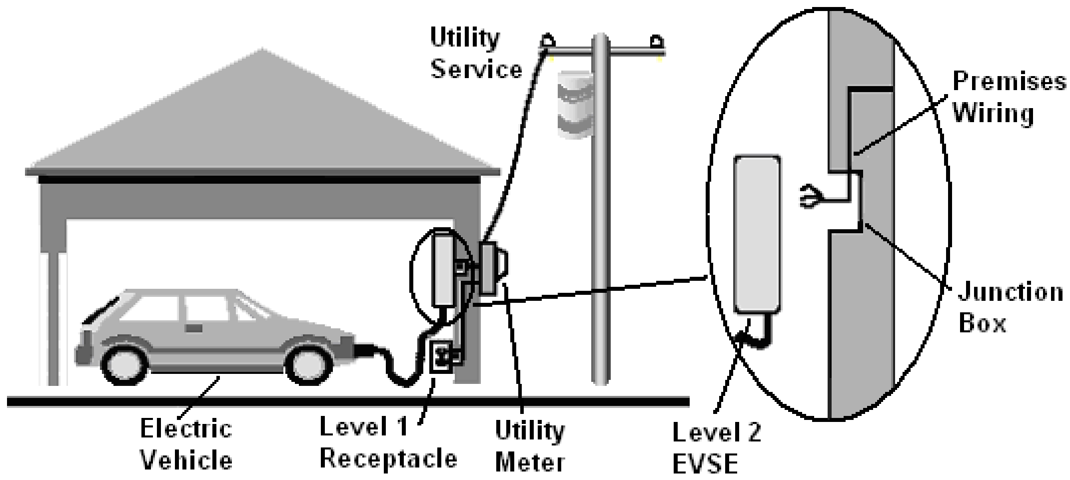

Figure 4-3 Typical Level 1 and Level 2 Installations for a Residential Garage

The specific steps involved in this process are shown in the flowchart below. In general, they include:

- Consultation with the EV dealer to determine whether Level 1 or Level 2 EVSE is required, whether ventilation will be required, and which EVSE to purchase
- Consultation with the electric utility to determine rate structure and whether there are 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 the current utility service, and to obtain installation quote
- Submission of required permitting documents and plans
- Completion of EVSE installation and utility service components, if required
- Inspection of final installation

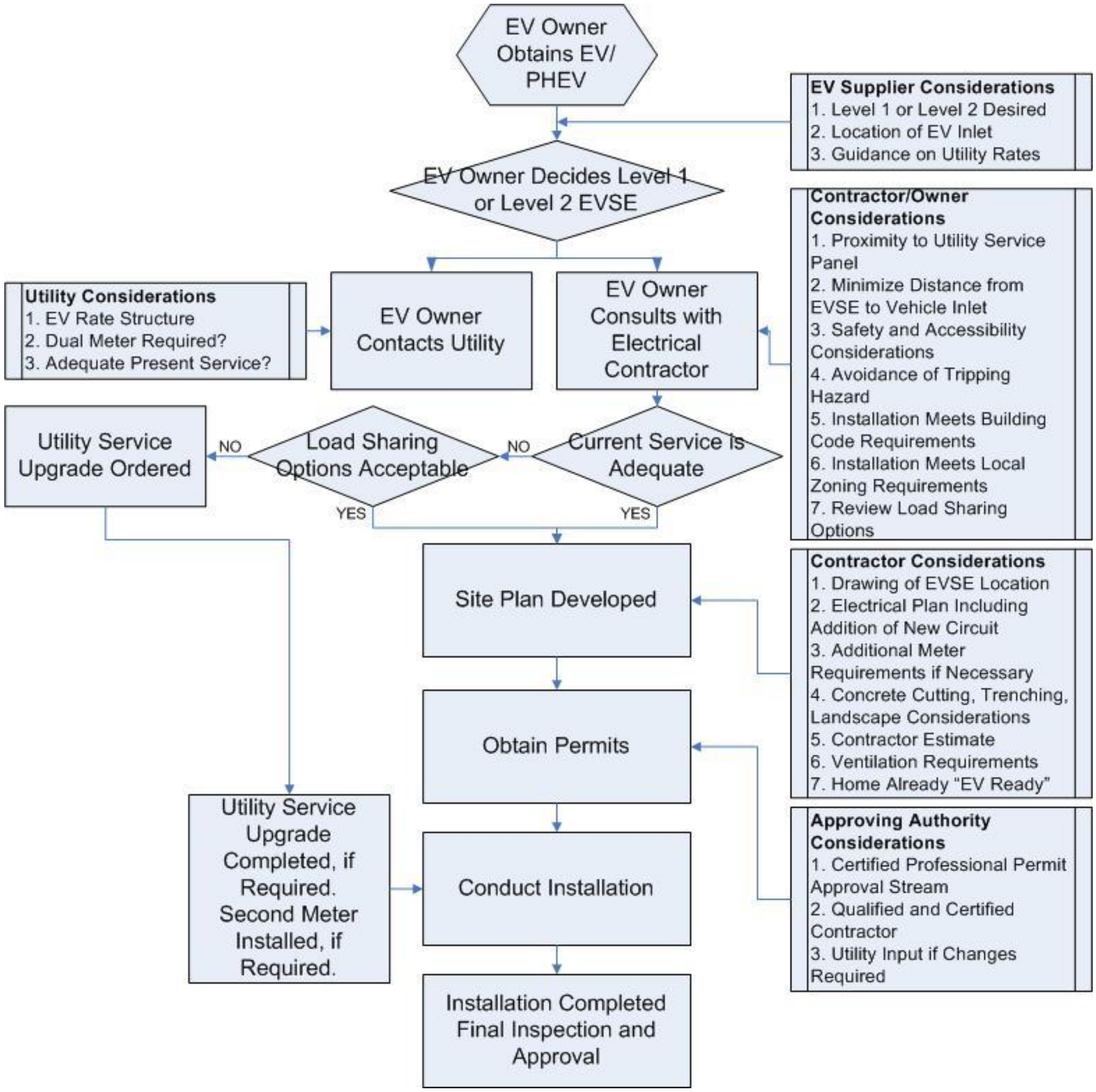

Figure 4-4 Installation Process for a Residential Garage/Carport

If the garage has a pre-existing raceway (conduit that houses electrical cables) mounted on interior walls, a circuit can be installed. Some homes may not have sufficient utility electrical service to install the circuit. In that case, either a new service must be added as noted previously, or installation of an approved load control device may allow the homeowner to avoid a major panel upgrade and the utility to avoid upgrading the electrical service to the homeowner.

Although a new home may already have the raceway installed, a permit for the service still is required. Increasingly, standards are directing that a raceway for an electric vehicle be included in new home construction. The conductors may or may not be included.

B. Carport

Power Requirements

Power requirements are the same as for the Garage scenario above.

Cost Estimates

$2,000 - $2,500 for a generic installation. Costs will vary based on length of the circuit run, electrical panel upgrades, and other factors.

Siting Requirements

The siting requirements for the carport will include those identified above for the garage. Some owners may elect to place the EVSE in the garage, but charge the EV outdoors. This scenario is similar to the carport requirements. A carport is considered to be an outdoor area, and the EVSE should be properly designed for exterior use. Consideration must be given to precipitation and temperature extremes. In geographic areas that experience high precipitation, pooling of water in the carport or driveway may be a concern. While the EVSE is safe, EV owners will not be comfortable with standing in pooled water while connecting the EVSE. Consultation with the owner will be required when locating the EVSE.

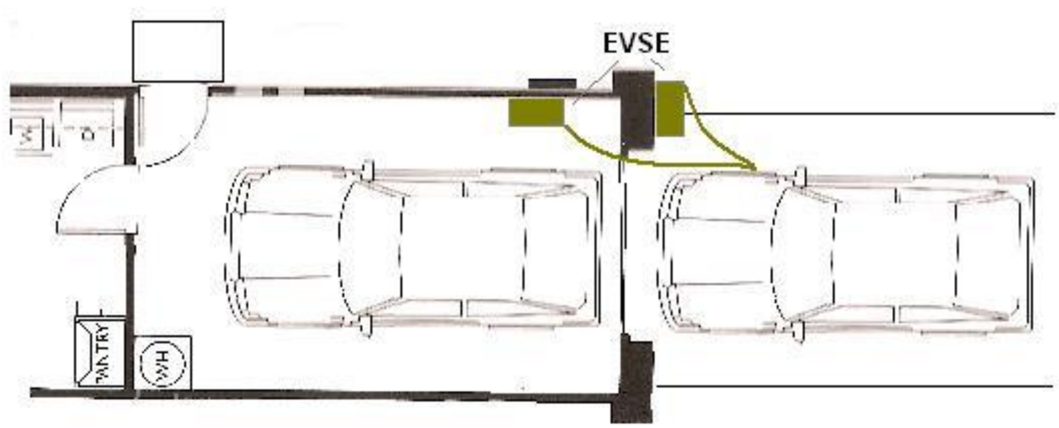

Figure 4-5 Installation Considerations for Outdoor Parking

Freezing temperatures can cause cords to freeze to the parking surface, so cord support should be considered. Adequate lighting is an additional consideration, as well as with mitigating efforts to prevent vandalism, as discussed in Section 5. The installation process for a carport is similar to the garage process.

C. Multi-Family Dwellings

Power Requirements

Power requirements are the same as for the Garage scenario.

Cost Estimates

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

Siting Requirements

In multi-family dwellings, there will be additional considerations, because the apartment or condominium owner must also be involved in any siting decisions. It is best that the potential EV owner work through the details identified here prior to purchasing an EV. The EV owner will prefer a site close to the owner's dwelling, but this location may not be in the best interests 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, as well as damages if the EVSE is vandalized. All of these concerns should be discussed prior to the EV purchase.

Should the EV owner later relocate, 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 takes the EVSE, site restoration may be required. Circuit removal or de-energizing methods should be settled. Discussion with the utility is also required, since there may be metering questions or issues to be resolved. In condominiums, the Homeowners Association (HOA) may be involved to approve EV additions.

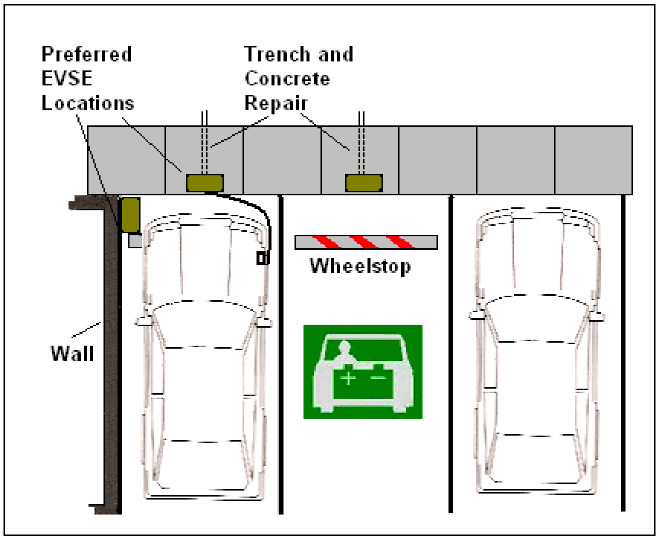

Figure 4-6 Typical EVSE Installation in Multi-Family Lot

In general, the EVSE will need to be outdoor rated unless the location is well protected from the environment. Installation of the EVSE at the front of the vehicle may be the only choice unless an adjacent wall is available. If it is installed at the front of the parking stall, the EVSE should be located on the vehicle side of any walkway to minimize the cord becoming a tripping hazard. The walkway for pedestrians would be on the back side of the EVSE. Because a wheel stop will be installed, consideration should also be given to make sure the EV parking is not in an area of normal pedestrian traffic in order to avoid pedestrians tripping over the wheel stop 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

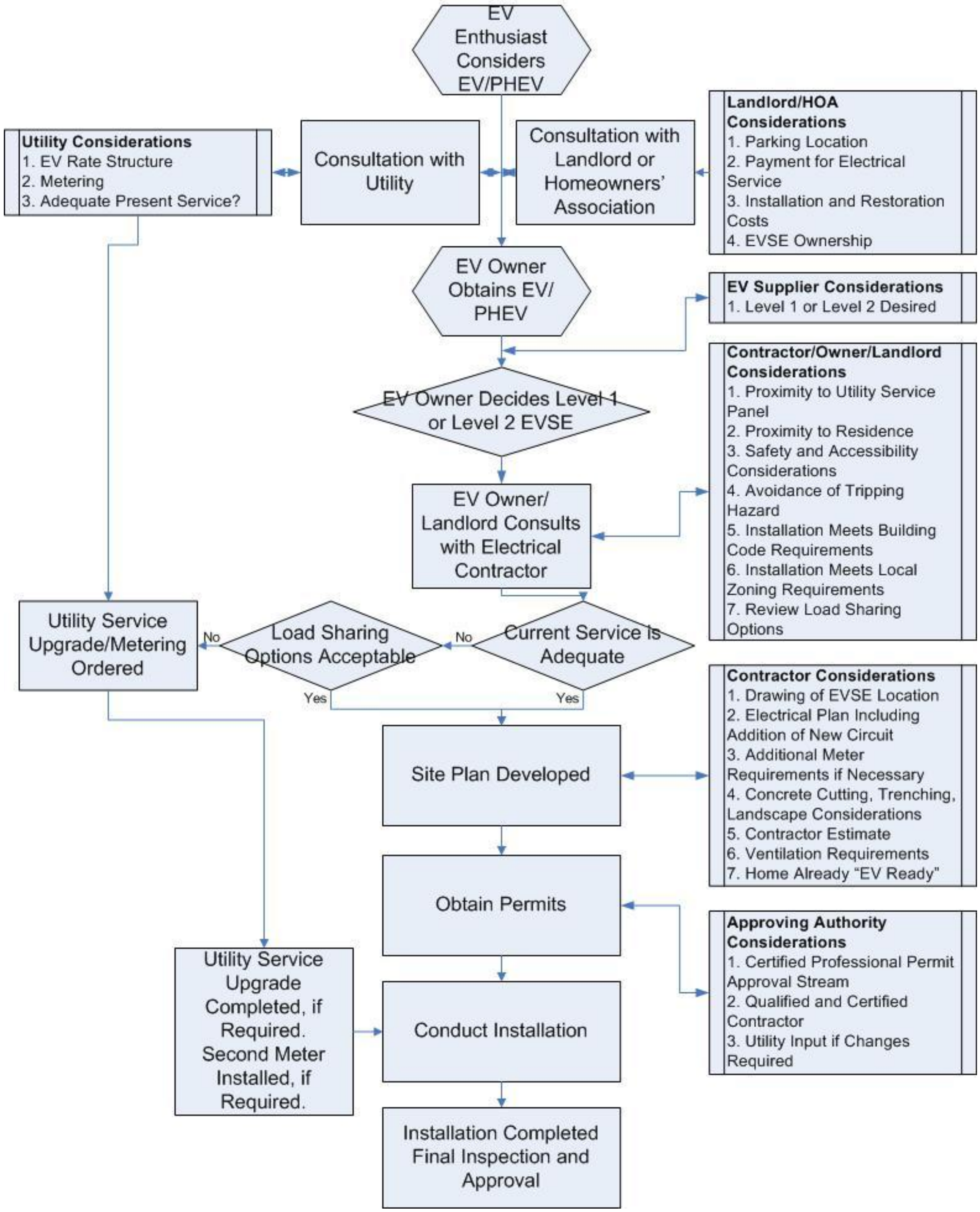

Figure 4-7 Installation Process for Multi-Family

If the parking area has a pre-existing raceway (conduit that houses electrical cables) it will require review by the electrical contractor to make sure the service panel is sufficient to support the circuit. Although a raceway may have been installed previously, a permit for the service still is 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 the situation. For example, the consultant 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

Dedicated branch circuits hardwired to permanently-mounted EVSE with the following specifications: 240VAC / Single Phase, 4-wire (2 Hot, GND, Neutral), 40Amp Breaker.

Commercial fleet charge stations probably will include multiple charge locations and therefore with new construction, the additional load will need to be accounted for when sizing the main service entrance section (SES). 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 new SES and/or utility supply.

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

Cost Estimates

$40,000 - $50,000 for a generic installation of ten EVSE stations. Costs will vary based on length of the circuit run, trenching, electrical panel upgrades, and other factors.

Siting Requirements

At the present time, commercial fleets make up the highest population of EVs. Utilities, governmental agencies, and other private fleets have been encouraged and are encouraging the private adoption of EVs. A significant amount of planning is required to correctly size an EV parking and charging area. Consideration should be given to the 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 on the utility. For that reason, electrical utility planners need to be involved early on in the fleet planning process.

The individual homeowner will be interested in charging his/her vehicle at off-peak times. That interest will be greater for the fleet manager.

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

Installation of the EVSE in a commercial facility typically consists of installing new dedicated branch circuits from the central meter 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.

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 that the threat of vandalism is minimized.

Fleet managers also must be aware of other equipment to 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 the DCFC. The higher recharge rate means a shorter turnaround for each vehicle and maximizes on-road time. The 480/600 VAC required is generally available in commercial facilities.

Figure 4-8 Level 2 Commercial EV Charging Location

Installation Process

The installation process is similar to the processes shown above, except that much more detailed planning is involved prior to the owner's final decision and obtaining permits.

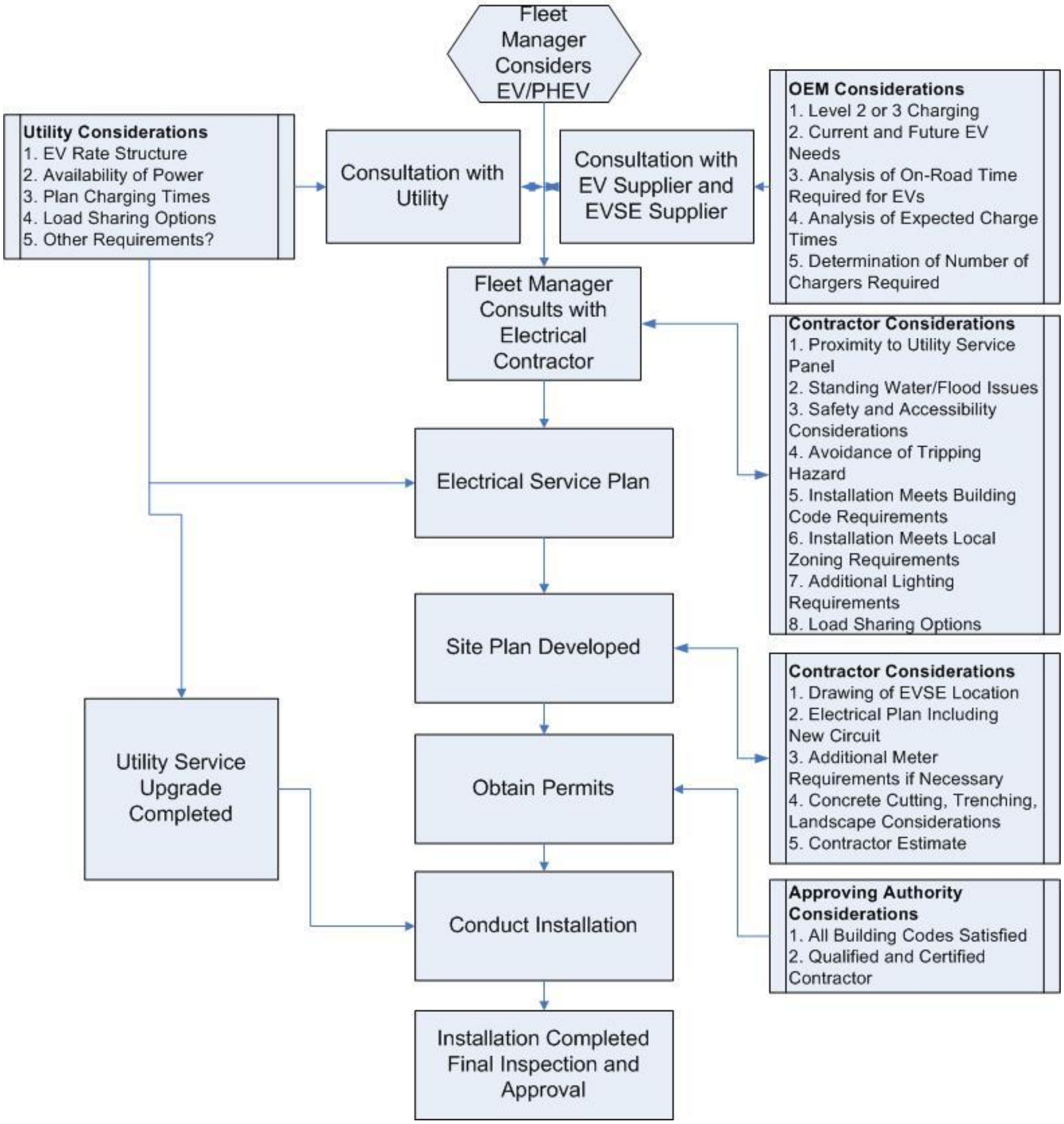

Figure 4-9 Installation Process for Commercial Fleet Operations

E. Publicly Available Charging Stations

A significant factor in the consumer adoption of EVs will be the ability to extend the range of battery-only power. This can be accomplished by the wise installation of publicly available charging locations. The EV Micro-Climate program focuses on this area because of its importance.

Publicly available charging may employ a mix of Level 1, Level 2, and DCFC stations; however, the charge return generated by a dedicated Level 1 charging station will be minimal for a BEV and its use is neither recommended nor included in the EV Micro-Climate program. The recommended configuration for a publicly available Level 2 charging station is one equipped with J1772 connector. This will accommodate 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 public-owned property such as city or county property; curbside chargers are a typical example. Commercial charging stations are those EVSE 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 appreciable recharge can occur during this time period. Locations where owners can be expected to park for this length of time include restaurants, theaters, shopping malls, governmental facilities, hotels, amusement parks, public parks, sports venues, arts productions, museums, libraries, outlet malls, airports visitor lots, and major retail outlets, among many other choices.

Businesses such as electric utilities or those that wish to promote EV usage will install public charging near their building entrance in highly visible areas, even though EV owner stay times may be shorter. These stations also should be Level 2.

The determination of publicly available DCFC 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, where an appreciable recharge can occur during this time period. Locations where owners can be expected to park for this time include convenience stores, coffee houses, service stations, drug stores, and fast food restaurants, among many other choices. For DCFC, the availability of 480/600 VAC will be a 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 5.

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. This system was developed by the U.S. Green Building Council, and it provides standards for environmentally-sustainable construction and facilities operation. It requires a study of the CO_2 emissions by company personnel and encourages, through monetary incentives or preferred parking, the use of alternative-fuel vehicles. It provides credits for installing EV charging stations and suggests certain percentages of parking be devoted to alternative-fuel vehicles. These locations will apply to employees, as well as 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: 240VAC / Single-Phase, 4-wire (2 Hot, GND, Neutral), 40Amp 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 240VAC/3-Phase or 480VAC/3-Phase. For fast chargers greater than 30kW, they likely will require 480VAC/3-Phase.

<u>Example Sizes</u>

1. For 30kW Output Power, typical input power requirements are:
   - 240VAC/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, typical input power requirement is
   - 480VAC/3-Phase, 4-wire (3-Hot, GND), 125 Amp Breaker

Communication probably will be desired for any publicly available charge stations, but it is not necessarily required. Wireless methods are the most likely to be used, but if a hardwired internet connection is available, it is generally preferable to wireless.

Cost Estimates

- $15,000 - $18,000 for a generic installation of a publicly available Level 2 charging station for two charging stations located side-by-side, as shown in Figure 4-10.
- $65,000 - $70,000 for a generic installation of a publicly available DCFC station, as shown in Figure 4-17.

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

Siting Requirements

Siting requirements for publicly available charging are similar to the stations discussed previously, but involve many additional considerations. Topics 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 around standing water or high precipitation. As noted above, EV drivers will not be comfortable operating the EVSE in standing water. Unlike fleet use, the area designated for public use should be in a preferred parking area. Also unlike fleet use, the area is public, so the threat of vandalism will be greater. This likely will be in a high pedestrian traffic area, so it is very important to place the charger to avoid the charge cord or the wheel stop from being tripping hazards.

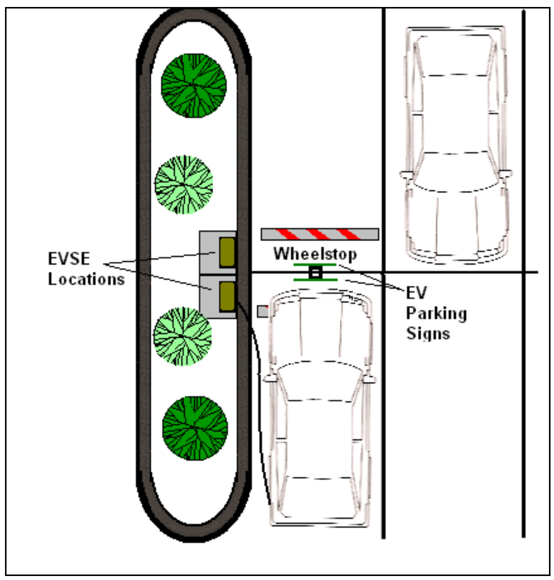

Figure 4-10 Example Publicly Available Charging Layout

There are a variety of ways to address protection of the equipment, shelter, signage, and pedestrian safety. The following pictures provide several examples.

Figure 4-11 Publicly Available Charging Examples

Some publicly available charging installations will be driven by commercial businesses interested in promoting electric vehicle use due to personal preference or as part of LEED certification. These businesses may decide on their own to purchase and install systems or to participate in these costs. Other business owners will be receptive to placing charging stations in their parking lots once approached with incentives. And other public, private, and governmental agencies will install EVSE out of support for EVs. Mapping these selected locations will provide input to an overall municipal plan identifying the ideal sites that will ensure wide coverage of publicly available charging.

Publicly available sites should consider accessibility of EVSE for persons with disabilities. This is further discussed in Section 5.

Lighting and shelter are extremely important in public sites. The EV owner must feel safe when parking at night, in addition to being able to read directions and properly locate the EV connector and insert 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.

Installation of the EVSE in a public area typically consists of installing new dedicated branch circuits from the central meter distribution panel to a Level 2 EVSE. There probably will be 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 charging stations will have a significant impact on the cost.

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. For example, it may be more convenient for the EV owner for a large shopping mall to have two or three EV parking areas rather than one large area, although the cost for three parking areas will be greater than the cost for one.

Figure 4-12 Example Shopping Mall EVSE Parking

Local area aesthetics are also important 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 can be very important in public charging areas. Each publicly available charging area should be equipped with a method whereby the EV user can notify the equipment owner of trouble found with the equipment. Public satisfaction will suffer if stations are found to be out of service or are not kept in an appealing condition. This may be a normal business call number or a service call number that monitors many publicly available charging locations. This will require a communications line. At a minimum, a sign may be posted at the EVSE location directing comments to a particular office or store location.

Figure 4-13 Indoor Charging

Figure 4-14 Outdoor Charging

Installation Process

The installation process is similar to the processes shown above, except that much more detailed planning is required prior to submitting plans for obtaining permits.

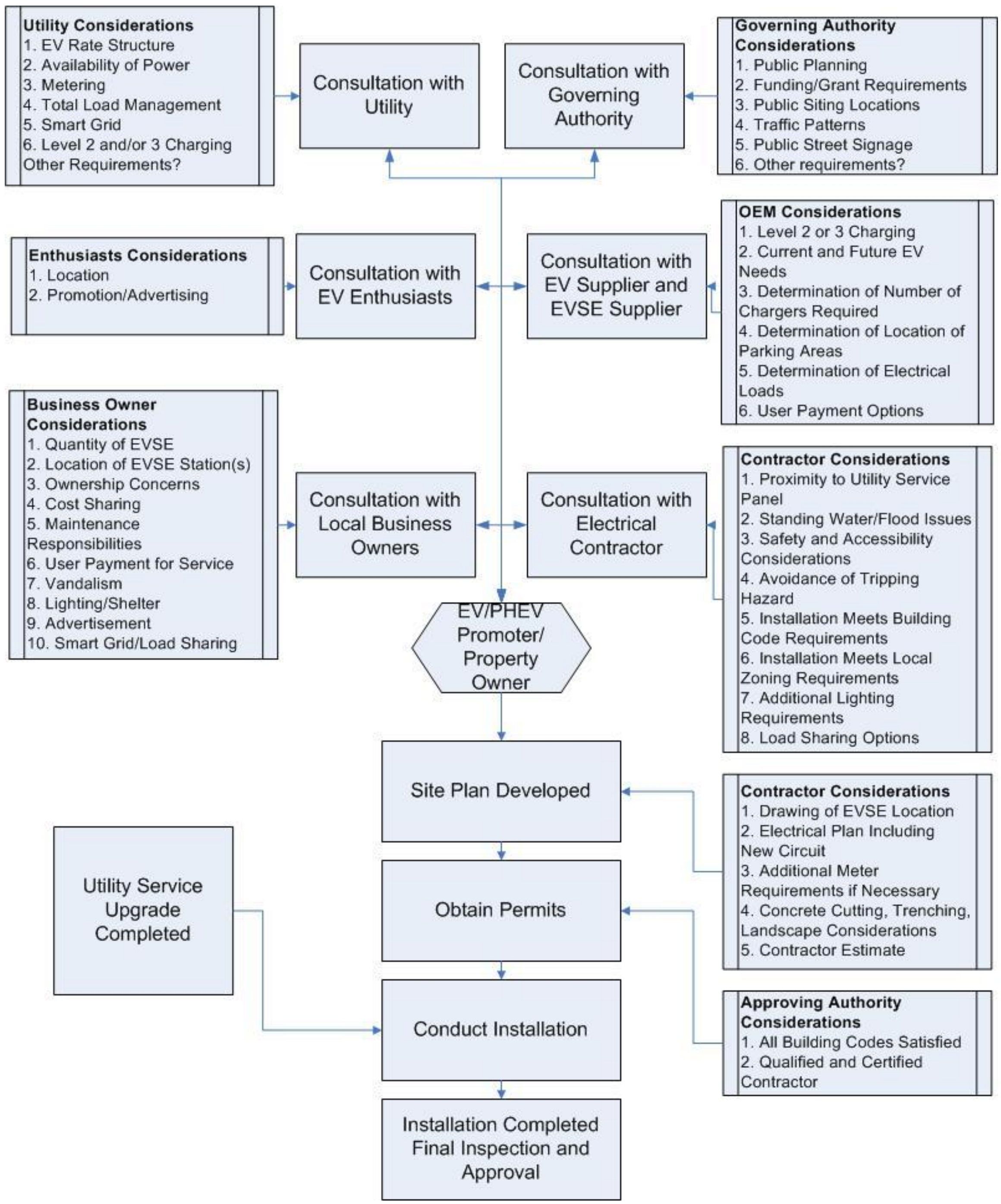

Figure 4-15 Installation Flowchart for Public Charging

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 is not necessarily associated with a commercial business. Generally speaking, these areas are owned by the municipality rather than private interests. Many of the same considerations noted above apply.

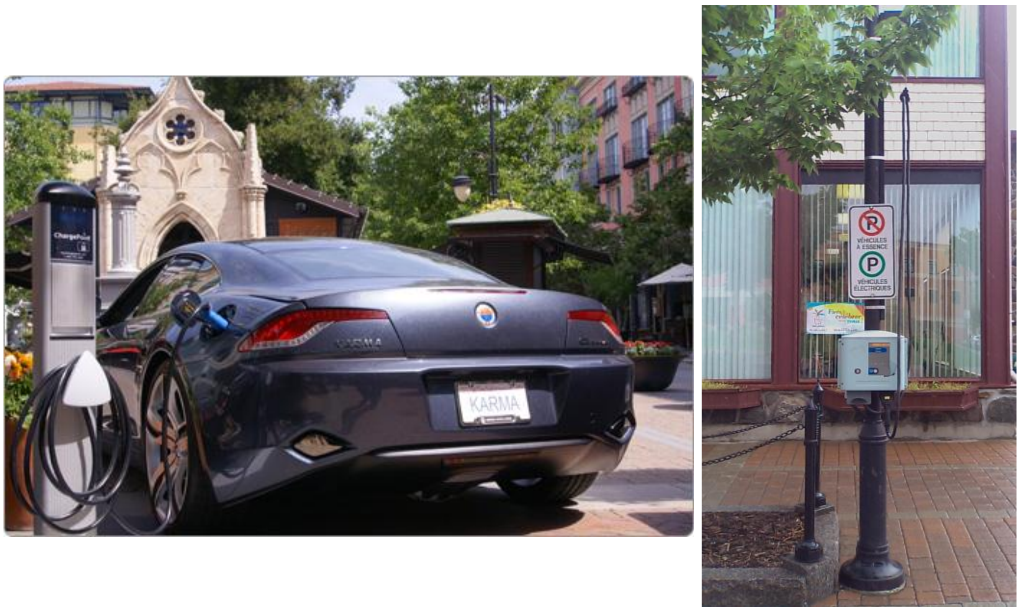

Figure 4-16 Curbside Charging

Figure 4-17 Conceptual DCFC Station and Connector

5. Additional Charging Station Considerations

A. Signage

In addition to the signs and warnings required by NEC identified in Section 6, information signage is recommended for publicly available charging stations. Signage has two purposes: keeping non-EV vehicles from parking in charging station spots and helping EV drivers to locate charging stations.

Figure 5-1 No Parking Except for Electric Vehicles Sign

Previous experience has shown that signs that follow the red-on-white standards for “No Parking” work best to keep non-EV drivers from occupying charging station spots. 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 5-1 follows MUTCD standards. Sites that have friendly green or blue “EV Parking” or “EV Parking Only” signs are not recognized by the public. If the signage is blue in color, it can be mistaken for an accessible location. Green signs are often mistaken for short-term parking signs.

Figure 5-2 MUTCD Approved Wayfinding Sign

Widespread adoption of EVs will include maps or websites identifying charging locations. 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 key 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 either the vehicle or the charging station. Ideally, a common design will be used across the country, from federal and state highways, to local streets, to above the charging stations.

B. Lighting and Shelter

For commercial, apartment, condominium, and fleet charging stations, adequate lighting is recommended for safety and convenience. Shelter is not typically required for outdoor-rated equipment, but for geographic locations that have significant rainfall or snow, providing shelter over the charging equipment will provide added convenience to potential 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. In residential garages or carports, lighting is also important, helping pedestrians to avoid tripping over extended charge cords while the EV is charging.

Figure 5-3 Public Charging with Shelter and Lighting

C. Accessibility Recommendations

State and federal statutes that guide accessibility requirements include:

- Revised Code of Washington 70.92
- Washington Administrative Code Section 51-40
- 28 CFR Part 36

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.[9]

There are two 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 to be 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 an accessible route between the charging station, and be accessible all around the vehicle.

Accessible EV charging stations should be provided according to Table 5-1.

Table 5-1 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 stations do not need to be located immediately adjacent to the buildings and other facilities as required by traditional ADA parking, since EV charging, not parking, is considered to be the stations' primary purpose.

Accessible Parking is the Primary Purpose

If charging stations are placed in existing accessible parking spaces, 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.

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[9] In their January 2010 report to Governor Kulongoski, the Oregon Alternative Fuel Vehicle Infrastructure Working Group recommended that when new EVs represented 5%of new vehicle sales, the government review the appropriateness of building code amendments relating to EVs.

The federal Americans with Disabilities Act (ADA), Revised Code of Washington, and Washington 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 should allow adequate space (minimum of 36 inches) for a wheelchair to pass the vehicle wheel stop.

D. Safety Issues Related to Indoor Charging

Most vehicle manufacturers will clearly specify whether their batteries require ventilation.

The on-road, highway-speed EVs that that are coming to market in the near future almost all utilize lithium-ion batteries that do not require ventilation systems (see Figure 2-4).

EVs using lead-acid or zinc air batteries emit hydrogen gas when charged, and require ventilation. Without adequate ventilation, the hydrogen gas levels may increase to an explosive condition. When the EVSE connector makes contact with the EV inlet, the pilot signal from the vehicle will determine whether the battery requires ventilation; if so, the EVSE only will allow charging if ventilation is available. The EVSE contains controls to turn on the ventilation system when required, and also to stop charging should the ventilation system fail. Because hydrogen is lighter than the air and concentrations would accumulate near the ceiling, the ventilation system should exhaust high and replenish lower.

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

E. Installations Located in Flood Zones

Permits for construction of 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."[10]

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). All locations approved for EVSE installation should be above the DFE. This may mean that the EVSE is located outside a garage if inside would be below the DFE, or that certain areas of a condominium parking lot would not contain any EVSE if that elevation is not achievable. It may require the installation of EVSE charging stations 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 floodproofing 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 floodproofing 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.[11] If the entire building is protected from flood water, the EVSE is also protected.

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[10] 44CFR60.3(a)(3)

[11] 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, most owners of publicly available charging stations will 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 will favor having the option for point of sale. In most areas, only electric utilities can actually sell electricity, so a fee for convenience/service probably will be the strategy. Often a credit card transaction fee will well exceed the electricity cost of charging an EV. However, the availability and convenience of charging will be a service that the public will desire and purchase. A fee for service can help the EVSE owner recover the cost of equipment, installation, service, and maintenance. Several options for point of sale services are available.

Card Readers

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

A smartcard is a card that is embedded with a microprocessor or memory chip, allowing it securely store more detailed information than a credit/debit card. The smartcard could be sold with a monthly subscription and embedded with more information on the user. That information could be captured during each transaction and used for data recording, as discussed in Section G below. The smartcard could be used either for a pre-set number of charge opportunities, or to bill a credit card number each time services are used.

In both cases, a communication system from the reader to a terminal for off-site approval and data recording will be required. Receipt of approval could then close a contact so power can be supplied to the EVSE. The cost of this system and its integration into the EVSE will be a design consideration.

Figure 5-4 Smartcard Reader[12]

[12] ACR-38 Smart Card Reader by Advanced Card Systems

Parking Area Meters

People are very familiar with the parking meters used in public parking. A simple coin-operated meter is an option for EV parking areas and can be installed at the head of each EVSE parking stall. Another method in common use is public pay parking lots where a central kiosk is used 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 entire parking lot. This system will require an attendant to periodically monitor the area for violations; penalties for violators will need to be determined. Note that a coin-operated meter may invite 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 could be based on either the number of actual uses or a set fee. The reader would be programmed for the accepted RFID.

Figure 5-5 RFID Fob[13]

[13] Texas Instruments RFID

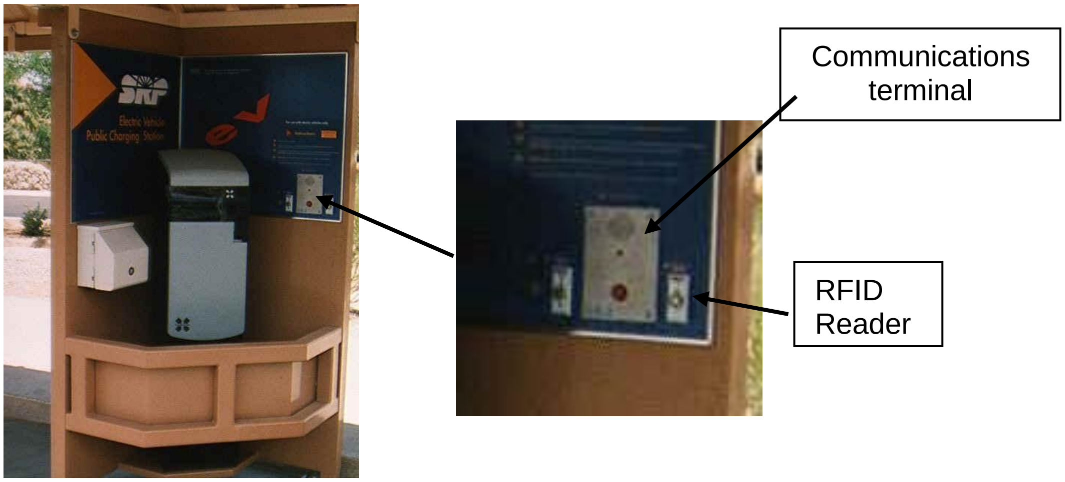

Figure 5-7 RFID Reader[14]

[14] Texas Instruments RFID

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 publicly available charging locations. In addition, the time of day usage may show peak usage at unexpected times, which could impact power utilization. Some EVSE may include features to allow a wide range of data to be collected.

H. Vandalism

Publicly available charging carries the possibility of vandalism and theft. Destruction of property due to purposeful defacing of equipment is a possibility, although this kind of vandalism actually proved to be very minor during EV usage in the mid-1990s. Still, as public acceptance and the number of publicly available charging sites continue to grow, steps should be taken to minimize this possibility.

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

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

I. Station Ownership

There is a variety of possible ownership models for individual charging stations –

- 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 both.
- The EVSE may be rented or leased equipment.

Before planning any installation, it is important to identify the entities that have legal rights with respect to the equipment and its installation. Whose approvals are required to obtain the permits and whose approvals are required to remove the equipment later?

For individual EV owners, the ownership of the EVSE should reside with the EV owner. The ownership 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 in order to manage power requirements. In a successful EV market penetration, ownership of new public charging stations may shift to private ownership. Several businesses may join together to promote EV usage and share in the EVSE ownership. However, there always should be one individual business entity tasked with the responsibility of ownership, as well as providing the proper contact information to the local utility.

J. Maintenance

EVSE typically will not require routine maintenance. However, all usable parts can wear, and periodic inspections should be conducted to ensure that all parts remain in good working order. Depending on local conditions, periodic cleaning may be required. Communications systems and lighting should be tested 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.

6. Codes and Standards

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

Equipment is designed to standards set by organizations such as Society of Automotive Engineers, and is tested through certifying laboratories such as Underwriters Laboratories. This 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 modified by state or local governing bodies. Frequently, these codes also will affect the standards, as is the case for electric vehicles.

In order to protect public health and safety, regulatory agencies are responsible for monitoring each EVSE installation to ensure that the proper codes and standards are being implemented.

A. State of Washington Regulatory Agencies

The Revised Code of Washington (RCW) …

> "…is the compilation of all permanent laws now in force. It is a collection of Session Laws (enacted by the Legislature, and signed by the Governor, or enacted via the initiative process), arranged by topic, with amendments added and repealed laws removed. It does not include temporary laws such as appropriations acts. The official version of the RCW is published by the Statute Law Committee and the Code Reviser."[15]

The most recent update of the RCW is October 19, 2009.

RCW Title 19 relates to business regulations.

- Section 19.27 refers to State Building Code, addressed in Section D below.
- Section 19.28 refers to electricians and electrical installations, addressed in Section B below.

[15] Washington State Legislature website

B. National Electric Code (NEC)

RCW 19.27.031 adopts among other codes, the International Fire Code and those portions of the National Fire Protection Association referenced by the International Fire Code. RCW 19.27.040 allows counties and cities to amend these codes, but requires maintaining the minimum performance standards.

The 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. It is adopted by state and local jurisdictions and may be modified by those jurisdictions. When identifying the electrical requirements for EVSE installation, it is important to check local requirements, as well. The NEC is updated every three years; the current approved edition is 2008. However, not all jurisdictions have adopted that edition. To become certified in electrical construction, a person must pass a certifying test.

The NEC is amended and adopted by Washington State in RCW 19.28 and WAC Rule 296-46B. The following local jurisdictions amend, adopt, and inspect their own versions of electric code:

- Aberdeen
- Bellingham
- Bellevue
- Burien
- Des Moines
- Eatonville
- Everett
- Federal Way
- Kirkland
- Lacey
- Longview
- Lynnwood
- Marysville
- Mercer Island
- Milton
- Mountlake Terrace
- Normandy Park
- Olympia
- Port Angeles
- Redmond
- Renton
- Sea Tac
- Seattle
- Spokane
- Tacoma
- Tukwila
- Vancouver

Section 625 of the NEC specifically addresses electric vehicles. Specific requirements are highlighted here for information purposes, but this is not intended to be a substitute for the actual document.

- **Section 625.9: The electric vehicle coupler shall comply with:**
  - Polarization. The electric vehicle coupler shall be polarized unless part of a system identified and listed as suitable for the purpose.
  - (B) Non-interchangeability. The electric vehicle coupler shall have a configuration that is non-interchangeable with wiring devices in other electrical systems.
  - (C) Construction and Installation. The electric vehicle coupler shall be constructed and installed so as to guard against inadvertent contact by persons with parts made live from the electric vehicle supply equipment or the electric vehicle battery.

  - (D) Unintentional Disconnection. The electric vehicle coupler shall be provided with a positive means to prevent unintentional disconnection.
  - (E) Grounding Pole. The electric vehicle coupler shall be provided with a grounding pole, unless part of a system identified and listed as suitable for the purpose in accordance with Article 250.
  - (F) Grounding Pole Requirements. If a grounding pole is provided, the electric vehicle coupler shall be so designed that the grounding pole connection is the first to make and the last to break contact.
- **Section 625.13 Electric Vehicle Supply Equipment.**
  - Electric vehicle supply equipment rated at 125 volts, single-phase, 15 or 20 amperes or part of a system identified and listed as suitable for the purpose and meeting the requirements of 625.18, 625.19, and 625.29 shall be permitted to be cord-and-plug-connected. All other electric vehicle supply equipment shall be permanently connected and fastened in place.
- **Section 625.14 Rating.**
  - Level 1. 125VAC. This method, which allows broad access to charge an EV, permits plugging into a common, grounded 125-volt electrical receptacle (NEMA 5-15R or 5-20R) when cord-and-plug is approved.
  - Level 2. 240 VAC, 40 amp. electric vehicle supply equipment shall be permanently connected and fastened in place.
- **Section 625.15 Marking.**
  - All EVSE shall be marked “FOR USE WITH ELECTRIC VEHICLES” and “VENTILATION NOT REQUIRED” or “VENTILATION REQUIRED”
- **Section 625.16 Means of Coupling.**
  - The means of coupling to the electric vehicle shall be either conductive or inductive. Attachment plugs, electric vehicle connectors, and electric vehicle inlets shall be listed or labeled for the purpose.
- **Section 625.17 Cable.**
  - The electric vehicle supply equipment cable shall be Type EV, EVJ, EVE, EVJE, EVT, or EVJT flexible cable, as specified in Article 400 and Table 400.4.
  - The overall length of the cable shall not exceed 7.5 meters (25 feet) unless equipped with a cable management system that is listed as suitable for the purpose.

- **Section 625.18 Interlock.**
  - Electric vehicle supply equipment shall be provided with an interlock that de-energizes the electric vehicle connector and its cable whenever the electrical connector is uncoupled from the electric vehicle. An interlock shall not be required for portable cord-and-plug-connected electric vehicle supply equipment intended for connection to receptacle outlets rated at 125 volts, single-phase, 15 and 20 amperes.
- **Section 625.19 Automatic De-Energization of Cable.**
  - The electric vehicle supply equipment or the cable-connector combination of the equipment shall be provided with an automatic means to de-energize the cable conductors and electric vehicle connector upon exposure to strain.
- **Section 625.22 Personnel Protection System.**
  - The electric vehicle supply equipment shall have a listed system of protection against electric shock of personnel. Where cord-and-plug-connected electric vehicle supply equipment is used, the interrupting device of a listed personnel protection system shall be provided and shall be an integral part of the attachment plug or shall be located in the power supply cable not more than 300 millimeter (12 inches) from the attachment plug.
- **Section 625.25 Loss of Primary Source.**
  - Means shall be provided such that, upon loss of voltage from the utility or other electrical system(s), energy cannot be back fed through the electric vehicle and the supply equipment to the premises wiring system unless permitted by 625.26.
- **Section 625.26 Interactive Systems.**
  - Electric vehicle supply equipment and other parts of a system, either on-board or off-board the vehicle, that are identified for and intended to be interconnected to a vehicle and also serve as an optional standby system or an electric power production source or provide for bi-directional power feed shall be listed as suitable for that purpose.
- **Section 625.29 Indoor Sites.**
  - (B) Height. Unless specifically listed for the purpose and location, the coupling means of the electric vehicle supply equipment shall be stored or located at a height of not less than 450 millimeter (18 inches) and not more than 1.2 meters (4 feet) above the floor level.
- **Section 625.30 Outdoor Sites.**
  - (B) Height. Unless specifically listed for the purpose and location, the coupling means of electric vehicle supply equipment shall be stored or located at a height of not less than 600 millimeters (24 inches) and not more than 1.2 meters (4 feet) above the parking surface.

C. SAE and UL

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

Applicable SAE standards include:

- SAE J1772
- SAE J2293 - Establishes requirements for EV and the off-board EVSE used to transfer electrical energy to an EV from a utility source. This 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 the DC electrical energy that can be used to charge the storage battery of an EV.
- SAE J2847 - Provides specifics on digital communications.
- SAE J2836 - Provides use cases for digital communications between a plug-in vehicle and EVSE.
- SAE J2894 - Addresses on-board charger power quality.
- SAE J551 - Provides standards for electromagnetic compatibility.

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. Washington State Building Code

RCW 19.27.070 establishes the Washington State Building Code Council. RCW 19.27.095 establishes the requirements for building permits.

On November 17, 2006, the Washington State Building Code Council (SBCC) voted to adopt the 2006 Editions of the national model’s codes with some new amendments and some changes to existing amendments. The Council also adopted changes to the Washington State Energy Code and Ventilation and Indoor Air Quality Code.

RCW 19.27.031 adopts among other codes, the International Building Code, the International Residential Code, and the International Fire Code, as well as those portions of the National Fire Protection Association code referenced by the International Fire Code. RCW 19.27.040 allows counties and cities to amend these codes, but requires maintaining the minimum performance standards.

RCW 19.27.540 requires the SBCC to set rules for Electric Vehicle Infrastructure (see Section E below) and must be consistent with RCW 19.28.281, as discussed above.

E. 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.[16]

The Washington State Department of Labor and Industries publishes the Safety and Health Core Rules, which are the basic safety and health rules needed by most employers in Washington State.

F. Engineering, Permitting, and Construction

The process flowcharts identified in previous sections all require the electrical 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 voltage and amperage of the system; the name, address, and license number of the qualified contractor; and whether additional trades will be involved.

Service load calculations may be required. The electrical contractor will review the current service loading and consider the rating of the EVSE to be installed. A new loading calculation then will determine whether the existing service panel is adequate or new service is required. Many inspectors will require this calculation to be submitted with the permit application.

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 generally a Level 2 EVSE will be preferred. Minimizing the time span from EV purchase to fully functional and inspected EVSE installation will be important for customer satisfaction.

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

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[16] OHSA website www.osha.gov

For fleet and publicly available 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. Prior to any actual on-site work, the permit must be approved and posted at the site. This permit will identify periodic inspections and approvals of work, if necessary. Work shall not be concealed until the inspection is completed and work approved.

7. 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 them to control various electrical loads on their system. Through these Smart-Grid technologies, utilities can minimize their investment in new power plants and electrical distribution and transmission by shifting and controlling load while minimizing the impact to the customer.

Advanced Metering Infrastructure (AMI), or *smart meters*, are being deployed by many utilities to provide remote meter reading. Smart meters also have the ability to control various customer loads with customer's permission.

EVs are one of the better loads for utilities to control through smart meters because EVs have an on-board storage system, and delaying the charge of the battery has no noticeable impact on the customer, unlike a lighting or air-conditioning load that immediately impacts the customer when turned off. Furthermore, a neighborhood transformer may not be sized for every EV-owning customer in an area to be charging at the same time. The ability to schedule the EV charging connected to a neighborhood transformer could significantly extend the life of that transformer, possibly delaying or even eliminating the need to replace the transformer with a larger size.

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.

Figure 7-1 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 homeowner may elect to have the utility control total home consumption or in the future, deliver power back to the utility through the storage capability of the EV.

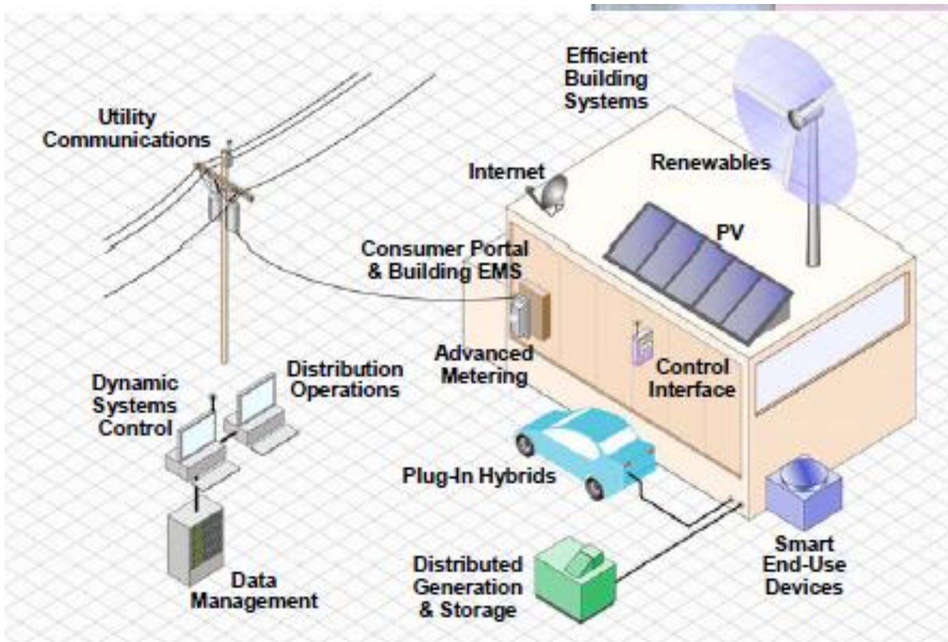

Figure 7-1 Smart Grid Infrastructure[17]

Some of the mechanisms that would allow utilities to control EV load include the following.

Time-of-Use (TOU) Rates

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 on weekends, during a timeframe where demand on the utility electrical grid is at its lowest point. TOU currently is being implemented by some utilities, but there is not a common approach at this time. Discussion with the local utility prior to installation of the EVSE is recommended to determine whether TOU rates are an option and cost effective.

Dual Metering

The use of a "revenue grade" meter in the EVSE and a communications path to allow the utility control may obviate the need for a second meter.

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[17] Successful Integration of Plug-in Electric (PEV) Transportation Systems, EPRI, Plug-In 2009 Canada, September 2009

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. The customers are compensated when they participate in these programs to make it worth their while. EVs may participate in such programs in the future as deployment of smart meters becomes more prevalent. Utilities may enter into contracts with EV owners to allow the utility to maintain more control on EV charging.

Real-Time Pricing (RTP)

RTP is a concept that could be implemented in the future for EVs, whereby 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 make sure the car is fully charged by 6am, 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 EVSE 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 EVs 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, whereby the energy stored in the vehicle battery could supplement the home's electrical requirements. V2G requires that the on-board vehicle charger be bi-directional (energy can flow both directions) and that the EVSE at the premises 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, this concept for on-road EVs likely is several years away from implementation in any commercial sense.

B. Interconnection Requirements

Although 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 are typically already in place for solar photovoltaic and wind systems that are grid-tied to the utility.

C. Commercial Electrical Supply/Metering

There are typically two scenarios for connection to a commercial electrical supply. The first utilizes the existing main SES or an otherwise adequate supply panel at the commercial establishment and the second is to obtain a new service drop from the local electric utility.

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 proximity of the existing SES or an adequate electrical supply to the proposed EVSE 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 will require the establishment of a new customer account, which may include a credit evaluation of the entity applying for the meter, as well as a monthly meter charge in addition to the energy and demand charges. In addition, the local utility may require an analysis of the anticipated energy consumption, in order to justify covering the cost of the new service drop.

D. Customer Requirements for Adding Loads

The utility will need to be notified of the additional load of an EV as required by local codes. The utility will treat service increase applications to provide for additional loads for EVs just like any other load increase request.

The internal process when adding load to a service or neighborhood is that periodically transformer and conductor capacity is reviewed and upgrades are installed. Capacity should not be a problem unless customers add loads to their services without notifying the utility as required by local codes.