Electric Vehicle Charging Infrastructure Deployment Guidelines for the State of Tennessee

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ELECTRIC TRANSPORTATION ENGINEERING CORPORATION

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These guidelines were authored through the eTec process specifically for the EV Project. Working in conjunction with project partners and local area stakeholders through the creation of State and Area Advisory Boards, eTec received content contributions and content review from the following Advisory Board member organizations.

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Acronyms

AC	Alternating Current
AMI	Advanced Metering Infrastructure
ARRA	American Reinvestment and Recovery Act
BEV	Battery Electric Vehicle - vehicles 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.
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
LSV	Low Speed Vehicle
MUTCO	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
NFID	National Flood Insurance Program
NFPA	National Fire Protection Association
OSHA	Occupational Safety and Health Act

PHEV Plug-in Hybrid Electric Vehicle – vehicles utilizing a battery and an internal combustion engine (ICE) powered by either gasoline or diesel.

PV Photovoltaic

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

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 Volts Alternating Current

Electric Vehicle Charging Infrastructure Deployment Guidelines

1. Introduction

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 automotive industry direction. As major automotive manufacturers plan to launch plug-in electric vehicles (EV) 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.

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 EV Micro-Climate© as an integrated turn-key program to ensure 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.

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

Electric vehicles have unique requirements that differ from internal combustion engine vehicles, and many stakeholders are currently not familiar with these requirements. eTec's *Electric Vehicle Infrastructure Deployment Guidelines* provide the necessary background information for understanding EV requirements and are the foundation upon which the EV Micro-Climate program builds in order to provide the optimum infrastructure to support and encourage the adoption of electric vehicles.

2. Electric Vehicle Technology

This section describes the basic EV technologies that are either currently available or coming to the US market in the near future. The focus of this section is on street-legal vehicles that incorporate a battery energy storage device that is able to connect to the electrical grid for the supply of some or all of its fuel energy requirements. These vehicles are sometimes referred to as “grid-enabled” or “grid-dependent” vehicles, as they are dependent on the electricity grid for fuel. 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, as well as the 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 when 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 can typically provide enough power to operate some small accessory loads, such as a radio.

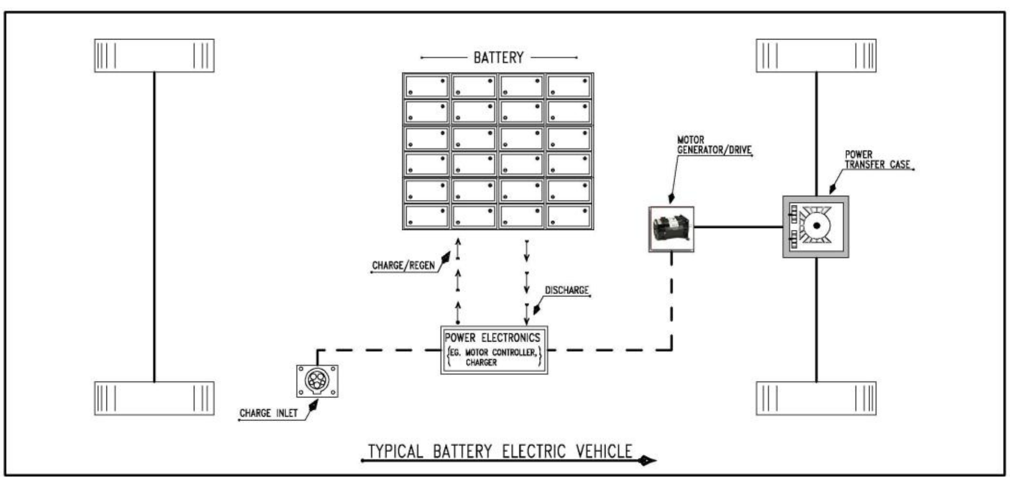

Figure 2-1 Battery Electric Vehicle

A typical BEV is shown in the block diagram in Figure 2-1. Since the BEV has no other significant energy source, the battery must meet the BEV range and power requirements. BEV batteries are typically larger and more powerful 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 internal combustion engine (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 propelling the vehicle solely based on battery power.

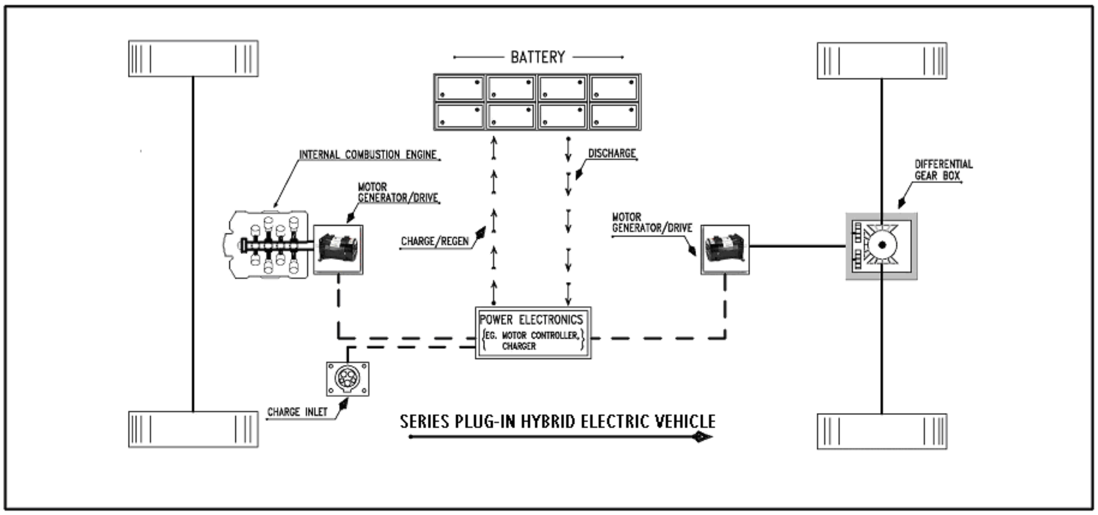

Figure 2-2 Series Plug-In Hybrid Vehicle Block Diagram

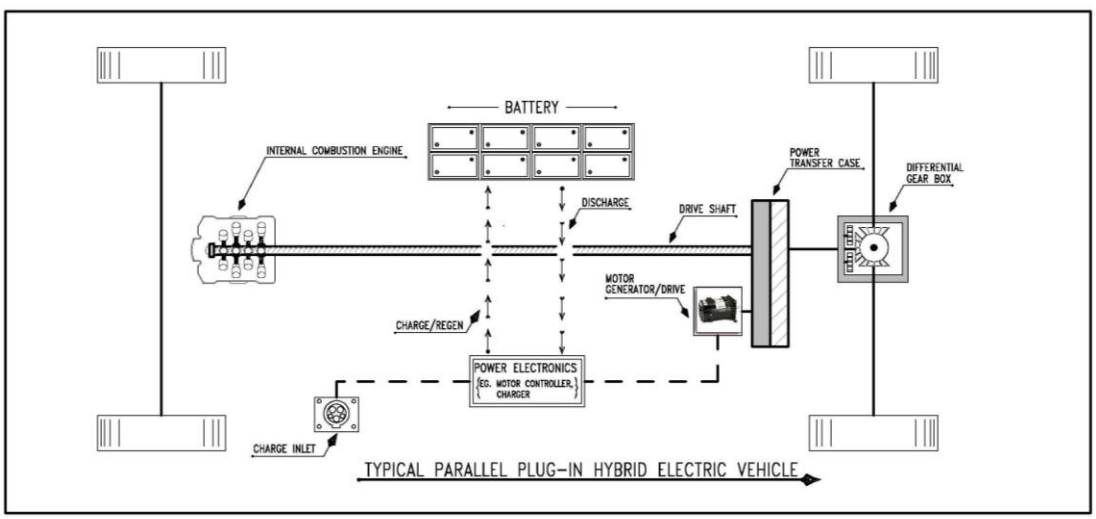

Figure 2-3 Parallel Plug-In Hybrid Vehicle Block Diagram

Manufacturers of PHEVs use different strategies in combining the battery and ICE. For example, the Chevy Volt will utilize the battery only for the first several miles, with the ICE providing generating power 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 Vehicles* have been BEVs that are capable of driving on most public roads, but generally are not driven on highways. Top speed is typically limited to 55 mph.
- **Neighborhood Electric Vehicles (NEVs)**
  Neighborhood Electric Vehicles (NEVs), also known as *Low Speed Vehicles* (LSVs), are BEVs that are limited to 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 application.

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 EV infrastructure standpoint, it is important to consider that, as battery costs are driven down over time, the auto companies will increase the size of the lithium-based battery packs, and thus the range of EVs will increase.

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 much 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 more kW. The common 120 volts AC (VAC), 15 amp circuit will deliver at minimum 1.1 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 kW to a battery. Table 2-1 provides information on several different on-road highway speed electric vehicles, their battery pack sizes, and charge times at different power levels to replenish a depleted battery.

Table 2-1 EV Charge Times

EV Configuration	Battery Size (kWh)	Circuit Size and Power in kW Delivered to Battery			
		120 VAC, 15 amp 1.2 kW	120 VAC, 20 amp 1.6 kW	240 VAC, 40 amp 6.5 kW	480 VAC, 85 amp 60 kW
PHEV-10	4	3 h 20 m	2 h 30 m	35 m	n/a
PHEV-20	8	6 h 40 m	5 h	1 h 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 electric vehicles in the near future. A summary table of these plans is shown in Figure 2-4.

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[1]

[1] Credit Suisse "Electric Vehicles", Equity Research, Energy Technology/Auto Parts & Equipment, October 1, 2009

3. Charging Requirements

This section discusses the terminology and general requirements for EVSE, which provides 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.

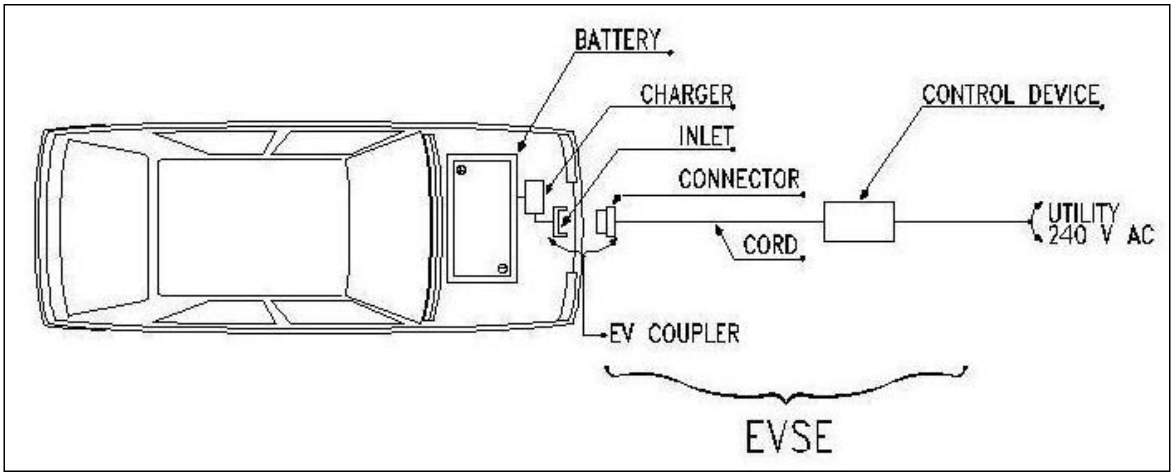

Figure 3-1 Level 2 Charging Diagram

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 1990s, there was no consensus on EV inlet and connector design. Both conductive and inductive types of couplers were designed and in both cases, different designs of each type were provided by automakers. At the present time, however, the Society of Automotive Engineers (SAE) has agreed that all vehicles produced by automakers in the United States will conform to a single design, known as the J1772 Standard.[2]

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

J1772 Connector **J1772 Inlet (right side)**

Figure 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 electric vehicle charging and cannot be used for other purposes.

The EV inlet -

- must be de-energized until it is attached to the EVSE.
- must de-energize prior to removal of the connector.

The EVSE -

- must be tested and approved for use by Underwriters Laboratory (UL), or a similar nationally-recognized, independent testing lab.
- must be able to initiate area ventilation for those specific batteries that may emit potentially explosive gases.
- must have a charge current interrupting device (CCID) that will shut off the electricity supply if it senses a potential problem that could result in electrical shock to the user.

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

The J1772 coupler and EV inlet will be used for both Level 1 and Level 2 charging levels, 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. Level 1, Level 2, and DCFCs were defined by the IWC, as well as the corresponding functionality requirements and safety systems. EPRI published a document in 1994 that describes the consensus items of the IWC[3].

Note: For Levels 1 and 2, the conversion of utility AC power to the DC power required for battery charging occurs in the vehicle's on-board charger. In DCFC, the conversion from AC to DC power typically occurs off-board, so that DC power is delivered directly to the vehicle.[4]

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.

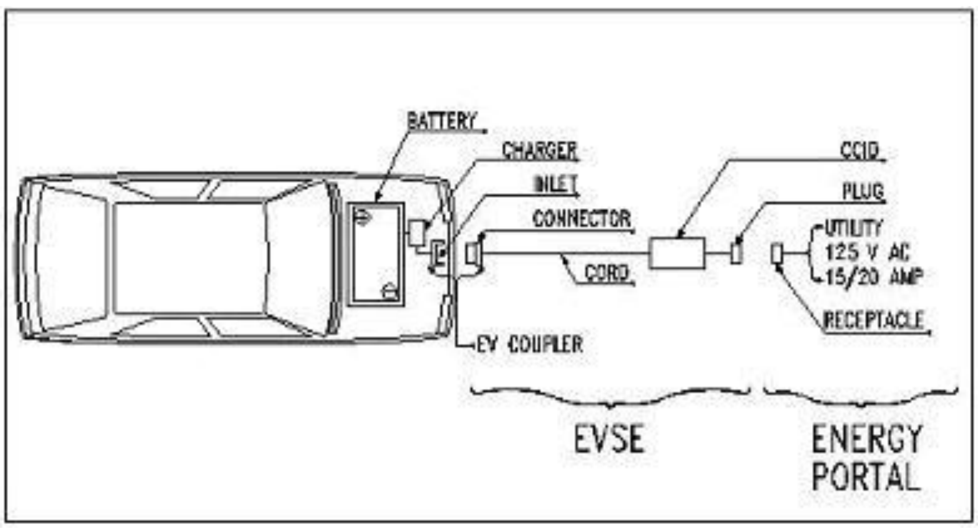

Figure 3-3 Level 1 Charging Diagram

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

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

Figure 3-4 Level 1 Cord Set[5]

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 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 J1772 Standard. This connector will mate properly with the vehicle inlet, also approved by J1772.

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 internal combustion 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 of 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,” standard,” or “preferred” method for the EVSE for both private and publicly available facilities, and specifies a single-phase branch circuit with typical voltage ratings from 220 – 240 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.

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

Figure 3-5 Level 2 Charging

DC Fast Charging (DCFC)

DCFC, or "Fast Charging", is designed 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.

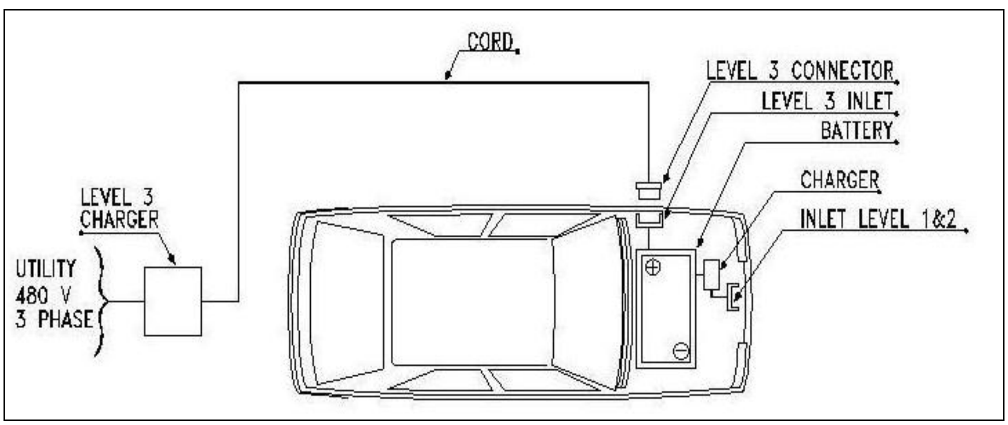

Figure 3-6 DCFC (DC Charging or Fast Charging)

This off-board charger is serviced by a three-phase circuit at 208, 480, or 600 VAC. The SAE standards committee is working on a standardizing the DCFC connector as they have with the Level 2 J1772 connector, but has placed the highest priority in getting the Level 1 and 2 connector approved first. The DCFC connector standard is expected to be approved soon.

eTec will be utilizing DCFC equipment in infrastructure developed in 2010. DCFC was accomplished by eTec for the Chrysler EPIC in the 1990s and in many industrial applications since 1998. Similar, though smaller, equipment will be used for the coming generation of EVs.

Figure 3-7 Chrysler EPIC DCFC (90kW) circa 1997

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 electric vehicle 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 EV charging, the preferred method of residential charging will be Level 2 (240VAC/single phase power). This provides the EV owner a reasonable charge time and also gives the local utility the ability to shift load as necessary while not impacting the customer's desire to obtain reliable power. For other PHEV owners, a dedicated Level 1 circuit may adequately meet all of the owner's charging needs.

General Requirements

This section identifies general requirements of Electric Vehicle Supply Equipment, also referred to as EVSE.

- **Certification:** EVSE will meet the appropriate codes and standards, and will be certified and so marked by a nationally-recognized, independent 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. The EV inlet location on each EV model will vary by manufacturer; however, this standard length should be sufficient to reach from a reasonably-positioned EVSE to the inlet.
- **Tripping hazard**: An extended EV cord may present a tripping hazard, so the EVSE should be located in an area with minimum pedestrian traffic. If the EVSE must be installed in an area with high pedestrian traffic, it would be appropriate to install a cord management system.

- **Ventilation Requirements:** Charging of the Nissan LEAF will not require ventilation. The charging within the EV Project also will not involve the need for ventilation. However, if there are special ventilation requirements for a battery charged by publicly available EVSE, the EVSE will be required to automatically energize a properly-sized ventilation system. This type of requirement is expected to be extremely rare, since automobile manufacturers are expected to use non-gassing batteries. Some EV owners who convert their own vehicles to electric or purchase conversion vehicles may use gassing batteries. The approved EVSE will communicate with the vehicle to specifically check for any ventilation requirements for the battery being charged; 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 may already have ventilation systems for exhaust of normal vehicle emissions, that system typically would be expected to suffice. However, professional calculations should verify this result. It may also be impractical to wire the charger to the ventilation controls or 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 to be electrically energized equipment. Because it operates above 50 volts, Part 19 *Electrical Safety of the Occupational Health and Safety* (OHS) Regulation requires guarding of live parts. EVSE 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 for the optimum location for charging.

Figure 3-8 Wheel Stop[6]

Figure 3-9 Garage Wheel Stop[7]

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

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

- **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:** 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, which reduces installation costs.

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, and Neutral), 20, 30 or 40Amp Breaker.

  Level 2 Notes:

  - The breaker size recommended will meet the requirements of almost all BEVs and PHEVs. A PHEVs with a small battery pack (see Table 3.1) may only require a 20 or 30Amp breaker for its 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, the value of providing an internet connection at the EVSE location is unknown at this time, and is left up to the individual homeowner. It is likely that wireless methods will be available in cases where a hard connection is not available.
  - Many Level 2 EVSE suppliers will provide controls in the EVSE to control charging to programmable times to take advantage of off-peak power pricing. If not, homeowners may desire to install a timer device in this circuit to control charging times.

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 the EV will be at the farthest 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 positioning the EVSE out of the way.

If the EVSE is installed after the EV has been purchased and is accommodating a single vehicle, the location of the EV inlet will play a key 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.

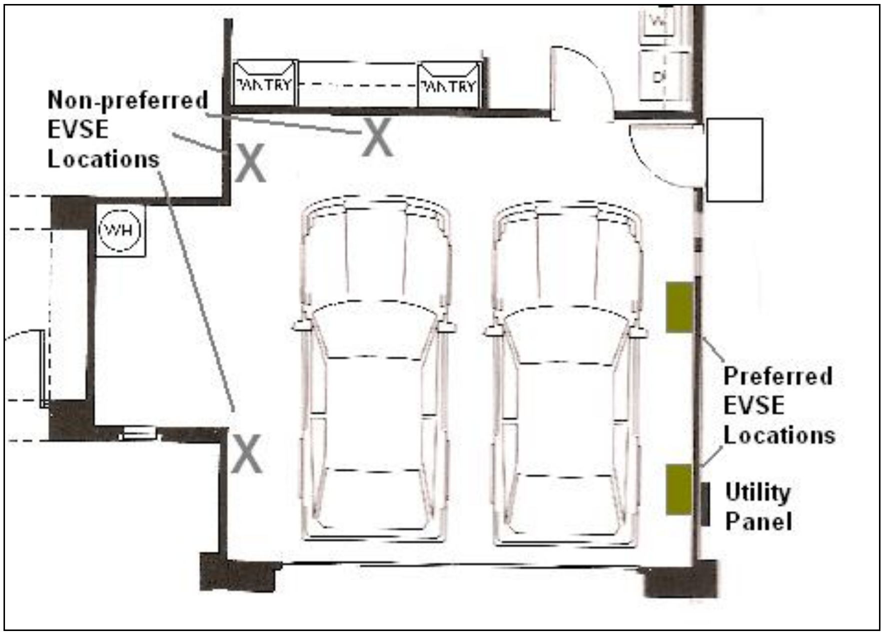

Figure 4-1 Double Garage Location for EVSE

In Figure 4-1, 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 locations are further away from the utility panel. An option for the EV owner's desire to place the EVSE in these locations could be accommodated by using 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.

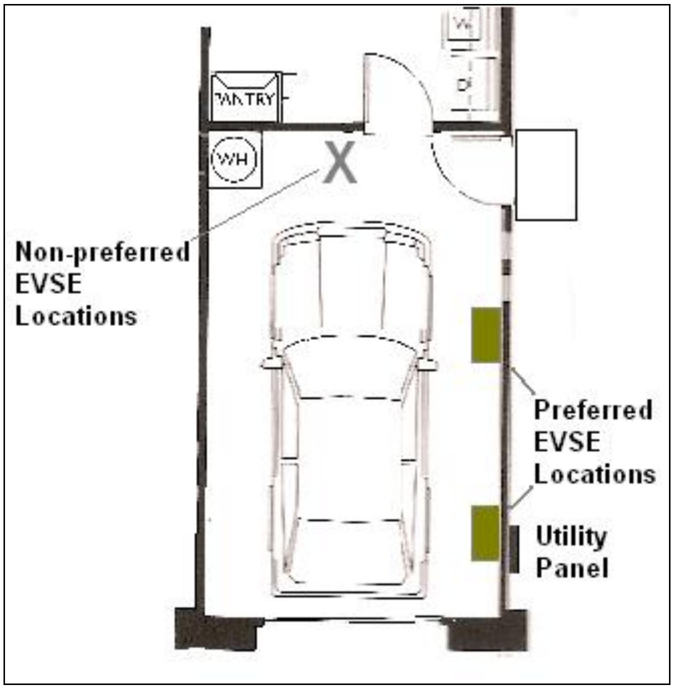

Figure 4-2 Typical Single Garage Location for EVSE

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

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

Detached garages will involve additional considerations when routing the electrical supply to the garage. Landscaping will be disrupted during the installation process. This may be of great significance to the owner and should be thoroughly planned 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 unit (operating at 240 VAC, 40 A) for Level 2 charging. If the garage was built with the conduit or raceway already installed from the panel to the garage, installation is simplified.

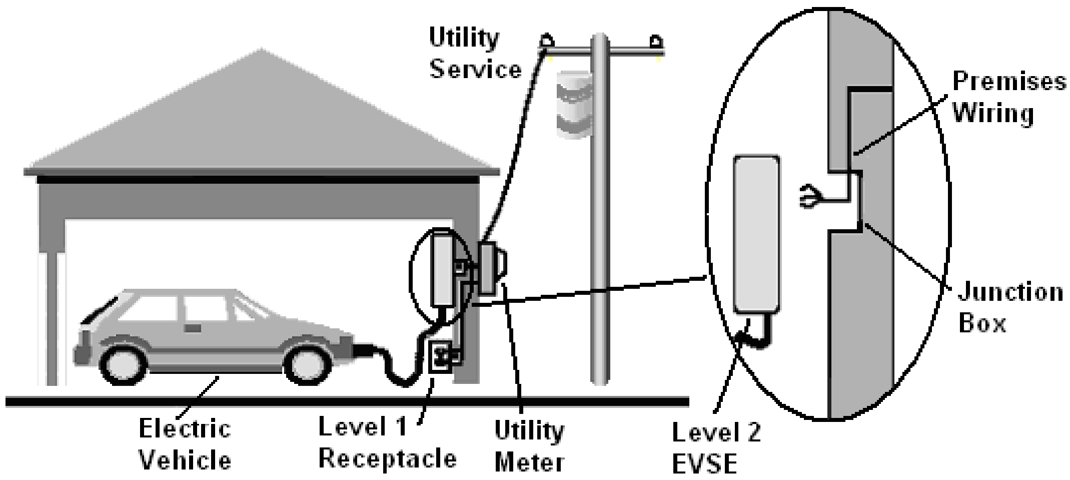

Figure 4-3 Typical Level 1 and Level 2 Installations for a Residential Garage

The specific steps involved in this process are shown in the installation flowchart in Figure 4-4. 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 notify them of the installation of an EVSE, including checking for any special requirements such as a second meter to sub-meter the energy used for EV charging.
- 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 an installation quote.
- Submission of required permitting documents and plans.
- Completion of EVSE installation and utility service components, if required.
- Inspection of final installation.

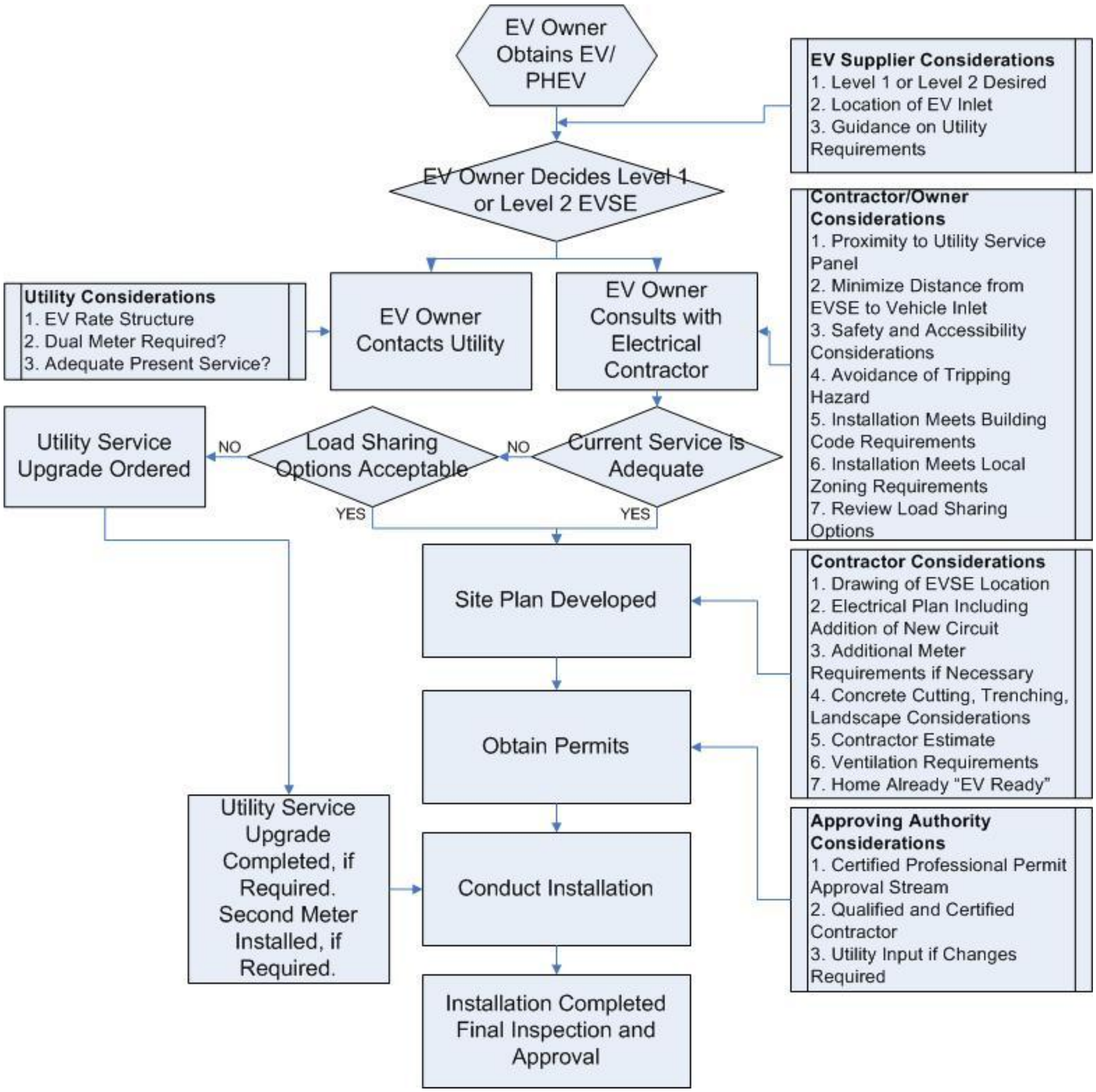

Figure 4-4 Installation Process for a Residential Garage/Carport

If the garage has a pre-existing raceway, a 120 VAC, 15/20 amp circuit or a 240 VAC, a 40 amp circuit can be installed. Some homes may not have sufficient utility electrical service to install this circuit. In that case, either a new service must be added 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 will be 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. If included, consideration should be given to sizing the conductors for the 240 VAC, 40 amp circuit, required for Level 2 charging, but installing the 120 VAC, 20 amp Level 1 breaker and receptacle. The homeowner then would have a functional circuit that could be upgraded easily to Level 2, if desired.

A local electrical contractor is needed to evaluate the need of adding a new service vs. upgrading the existing service, and utility fees may apply.

B. Carport

Power Requirements

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

Siting Requirements

The siting requirements for a carport will include those identified above for the garage. Some EV 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 charging is very safe when using the J1772, owners may be uncomfortable with standing in pooled water while connecting the EVSE. Consultation with the owner will be required when locating the EVSE.

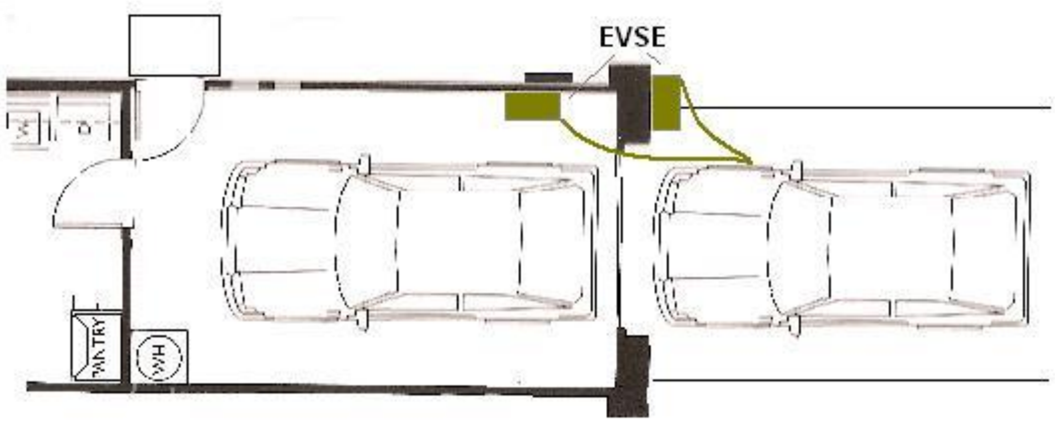

Figure 4-5 Installation Considerations for Outdoor Parking

Freezing temperatures can cause cords to freeze to the parking surface, and cord support should be considered. Adequate lighting is an additional consideration, along with mitigating efforts to prevent vandalism, as noted in Section 5. The installation process is similar to the garage process outlined previously.

Consultation with Landlord or HOA

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

C. Multi-Family Dwellings

Power Requirements

Power requirements are the same as the Garage scenario above.

Siting Requirements

In multi-family dwellings, there will be additional considerations because the apartment or condominium owner also must 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 generally will prefer a site close to his or her dwelling, but this may not be in the best interests of the apartment owner. In addition, special flooding or drainage conditions may be present. 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 other issues to be resolved. In condominiums, the Homeowners Association (HOA) may be involved to approve EV additions.

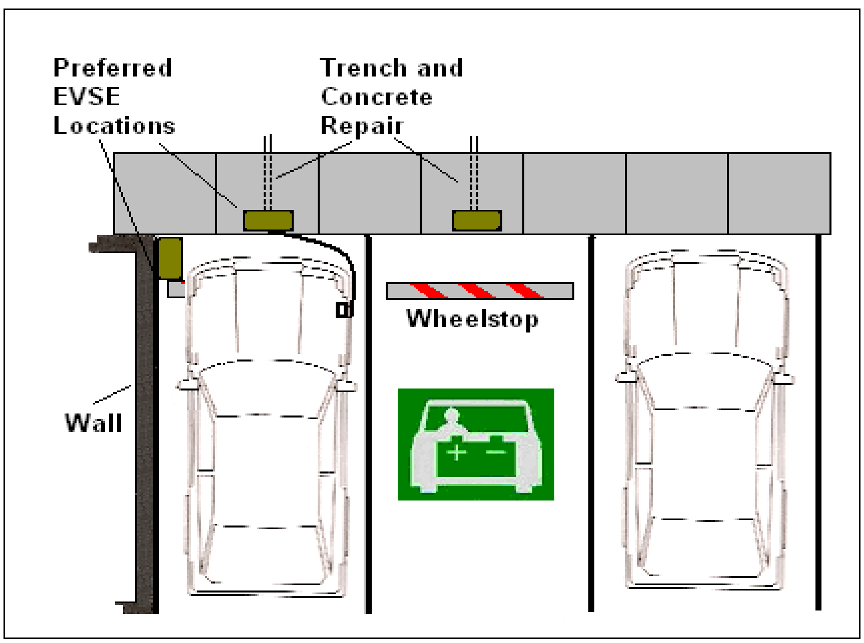

Figure 4-6 Typical EVSE Installation in Multi-Family Lot

In general, unless the location is well protected from the environment, the EVSE will need to be outdoor rated. Installation of the EVSE at the front of the vehicle may be the only choice unless an adjacent wall is available. If it is located at the front of the parking stall, the EVSE should be placed on the vehicle side of any walkway to minimize the cord becoming a tripping hazard. The walkway for pedestrians then 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.

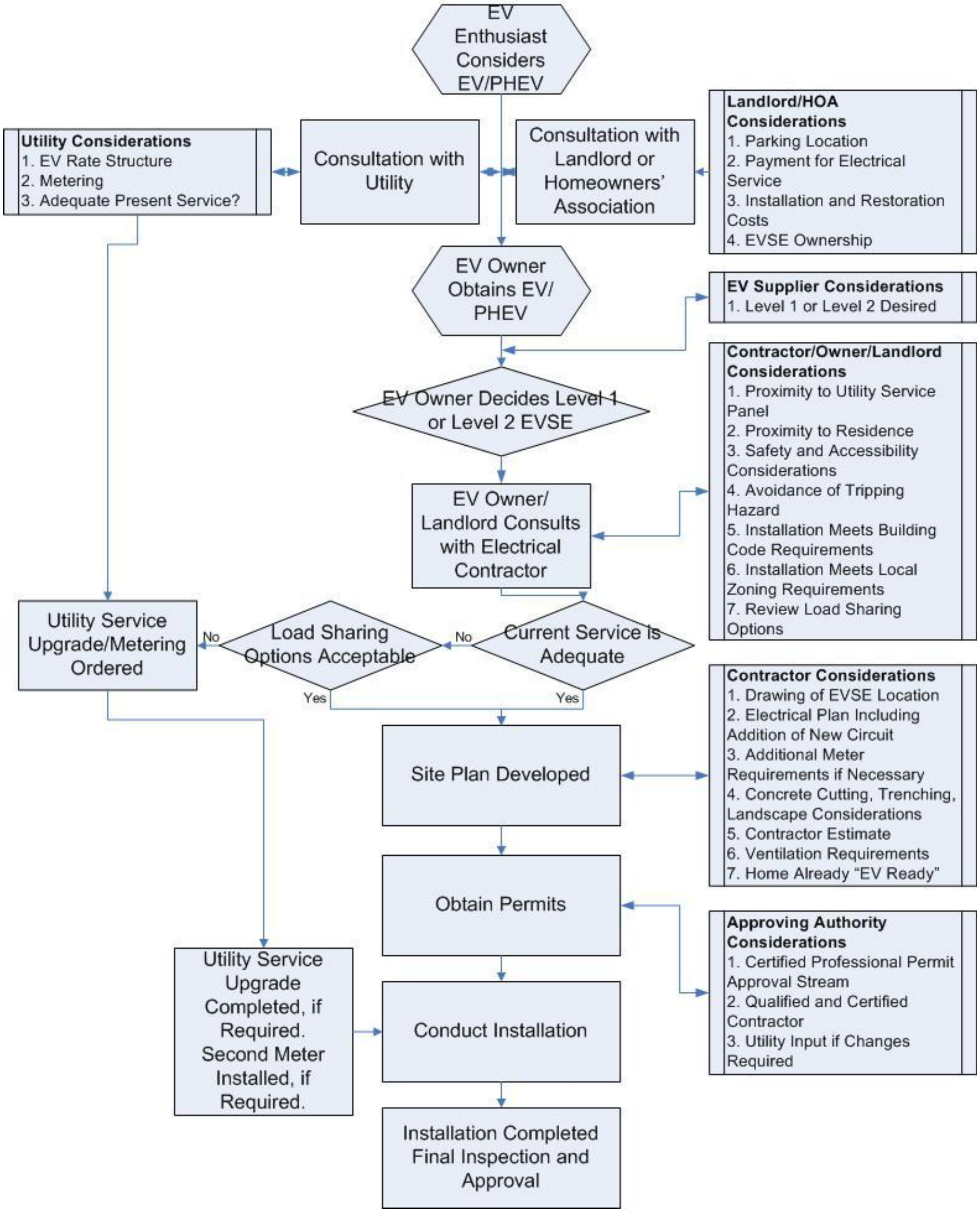

Figure 4-7 Installation Process for Multi-Family

Installation Process

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

Multiple Parking Stall Installation

In a new construction or retrofit situation, broad charging infrastructure installation in a multi-residential building will require the services of an electrical consultant to determine the best approach for 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: 208VAC or 240VAC / Single Phase, 4-wire (2 Hot, GND, Neutral), 40Amp Breaker

Commercial fleet charge stations probably will include multiple charge locations, and therefore, in new construction, the additional load required should be accounted for when sizing the main service entrance section (SES). Since it is likely that most workplace charging will occur during normal business hours when normal business loads are in use, for existing buildings, the additional load from the EV charging 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 is provided in close proximity to the charge stations. This connection may be required for interface with the building energy management system or to implement local utility load control strategies where available.

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 themselves and are encouraging the private sector adoption of EVs. A significant amount of planning is required to correctly size EV parking and charging area ratios. Consideration should given to current needs, 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 on the electric distribution system and on the utility itself. For that reason, electrical utility planners need to be involved early on in large fleet planning processes.

The individual homeowner will be strongly encouraged to do electric vehicle charging during off-peak times, as will fleet managers.

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

Installation of 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. The length of the circuit run and the number of units will have an impact on the installation and power costs.

Because these EVSE units are in designated areas set aside for EV charging, the potential for pedestrian traffic can be controlled. Although fleet charging often has limited access, it also has greater overall security, such as fences and gates, so the threat of vandalism is minimized.

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

Fleet manager interests and priorities can also lead to the implementation of 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 previously, except that much more detailed planning is involved prior to the owner's final decision and obtaining permits.

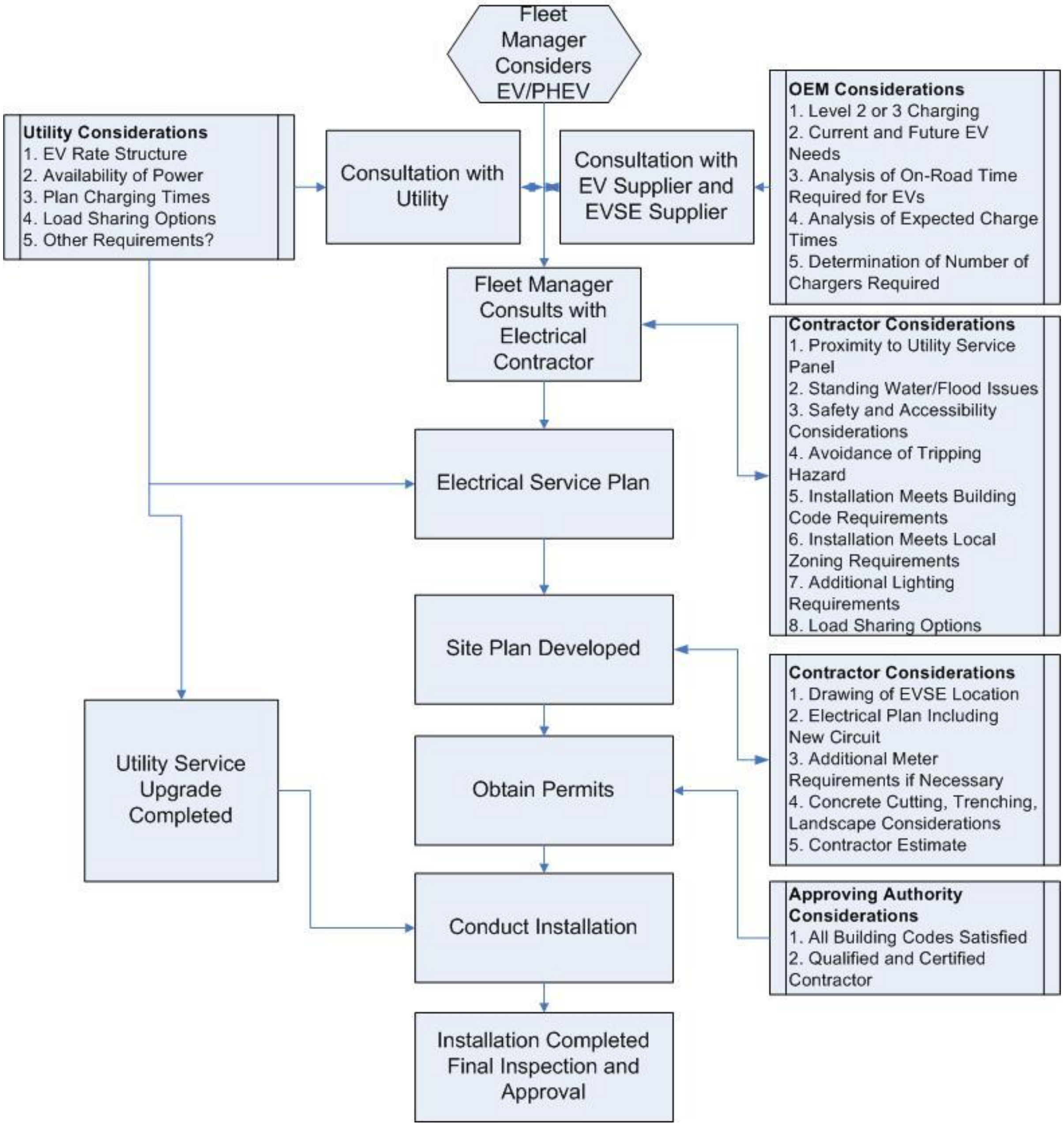

Figure 4-9 Installation Process for Commercial Fleet Operations

E. Publicly Available Charging Stations

A significant factor in the consumer adoption of BEVs will be the ability to extend the range of battery power so that EVs can rely solely on electricity for fuel. This can be accomplished by the installation of publicly available charging locations. The EV Micro-Climate program focuses on this area because of its importance in encouraging the widespread adoption of electric vehicles.

Publicly available charging may employ a mix of Level 1, Level 2, and DCFC charging 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 any EV Micro-Climate. The recommended configuration for a publicly available Level 2 charging station is one equipped with J1772 connector that accommodates all vehicles equipped with a J1772 inlet, including PHEVs and other EVs subscribing to the SAE standard.

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 time include restaurants, theaters, shopping malls, governmental facilities, hotels, amusement parks, public parks, sports venues, arts productions, museums, libraries, outlet malls, airports visitor lots, major retail outlets, and hospitals, among many other choices. Businesses that wish to promote EV usage might install public charging in highly visible areas. As noted above, these stations 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 the necessary 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 to provide standards for environmentally sustainable construction and facility 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: 208VAC or 240VAC / Single Phase, 4-wire (2 Hot, GND, Neutral), 40Amp Breaker
- **DCFC**
  Dedicated branch circuit hardwired to permanently-mounted charger supplied with the circuit, as specified in the installation manual. DCFC chargers rated up to 30kW may require either 208AVC/3-Phase or 480VAC/3-Phase. DCFC chargers greater than 30kW generally will require 480VAC/3Phase.

<u>Example Sizes</u>

1. For 30kW Output Power, typical input power requirements are:
    - 208VAC/3-Phase, 4-wire (3-Hot, GND), 125 Amp Breaker, -or-
    - 480VAC/3-Phase, 4-wire (3-Hot, GND), 60 Amp Breaker
2. For 60kW Output Power, 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 utilized, but if a hardwired internet connection is available, it is generally preferable to wireless.

Siting Requirements

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

Flood-prone area restrictions must be considered, as well as issues of standing water or high precipitation. As noted above, EV owners 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 for vandalism will be greater. This generally will be in a high pedestrian traffic area, so placing the charger in a way that avoids the charge cord or wheel stop being tripping hazards is very important.

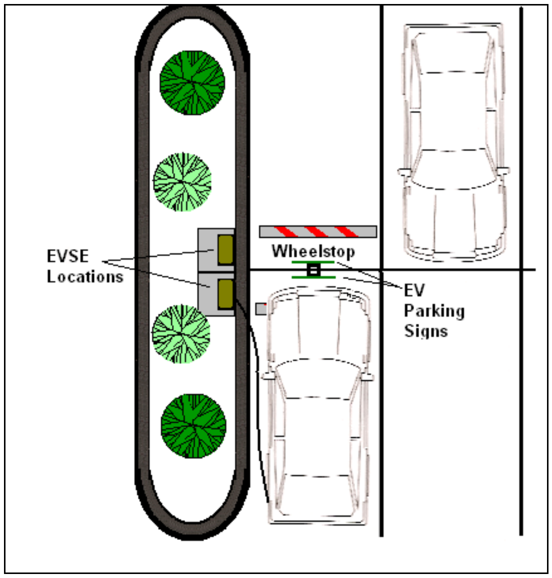

Figure 4-10 Example Publicly Available Charging Layout

There are several 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 will be driven by commercial businesses interested in promoting EV use due to personal preference or as part of LEED certification. These business owners may decide on their own to purchase and install systems or to participate in these costs. Other business owners will be receptive to placing chargers 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 to ensure wide coverage of publicly available charging.

Publicly available sites also will invoke accessibility requirements and affect the number of parking stalls with EVSE that are accessible and van accessible. 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, and must be able to read directions and properly locate the EV connector and insert into the EV inlet.

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 units will have a significant impact on the cost.

The cost of providing power to a EV parking location must be balanced with the convenience of the parking location to the facilities being visited by the EV owner. An EV owner may find it more convenient for a large shopping mall to have two or three EV parking areas, rather than one large area, although the installation cost for three areas will be greater than the cost for one; however, the utilization rate might be significantly higher.

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 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 Outdoor Charging

Figure 4-14 Indoor Charging

Installation Process

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

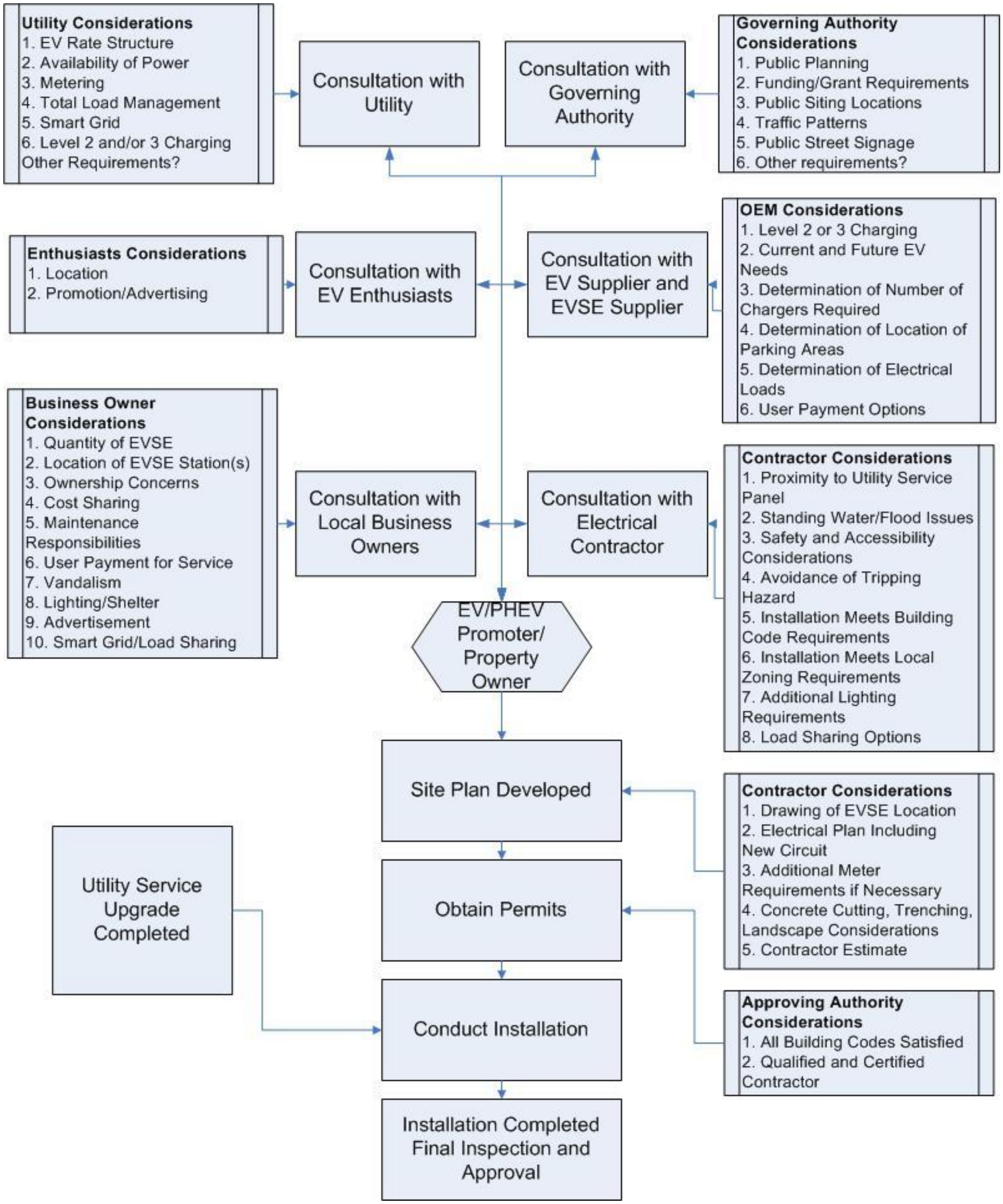

Figure 4-15 Installation Flowchart for Public Charging

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.

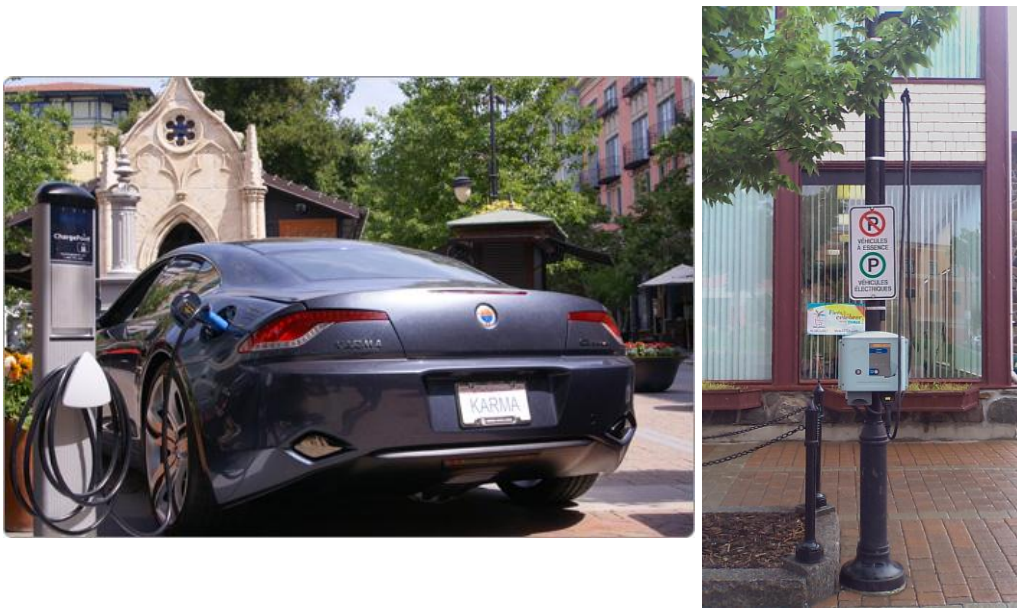

Figure 4-16 Curbside Charging

5. Additional Charging Considerations

A. Signage

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

Figure 5-1 EV Signs

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 designated charging spaces. 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 examples in Figure 5-1 follow MUTCD standards.

Sites that have friendly green or blue EV Parking or EV Parking Only are not recognized by the public. No Parking signs in blue may be mistaken for an accessible location. Green signs are often mistaken for short-term parking signs.

Wide spread 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.

B. Lighting and Shelter

For commercial, apartment, condominium, and fleet charging stations, adequate lighting is recommended for safety and convenience. Shelter is not required, however, for geographic locations that have significant rainfall or snow, providing shelter over the charging equipment can 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 rated for the outdoors.

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

Figure 5-2 Public Charging with Shelter and Lighting

Just as in residential garages or car ports, lighting is important so that pedestrians can avoid tripping over extended charge cords while the EV is charging.

C. Accessibility Requirements

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 National Electric Code for accessible EVSE, and some municipalities provide guidance for accessible EV parking locations. New standards may be developed; therefore, recommendations herein constitute the best guidance to date.

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

EV Charging is the Primary Purpose

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

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

Accessible EV charging stations should be provided according to Table 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 charging stations need not be located immediately adjacent to the buildings and other facilities like traditional ADA parking, since EV charging, not parking, is considered the primary purpose.

Accessible Parking is the Primary Purpose

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

D. Safety Issues Related to Indoor Charging

The possibility of invoking the ventilation requirements or hazardous environment requirements of the NEC exists when installing indoor charging. When the EVSE connector makes contact with the EV inlet, the pilot signal from the vehicle will identify whether that the battery requires ventilation. While most BEV and PHEV batteries do not require ventilation systems, some batteries, such as lead acid or zinc air, emit hydrogen gas when charged. Most vehicle manufacturers will specify clearly that their batteries do or do not require ventilation. Without adequate ventilation, the hydrogen gas concentration may increase to an explosive condition. The Lower Flammability Limit of hydrogen in air is a 4% mixture by volume. Locations are hazardous when 25% of the limit is reached, which is a 1% mixture by volume. The EVSE contains controls to turn on the ventilation system when required, and also to stop charging should that ventilation system fail.

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

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

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."[8]

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).

Elevation refers to the location of a component above the Design Flood Elevation (DFE). This is the primary protection for EVSE. 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 EVSE charging stations be installed on the third level of a parking garage, rather than the first.

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

Wet 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.[9] If the entire building is protected from floodwater, the EVSE is also protected.

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[8] 44CFR60.3(a)(3)

[9] 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 for each use. However, as the public acceptance and ownership of EVs grow, more station owners will favor having the option of point of sale. In most areas, only electric utilities can actually sell electricity, so a fee for convenience/service access will be the likely paradigm. The credit card transaction fee will not pay for the actual electricity consumed or the associated cost of charging an EV. However, the availability and convenience of charging will be a service the public will desire and purchase. A fee for service access can assist the EVSE owner in recovering equipment, installation, service, and maintenance costs. Several options for point of sale transactions are possible with the capabilities of EVSE.

Card Readers

Several types of card readers exist that may be incorporated with an 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 the unit is accessed, rather than length of time on charge.

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

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 then may close a contact for power to be supplied to the EVSE.

Figure 5-3 Smartcard Reader[10]

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

Parking Area Meters

Drivers are very familiar with the parking meters used in public parking. A simple coin-operated meter is 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 is issued that can be displayed in the vehicle. There is little cost for the meter and a single kiosk reduces the point of service cost for the whole parking lot. This system will require an attendant to periodically monitor the area for violations. Penalties for violators will need to be determined.

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 or pre-paid model for the user keeps the fob active and the monthly fee can be based upon number of actual accesses or a set monthly fee. The reader is programmed for the accepted RFID.

Figure 5-4 RFID Fob[11]

[11] Texas Instruments RFID

Figure 5-5 RFID Fob[12]

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 usage at others may be heavier. 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 may 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 risk of vandalism and theft. Destruction or damage of property through purposeful defacing of equipment is a possibility, however, such vandalism actually proved to be very minimal during EV usage during 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 removal of graffiti. Careful planning of site locations to include sufficient lighting and equipment protection will discourage damage and theft. Motion sensor activated lighting may be a benefit to users and a deterrent for abusers. EVSE with cable retractors or locking compartments for the EVSE cord and connector may be designed. Location of the EVSE in security-patrolled areas or within sight of manned centers will discourage vandalism.

EVSE owners in condominiums and apartments may wish to protect the equipment by installing it behind existing gates or with an additional lockable, secure cabinet to prevent unauthorized use and for protection from vandalism.

I. Station Ownership

Ownership of an individual charging station may not be entirely clear. 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. 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.

For individual EV owners, the ownership of the EVSE resides with the owner. The ownership of the installation resides with the property owner. However, both may share legal responsibilities and liabilities for the equipment and both should be protected by insurance.

[12] Texas Instruments RFID

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. Upon widespread EV market penetration, ownership of new public charging may then shift to private ownership. Several businesses may join together to promote EV usage and may share in the EVSE ownership.

J. Maintenance

The 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. Periodic cleaning may be required, depending upon local conditions. Testing of communications systems and lighting should be conducted periodically. Repair of accidental damage or purposeful vandalism may also be required. Unless otherwise agreed, these responsibilities generally fall to the owner identified in Section G above.

6. Codes and Standards

In the initial introduction of EVs in the early 1990s, stakeholders representing the automotive companies, electric utilities, component suppliers, EV 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 stations accessible for use.

Equipment is designed to standards set by organizations such as the 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, the codes also affect the standards, as is the case for electric vehicles.

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

A. Regulatory Agencies

Tennessee Code Annotated (T.C.A.) § 68-120-101 requires the State Fire Marshal (Commissioner of the Department of Commerce and Insurance) to adopt rules establishing minimum statewide building construction safety standards. T.C.A. §§ 68-102-113 and 143 authorize the Commissioner of the Department of Commerce and Insurance to adopt an electrical code and require the inspection of electrical installations.

The Department of Commerce and Insurance adopted minimum statewide building construction safety standards and requires plans review of educational and daycare occupancies, state buildings, detention and correctional occupancies, assembly occupancies with a capacity of 300 or more, covered malls and high hazard occupancies, business occupancies of three or more stories, and residential occupancies, excluding one- and two-family dwellings and townhouses.

Local units of government are allowed to adopt and enforce building construction safety standards for most buildings regulated by the Department of Commerce and Insurance and the electrical code, so long as it adequately enforces its codes and its codes are within seven years of the most recent edition of the state code.

Local governments are allowed to adopt and enforce building construction safety codes for those buildings and occupancies not regulated by the Department of Commerce and Insurance.

B. National Electric Code

Tenn. Comp. Rule and Reg. 0780-02-01-.02, effective January 28, 2009 adopts the 2008 edition of the National Electric Code.

In order to have statewide uniformity, the Tennessee Department of Commerce and Insurance is in the process of developing rules that would retain state jurisdiction for permitting of the electrical installation of EV charging stations. The Department expects emergency rules to be filed in the summer of 2010 and permanent rules to be effective in Fall 2010.

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. The NEC is updated every three years. The current approved edition is 2008.

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:
    - A) 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. 125 VAC. 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 millimeters (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 millimeters (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, the Inductive Charge Coupler, is still active, none of the automakers are using this method.

Applicable SAE Standards include:

- SAE J1715 *Hybrid Electric Vehicle (HEV) & Electric Vehicle (EV) Terminology*
- SAE J1772 *Electric Vehicle and Plug-in Hybrid Electric Vehicle Conductive Charge Coupler*
- SAE J2847 *Communication between Plug-in Vehicles*
- SAE J2836 *Use Cases for Communication*
- SAE J2894 *Power Quality Requirements for Plug-in Vehicle Chargers*
- SAE J2931 *Power Line Carrier Communications for Plug-in Electric Vehicles*
- SAE J551 *Vehicle Electromagnetic Immunity*

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 DC electrical energy that can be used to charge an EV's storage battery. J2847 provides specifics on digital communications. J2836 provides use case for digital communications between vehicle and EVSE. J2894 addresses on-board charger power quality. J551 provides standards for electromagnetic compatibility.

The 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*
- UL2594 *Electric Vehicle Supply Equipment*

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. Construction Codes

- Tenn. Comp. Rule and Reg. 0780-02-02-.01, effective September 1, 2008, adopts the 2006 edition of the International Building Code, except for Chapters 11 (accessibility) and 27 (electricity).
- Tenn. Comp. Rule and Reg. 0780-02-02-.01, effective December 16, 2008, adopts the 2006 edition of the International Fire Code.
- Tenn. Comp. Rule and Reg. 0780-02-03-.02, Submission of Plans, requires the submission of plans and specifications for certain buildings, but the installation of EVSE is unlikely to require submission of plans unless the installation is part of a larger project or construction on state property.
- Chattanooga, Knoxville, and Nashville and many of their surrounding communities have adopted local codes, and each county and municipality may have its own specific requirements regarding permits.
- The City of Chattanooga has adopted the following codes:
    - Building – 2006 IBC
    - Mechanical – 2006 IMC
    - Electrical – 2005 NEC
    - Residential – 2003 IRC

    - Fire – 2006 IFC
    - Energy – 2006 IECC
    - Fuel – 2006 IFGC
    - Plumbing – 2006 IPC
- Hamilton County has adopted the following codes:
    - Building – 2003 IBC
    - Mechanical – 2003 IMC
    - Electrical – 2005 NEC
    - Residential – 2003 IRC
    - Fire – 2003 IFC
    - Energy – 2003 IECC
    - Fuel – 2003 IFGC
    - Plumbing – 2003 IPC
- The City of Knoxville has adopted the following codes, with local amendments:
    - Building – 2006 IBC and 2006 IEBC
    - Mechanical – 2006 IMC
    - Electrical – 2005 NEC
    - Residential – 2006 IRC
    - Fire – 2006 UFC
    - Energy – 2006 IECC
    - Fuel – 2006 IFGC
    - Plumbing – 2006 IPC
- Nashville/Davidson County has adopted the following codes, all with local amendments:
    - Building – 2006 IBC
    - Mechanical – 2006 IMC
    - Electrical – 2005 NEC
    - Residential – 2006 IRC
    - Fire – 2006 IFC
    - Energy – 2006 IECC
    - Fuel – 2006 IFGC
    - Plumbing – 2006 IPC

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.[13]

In Tennessee, the Department of Labor and Workforce Development adopts the Safety and Health Rules, which are the basic safety and health rules needed by most employers in the state of Tennessee.

F. Engineering, Permitting, and Construction

The process flowcharts identified above all require the electrical permitting of the work. An electrical permit application includes the name of the owner or agent; the physical address where the work will be conducted; the amperage of the system; the name, address, and license number of the qualified contractor; and identification of the power supplier.

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.

For BEV purchasers, the Level 1 Cord Set provided with the vehicle will require a significant charge period, so a Level 2 EVSE will be preferred. Keeping the time span from EV purchase to a fully functional and inspected EVSE installation will be important for customer satisfaction.

An electrical contractor can complete the requirements for residential garage circuits. Prior to any actual on-site work, the permit must be approved and posted at the site. Work shall not be concealed until the inspection is completed and work approved.

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

[13] OHSA website www.osha.gov

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 monitor and control various electrical loads on their system. Through these Smart-Grid technologies, utilities intend to minimize or defer investment in new power supply, distribution, and transmission systems, while minimizing the impact to the customer.

Advanced Metering Infrastructure (AMI), or *smart meters*, are being deployed by some utilities to provide remote meter reading. Depending on the level of sophistication, smart meters may enable customers to manage their own energy use, and utilities to implement programs such as time-of-use rates, demand response, real-time pricing, and direct load control.

Electric vehicles, like water heaters, are one of the better residential loads for utilities to control through smart meters, because delaying the charge of the EV battery has no immediate impact on the customer, in contrast to lighting or air-conditioning loads, which may. Additionally, a neighborhood transformer may not be sized to accommodate every EV in the local area at the same time. The ability to schedule EV charging could significantly extend the life of that transformer and delay transformer replacement.

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

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

The electrical contractor will coordinate with the local utility to determine the lowest-cost method, as utility fees may apply.

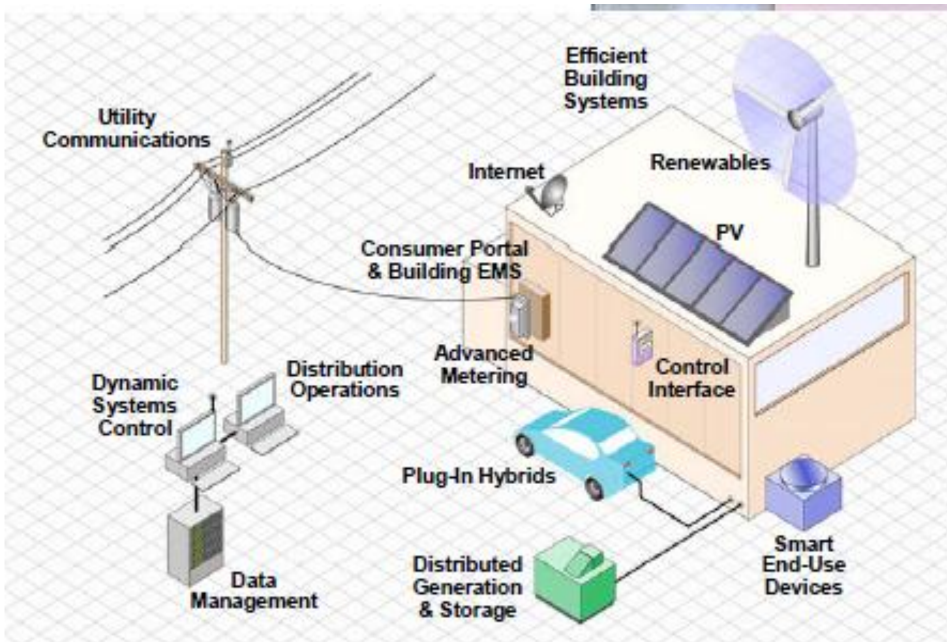

Figure 7-1 Smart Grid Infrastructure[14]

Figure 7-1 illustrates many features of a residential Smart Grid, including renewable and distributed energy resources and electric vehicle integration.

There are various mechanisms for utilities to control EV load, including the following.

Time-of-Use (TOU) Rates

TOU rates provide incentives for off-peak use and penalties for on-peak use of electricity. This allows the EV owner to save money by charging during designated "off-peak" times established by the utility. Typically, these off-peak times are in the late evenings through early mornings and/or on weekends, when demand for electricity is usually low. Some utilities also have seasonal considerations such as summer peak and winter peak, which vary the TOU rate schedules. TOU rates are currently being implemented by some utilities, but there is not a standard approach due to the individual needs of each utility and the geographic diversity of the industry. Discussion with the local utility prior to installation of the charge station is recommended in all cases.

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

Dual Metering

Some utilities may provide a special rate for EV charging and may require the installation of a second meter to track energy used as transportation fuel. This will require additional installation time, since the utility must install the meter before the EVSE can be used. The use of a "revenue grade" meter in the EVSE and a communications path to allow the utility direct access and control may eliminate the need for a second meter.

Demand Response

Demand response is a voluntary program that allows a utility to send out a signal to customers (typically large commercial customers) to cut back on loads when electrical use is high throughout their power service territories. 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 electric vehicles, whereby pricing signals are sent to a customer through a number of communication media that allow the customer to choose the most cost-effective time to charge their EV. For example, an EVSE 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, a fully-integrated, end-to-end utility system is required. End-to-end smart utility systems are being defined, developed, and standardized at the time of this writing.

Vehicle-to-Grid (V2G)

V2G is a concept that allows the energy storage in electric vehicles to be used to support the electrical grid during peak electrical loads, either to enhance reliability or to lower power delivery costs. A related concept is V2H, or vehicle-to-home, whereby the energy stored in the vehicle battery could provide power to the home during grid outages or when the grid is stressed. Both V2G and V2H require a bi-directional vehicle charger (energy can flow both directions) and EVSE. V2G further requires accommodating utility safety standards for flowing energy back into the electrical grid. Although there are various developmental pilot efforts in V2G, this concept for on-road EVs is probably several years away from implementation on any commercial scale.

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 feed energy back to the local grid, it will be necessary to contact the local utility to determine interconnection requirements. These requirements are in place to protect personnel and property. Generally utilities already have procedures in place for connecting solar photovoltaic and wind systems to the utility.

C. Electrical Supply/Metering

There are typically two primary scenarios for connection to an electrical supply. The first is utilizing the existing main service entrance section (SES) or an otherwise adequate supply panel, 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
- the location of the existing SES
- the location of the proposed electric vehicle charge station.

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 or a new service drop.

A new utility service drop typically will require establishing 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 applicable 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.

For commercial customers, consideration of peak demand charges and load factor also may be deciding factors in selecting between the use of Level 2 or DCFC for fleet applications. A commercial customer should consult with their utility for rate structure information.

D. Summary

The transition from petroleum to electricity as a transportation fuel is challenging the current paradigm for electric utilities and end-use customers. Given the complexities of this new paradigm, engaging the utility in the process at the earliest opportunity is the best practice to enhance the customer experience and minimize costs and redundant processes in EV charging infrastructure deployment.

8. Cost Estimating

This section provides cost estimate worksheets and sample costs for residential, commercial fleet, and public scenarios. The material and labor costs provided here are for general information purposes only, and should not be used for actual planning purposes.

A. Residential Cost Estimate Worksheet

Referring to Figure 4-1 for a Residential EVSE installation, Table 8-1 provides a generic Cost Estimate Worksheet that can be used as a guideline for residential installations. As noted in Section 4, some homes may require a service panel upgrade, but the following table assumes an upgrade is not required.

Table 8-1 Cost Estimate Worksheet for Residential EVSE Level 2 Installation

Description	Quantity	Cost Each	Total
Labor (hrs)			
Initial Site Visit	2	$ 75.00	$ 150.00
Permit Application / Acquisition	2	$ 75.00	$ 150.00
Installation	8	$ 75.00	$ 600.00
Approval	2	$ 75.00	$ 150.00
Labor Sub-Total			**$ 1,050.00**
Materials			
40amp Breaker	1	$ 35.00	$ 35.00
#8 THHN Wire	140	$ 0.30	$ 42.00
Conduit - 3/4 EMT	35	$ 3.00	$ 105.00
40Amp Fused Disconnect	1	$ 115.00	$ 115.00
Miscellaneous	1	$ 840.00	$ 840.00
Material Sub-Total			**$ 1,137.00**
Permit	1	$ 85.00	$ 85.00
		Total	**$ 2,272.00**

B. Commercial Fleet Cost Estimate Worksheet (10 Charging Stations)

Referring to Figure 4-8 for Commercial Fleet Charging Station, Table 8-2 provides a generic Cost Estimate Worksheet for a Commercial Fleet Charging Station with 10 charging stations.

Table 8-2 Cost Estimate Worksheet for Commercial Fleet Level 2 Installation (10 Charging Stations)

Description	Quantity	Cost Each	Total
Labor (hrs)			
Initial Site Visit	2	$ 95.00	$ 190.00
Engineering	16	$ 90.00	$ 1,440.00
Permit Application / Acquisition	2	$ 95.00	$ 190.00
Installation	24	$ 95.00	$ 2,280.00
Approval	2	$ 95.00	$ 190.00
Labor Sub-Total			**$ 4,290.00**
Materials			
Distribution Panel (400amp)	1	$ 650.00	$ 650.00
40amp Breaker	10	$ 35.00	$ 350.00
#12 THHN Wire	1000	$ 0.30	$ 300.00
Conduit - 3/4 EMT	250	$ 3.00	$ 750.00
40Amp Fused Disconnect	10	$ 115.00	$ 1,150.00
Signage	10	$ 250.00	$ 2,500.00
Miscellaneous	10	$ 2,560.00	$ 25,6000.00
Material Sub-Total			**$ 31,300.00**
Trenching & Repair	200	$ 45.00	$ 9,000.00
Permit	1	$ 85.00	$ 85.00
		Total	**$ 44,675.00**

C. Commercial Publicly Available Cost Estimate Worksheet (2 Charging Stations)

Referring to Figure 4-10 for a Level 2 Publicly Available Charging Station, Table 8-3 provides a generic Cost Estimate for a Publicly Available Level 2 Charging Station for two charging stations located side-by-side.

Table 8-3 Cost Estimate Worksheet for Level 2 Public Installation (Two Charging Stations)

Description	Quantity	Cost Each	Total
Labor (hrs)			
Consultation with Property Owner/Tenant	4	$ 95.00	$ 380.00
Initial Site Visit	2	$ 95.00	$ 190.00
Engineering Drawings	16	$ 90.00	$ 1,440.00
Permit Application / Acquisition	2	$ 95.00	$ 190.00
Installation	24	$ 95.00	$ 2,280.00
Approval	2	$ 95.00	$ 190.00
Labor Sub-Total			**$ 4,670.00**
Materials			
Distribution Sub-Panel (100Amp)	1	$ 250.00	$ 250.00
40amp Breaker	2	$ 35.00	$ 70.00
#12 THHN Wire	400	$ 0.30	$ 120.00
Conduit - 3/4 EMT	100	$ 3.00	$ 300.00
40Amp Fused Disconnect	2	$ 115.00	$ 230.00
Ground Signage & Striping (painted)	2	$ 125.00	$ 250.00
Signage (Post Mount)	2	$ 250.00	$ 500.00
Miscellaneous	2	$ 2,560.00	$ 5,120.00
Material Sub-Total			**$ 6,840.00**
Trenching & Repair	100	$ 45.00	$ 4,500.00
Permit	1	$ 85.00	$ 85.00
		Total	**$ 16,095.00**

D. DCFC Cost Estimate Worksheet (Two Charging Stations)

Figure 8-1 shows a conceptual image of a DCFC Station. Table 8-4 provides a generic Cost Estimate Worksheet for a DCFC installation.

Figure 8-1 Conceptual Fast Charge Station (2 Charging Stations)

Table 8-4 Cost Estimate Worksheet for DCFC Installation (Two Charging Stations – 30kW)

Description	Quantity	Cost Each	Total
Labor (hrs)			
Consultation with Property Owner/Tenant	16	$ 95.00	$ 1,520.00
Initial Site Visit	4	$ 95.00	$ 380.00
Engineering Drawings	24	$ 90.00	$ 2,160.00
Permit Application / Acquisition	4	$ 95.00	$ 380.00
Installation	24	$ 95.00	$ 2,200.00
Approval	4	$ 95.00	$ 380.00
Labor Sub-Total			**$ 7,020.00**
Materials			
Distribution Sub-Panel (480VAC/3Phase)	1	$ 650.00	$ 650.00
Point of Sale System	1	$ 2,500.00	$ 2,500.00
60amp 480VAC/3Pole Breaker	2	$ 45.00	$ 90.00
#6 THHN Wire	160	$ 0.30	$ 48.00
Conduit 1"	50	$ 3.50	$ 175.00
60Amp Fused Disconnect	2	$ 150.00	$ 300.00
Ground Signage & Striping (painted)	2	$ 125.00	$ 250.00
Signage (Post Mount)	1	$ 2,500.00	$ 2,500.00
Miscellaneous	1	$ 50,350.00	$ 50,350.00
Material Sub-Total			**$ 56,863.00**
Trenching & Repair	30	$ 50.00	$ 1,500.00
Concrete Work	1	$ 1,500.00	$ 1,500.00
Permit	1	$ 85.00	$ 85.00
		Total	**$ 66,968.00**