Electric Vehicle Service Equipment (EVSE) Guidelines for Installations

Charging Levels and Length of Stay. Before you decide to install a Level 1 or 2 charging station (or a combination of both), it is important to understand how the electric vehicle industry is evolving. Battery capacities will continue to increase and heavier duty chargers will become more common. If your typical customer will need charging for medium length stays (2-4 hours), such as visits to shopping malls, movie theaters, or sports venues, then Level 2 charging would be advised. Level 2 charging may offer the most efficient and cost-effective level of charging, because it can efficiently charge BEVs and PHEVs using a 240-volt circuit and can also provide 120-volt Level 1 slow charging.

Level 2 Charging Station Electrical Requirements

Requires a dedicated 40-amp or higher breaker on a 240-volt circuit with a GFI. A charging station is typically installed on a pedestal or wall. (EV charging stations are "continuous load" devices as defined by the National Electrical Code. The contact points for typical 240-volt outlets, such as those used for dryers or ovens, are not designed for continuous loads or for repetitive plugging and unplugging as would be normal with EV charging. Plugging a vehicle directly into a 240-volt outlet is considered hazardous and is not allowed under any circumstances.)

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., Underwriters Laboratories). Owners should be cautioned against using equipment that has not been certified for EV use.

• **Cord Length:** The EVSE will provide a maximum of 25 feet of flexibility from 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.

Publicly Available Charging Stations

Publicly available charging may employ a mix of Level 1, Level 2, and DC Fast Charging stations; however, the charge return generated by a dedicated Level 1 charging station will be minimal for a BEV. 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.

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.

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.

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

Example Sizes

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

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

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. EV drivers will not be comfortable operating the EVSE in standing water. If the station is located in a high pedestrian traffic area, it is very important to place the charger to avoid the charge cord or the wheel stop from being tripping hazards.

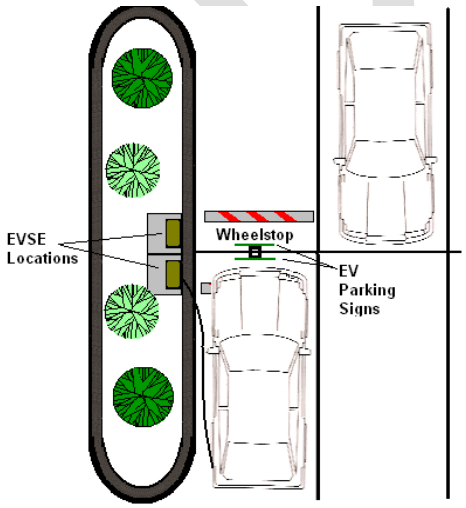

Figure 4-10 Example Publicly Available Charging Layout

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

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 4-16 Curbside Charging

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 Wayfinding Sign

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

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]

[15] Washington State Legislature website

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.

B. National Electric Code

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 National Electric Code (NEC) is part of the National Fire Code series established by the National Fire Protection Association (NFPA) as NFPA 70. The NEC codifies the requirements for safe electrical installations into a single, standardized source. 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.

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 m (25 ft) 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 mm (12 in.) 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 mm (18 in.) and not more than 1.2 m (4 ft) 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 mm (24 in.) and not more than 1.2 m (4 ft) above the parking surface.

C. SAE and UL

Currently, the Society of Automotive Engineers (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.

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

• UL 2202 *Electric Vehicle (EV) Charging System Equipment*

• UL 2231-1 *Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits: General Requirements*

• UL 2231-2 *Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits: Particular Requirements for Protection Devices for Use in Charging Systems*

• UL 2251 *Plugs, Receptacles, and Couplers for Electric Vehicles*

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

D. 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]

[16] OHSA website www.osha.gov

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.

Sources of information:

- Electric Vehicle Charging Infrastructure Deployment Guidelines for the Central Puget Sound Area, May 2010, Final Version 3.1, by the Electric Transportation Engineering Corporation, An Ecototality Company
- “Electric Vehicle Infrastructure – A Guide for Local Governments in Washington State”, July 2010, by the Washington Dept. of Commerce and Puget Sound Regional Council