# CANADIAN ELECTRIC VEHICLE INFRASTRUCTURE DEPLOYMENT GUIDELINES 2014

DC14-071

## REPORT FOR

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STRATEGIC OPTIONS FOR SUSTAINABLE POWER GENERATION INTEREST GROUP (SOIG)

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CANADIAN ELECTRIC VEHICLE INFRASTRUCTURE DEPLOYMENT GUIDELINES

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Sponsored by

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| **BC Hydro** | **Manitoba Hydro** |
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# NOTICE

## ABSTRACT

This report provides the essential information and resources required to implement electric vehicle (EV) charge infrastructure. The report touches various topics e.g. different power requirements for AC Level 1 and Level 2 chargers, DC Level 2 chargers, Electric Vehicle Technology, Canadian legislative codes and standards, and site planning of residential, commercial and public charging. CEATI International's goal for this project was to prepare an infrastructure installation guideline, an online resource for the proper deployment of electric vehicle charge infrastructure to further advance the electrification of transportation.

The audience targeted in this report ranges from civic and campus planners, facility engineers, architects, developers, operations personnel, and large building owners to individual or fleet electric vehicle consumers and charge infrastructure users. Safety issues, disability requirements and station ownership topics have also been touched upon. An overview of key cost factors for installation of electric vehicle charge infrastructure and lessons learned have also been provided in the guideline. The objective of the Canadian Electric Vehicle Charge Infrastructure Deployment Guideline is to educate the reader on installation considerations providing the necessary information and resources to properly implement electric vehicle charge infrastructure.

## ACKNOWLEDGEMENTS

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| | | |
|---|---|---|
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## EXECUTIVE SUMMARY

The goal of this project was to prepare an infrastructure installation guideline, an online resource for the proper deployment of EV charge infrastructure to further advance the electrification of transportation.

This National Deployment Guidelines project commenced with an informational workshop for stakeholders conducted in conjunction with the Electric Mobility Canada conference in September 2011. A broad overview of the British Columbia Deployment document was provided. The attendees and other invited stakeholders became the Advisory Group Participants who were instrumental in the National Guideline document preparation.

Using the British Columbia Deployment document and associated comments and suggestions, along with the updates and input from The EV Project Deployment Guidelines from the 5 major metropolitan areas, a revised British Columbia Charging Infrastructure Deployment Guideline document was prepared and presented to the Advisory Group Participants and Consortium Members for review and comment. Several other revisions and opportunities for review and comments by the Participants were conducted prior to the submittal of the final report.

Significant experience and knowledge had been gained since the publication of the British Columbia Deployment document. Primarily, the Nissan Leaf and Chevrolet Volt were in production and delivery. Many EVSE suppliers were providing public and residential equipment. DC Level 2 (also known as DC Fast Charge) equipment was now available and being installed.


**Figure 1**
Nissan Leaf charging at AC Level 2 EVSE

The experience in the planning and installation of EVSE provided insight into local procedures and processes that were addressed. Lessons learned to date from The EV Project and other demonstrations provided new input.

At the same time, the Advisory Group Participants and Consortium Members had become very familiar with local and national events and vehicle deployments to provide updated and relevant comments and suggestions for the final document.

The audience targeted in the National Deployment Guidelines ranged from civic and campus planners, facility engineers, architects, developers, operations personnel, and large building owners to individual or fleet EV consumers and charge infrastructure users. PEV technology, safety issues, disability requirements and station ownership topics were addressed. An overview of key cost factors for the installation of EV charge infrastructure and lessons learned has also been provided in the guideline document. The objective of the Canadian EV Charge Infrastructure Deployment Guideline is to educate the reader on installation considerations while providing the necessary information and resources to properly implement EV charge infrastructure.

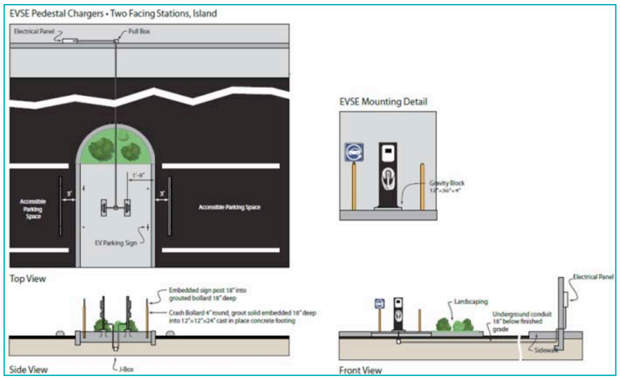


**Figure 2**
Sample AC Level 2 Installation Plan

The National Plug-in Electric Vehicle Charging Infrastructure Deployment Guidelines document met the objectives set forth in the original Invitation for Proposal.

The document successfully updates much of the prior work and includes significant input from recent activities and demonstration programs. It provides the definitions and common language that can be used across Canada for the implementation of deployment strategies and the installation of equipment. It references the local codes and standards required during installation as well as provides outlined processes for the installation efforts.

The adoption of PEVs into the mainstream vehicle buyer's market is still early but growing. Likewise, the deployment of public charging infrastructure is growing. Early trends from The EV Project show that the acceptance of charging away from home by the PEV driver is increasing, which supports longer daily PEV travel on battery power. It is also evident that drivers of Plug-in Hybrid Electric Vehicles (PHEVs), which have a gasoline power backup, still prefer to drive as much as possible on the battery power. The EV Project continues through 2013, at which time many more lessons learned and analyses will be presented.

Many of the lessons learned in the deployment processes to date have been incorporated into this document. Certain recommendations, such as establishing a National symbol for PEVs for use in signage has already been accomplished as shown in Figure 3 (adopted by the Ministry of Transportation in British Columbia and recommended for national use).


**Figure 3**
Recommended Identify Symbol for PEV

Questions which have already been addressed or which need to be addressed have been included. Among these are EVSE ownership, accessibility for disabled persons, vandalism, lighting and shelter, point of sale options and topics of particular interest to electric utility companies.

This document can be utilized in public education as well as planning efforts. It should be effective in assisting in the promotion of the adoption of PEVs throughout Canada.

## ABBREVIATIONS

1. A Amperage
2. AC Alternating Current
3. AMI Advanced Metering Infrastructure
4. ANCE Asociación Nacional de Normalización y Certificación del Sector Eléctrico (National Association for Standardization & Certification of the Electrical Sector)
5. BEV Battery Electric Vehicle
6. BMS Battery Management System
7. CCID Charge Current Interrupting Device
8. CDU Charge Dispenser Unit
9. CEC Canadian Electrical Code
10. CSA CSA Group
11. CSP Curtailment Service Provider
12. DC Direct Current
13. DCFC DC Fast Charging
14. DFE Design Flood Elevation
15. EPRI Electric Power Research Institute
16. EREV Extended Range Electric Vehicle
17. EV Electric Vehicle
18. EVSE Electric Vehicle Supply Equipment
19. GFCI Ground Fault Circuit Interrupter
20. GPU Grid Power Unit
21. HEV Hybrid Electric Vehicle
22. HOA Home Owners Association
23. IAEI International Association of Electrical Inspectors
24. ICC International Code Council
25. ICE International Combustion Engine
26. IEC International Electrotechnical Commission
27. IEEE Institute of Electrical and Electronics Engineers
28. ISO International Organization for Standardization
29. IWC Infrastructure Working Council
30. kW Kilowatt
31. kWh Kilowatt-hour
32. LSEV Limited Speed Electric Vehicle
33. MURB Multi-Unit Residential Buildings
34. OHS Occupational Health and Safety
35. PEV Plug-In Electric Vehicle
36. PHEV Plug-In Hybrid Electric Vehicle
37. REEV Range Extended Electric Vehicle
38. RFID Radio Frequency Identification
39. RTP Real Time Pricing
40. SAE The Society of Automotive Engineers
41. SES Service Entrance Section
42. TIL Technical Information Letter
43. TOU Time of Use
44. UL Underwriters Laboratories Incorporated
45. ULC Underwriters Laboratories of Canada
46. VAC Volts Alternating Current
47. V2G Vehicle-to-Grid

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# 1.0 INTRODUCTION

Transportation is changing. As the world embraces the benefits of electric transportation, Canada is committed to leadership in the safety, standardization and national acceptance of the electrification of transportation throughout each Province. Nations around the world are preparing communities, at both macro and micro levels, for the electric vehicles coming to market from nearly every major auto manufacturer. A market is being created, at this time, for the electric transportation industry whereby nations are prepared to invest in the proper deployment of electric charge infrastructure.

Local and National Governments are making investments into the planning effort for the adoption of electric vehicle technology. Understanding of the terminology, recharging types, the basic technology involved, types of vehicles expected to require charging, relevant electrical codes and related standards, typical charging scenarios and cost factors related to utility companies' plans to service these new vehicles are provided for within this document in order to enhance the understanding, standardization, and deployment of electric vehicle charging infrastructure. Stakeholders from around the nation, including utility companies, local and national government agencies, transportation and infrastructure departments along with auto makers and advocacy groups for electric transportation came together to create a resource for the implementation of electric vehicle charging stations in the home, at work and at stops along the way.

This document is intended to provide the information and resources required to implement a highly functional, electric vehicle charge infrastructure incorporating the Lessons Learned from several major projects underway in North America and interactive stakeholder working sessions. The target audience in this report varies from civic and campus planners, facility engineers, architects, developers, operation personnel to large building owners to individual and fleet electric vehicle consumers and charge infrastructure users.

## 1.1 CHARGING POWER

Electric vehicle manufacturers have various configurations of and placements for the inlets for charging and offer a range of charging options. The standard terminology is shown in figure 1-1 for the on-board and off-board equipment.

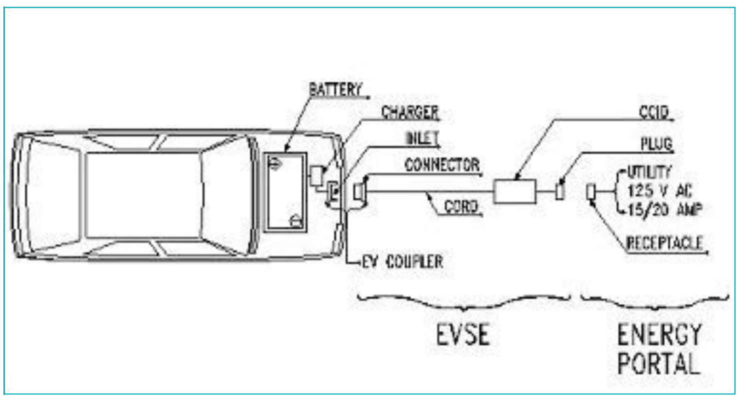


**Figure 1-1**
Charging diagram

The electric vehicle battery is located on-board the vehicle. Power is delivered to the onboard battery through the inlet. The inlet is considered part of the vehicle. A connector is a device that, by insertion into an electric vehicle inlet, establishes an electrical connection for the purpose of charging and information exchange. The inlet and connector together are referred to as the coupler. Electric vehicle supply equipment (EVSE) consists of the collective from cords, connector, and attachment plugs, to all other fittings, devices, power outlets, or apparatus installed specifically for the purpose of delivering energy to an electric vehicle. As outlined below, the interface between the EVSE and the premises wiring may be through a plug and receptacle interface, or hard wired into the electrical unit.

In 1991, the Infrastructure Working Council (IWC) was formed by the Electric Power Research Institute (EPRI) to establish consensus on several aspects of electric vehicle charging. AC Level 1, AC Level 2, and DC Fast Charging levels were defined by EPRI, along with the corresponding functionality requirements and safety systems. EPRI published a document in 1994 that describes the consensus items of the IWC[1]. More recently, The Society of Automotive Engineers (SAE) provided a summary document, with established Level 1 and Level 2 standards, and preliminary DCFC specifications[2].

**Figure 1-2**
J1772 Connector and Inlet

The amount of time needed to completely charge an electric vehicle (EV) battery when fully depleted is a function of several factors:

- Battery size
- Charging option selected: Level 1AC, Level 2 AC or DC Fast Charging
- The vehicle's Battery Management System (BMS)
- The on-board charger specifications
- The Voltage and Amperage of the Charging Station

The amount of electric power that an electrical circuit can deliver to a battery is measured in kilowatts (kW). Larger circuits, measured by voltage and amperage, provide a higher level of power and faster charging times.

### 1.1.1 Level 1-120 Volt AC

Level 1 AC electric vehicle cordsets can plug into a common shared 120VAC branch circuit intended for general use that is the lowest common voltage level found in both residential and commercial buildings. Typical amp ratings for these receptacles are 15 or 20 amps. A Level 1 AC Cord Set (120 VAC, 15 amp) as shown in figure 1-3 is provided by many electric vehicle manufactures with the sale or lease of an electric vehicle.

*[1] "Electric Vehicle Charging Systems: Volume 2" Report of the Connector and Connecting Station Committee*
*[2] SAE International, 'SAE Charging Configurations and Ratings Terminology', 2011 <http://www.sae.org/smartgrid/chargingspeeds.pdf> [accessed 13 January 2012].*

**Figure 1-3**
Level 1 Cord Set

Level 1 AC cordsets typically use a standard 3 prong electrical outlet (5-20R) as shown below in Figure 1-4. The cordset has a standard 15A 3-prong plug as shown below, with a charge current interrupting device (CCID) located in the power supply cable within 12 inches of the plug. The vehicle connector at the other end of the cord set is the SAE J1772 Standard shown in Figure 1-2 above.

Level 1, 120 VAC charging is specifically recognized in the Canadian Electrical Code (CEC) Section 86 for dedicated EV charging. (Note that the CEC rates branch circuits to 80% for continuous duty so the usable capacities for the 20 amp circuit would be 16 amps. Therefore, a 20 amp service is the minimum that can be installed to service the EVSE.) The dedicated 20A circuit intended for EV charging requires the use of Single 5-20R receptacle.

**Figure 1-4**
Left To Right: Typical 125 VAC 15A Plug (1), 20A Plug (2) and 20A Receptacle (3)

### 1.1.2 Level 2AC – Greater than 125 Volt AC or greater than 20 amps

Level 2 AC Charging specifies a 240 VAC, single phase branch circuit. The SAE J1772 approved connector at the vehicle end allows for 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. Figure 1-5 diagrams AC Level 2 charging components and figure 1-6 provides an in-use photograph.

This level of charge provides a higher voltage than a Level 1 AC charge which results in a significantly faster battery charge. The Level 2 AC method uses EVSE, also known as a charging station that plugs into a 240V receptacle (much like a residential clothes dryer plug), is hard wired to the premises and may conduct charging wirelessly to the EV.

In addition, when using Level 2 AC charging, the on-board vehicle charger will communicate with the EVSE to identify the circuit rating and adjust the charge to the battery accordingly. For safety purposes, this communication protocol ensures that the appropriate amount of electricity is delivered to the vehicle battery. For example, an EVSE that is capable of delivering only 25 amps will deliver that amount of current even though it is connected to a larger circuit, such as a 40 amp rated circuit.

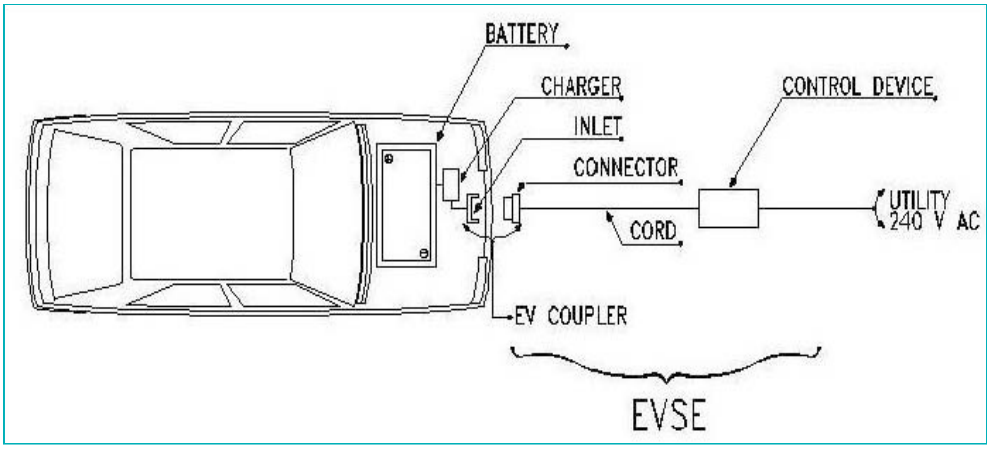


**Figure 1-5**
Level 2 Charging Diagram


**Figure 1-6**
Level 2 Charging

### 1.1.3 DC Fast Charging

DCFCs provide the fastest charging times and typically use an off-board charger to provide the AC to DC conversion. The vehicle's on-board BMS controls the off-board charger to deliver DC directly to the battery. Previously identified as Level 3 charging by the IWC, the SAE has redefined this as DC Level 2 charging. Figure 1-7 represents the components of DCFC.

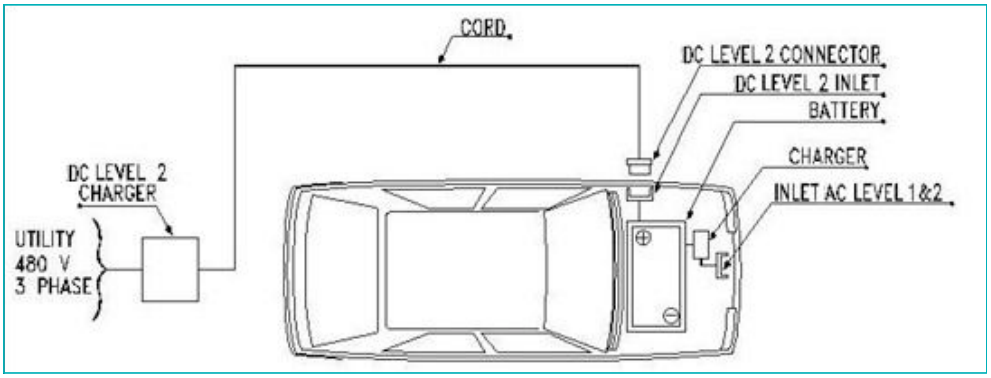


Figure 1-7
DC Charging

This off-board charger is serviced by a three phase circuit at 208, 480 or 600VAC. The SAE standards committee is working on a DCFC connector. It is expected that it will require the cord set to be permanently attached to the EVSE and the EVSE hard wired to the electrical service. DCFC capability is available on select vehicles since 2010 utilizing the Japanese ChAdeMO standard connector as shown in figure 1-8. SAE is currently developing an integrated coupler for plug-in electrical vehicles (PEVs). This is also a global standard that will allow PVs to be charged from either a conventional, 20-Amp AC wall outlet or a DC connection of up to 90 kW. The under development SAE J1772 "combo coupler" standard, which is under development is targeted for completion by the end of 2012.

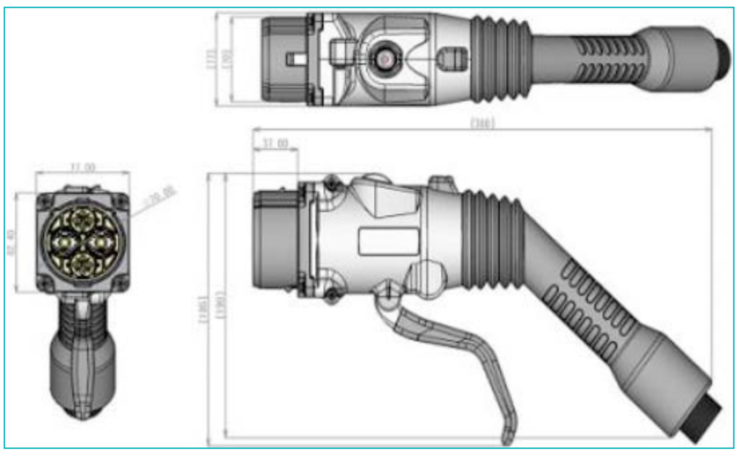

Figure 1-8
CHAdeMO
Standard Connector

## 2.0 PLUG-IN VEHICLE TECHNOLOGY

This section describes the basic EV technologies and focuses on street-legal vehicles that incorporate a battery energy storage device with the ability to connect to the electrical grid for the supply of some or all of its energy requirements. Two main vehicle configurations are described, along with the four main categories of vehicle applications. Vehicle categories and the relative size of their battery packs are discussed in relation to charging infrastructure.

## 2.1 ELECTRIC VEHICLE CONFIGURATIONS

There are two basic EV configurations at this point in time: battery electric vehicles (BEVs) powered exclusively by batteries, and plug-in hybrid electric vehicles (PHEVs), powered by a combination of batteries and another power source, such as an Internal Combustion Engine (ICE). Together, BEV and PHEVs are called Plug-In Electric Vehicles (PEVs).

### 2.1.1 Battery Electric Vehicle (BEV)

BEVs are powered only by the battery energy storage system available on-board the vehicle. The Nissan LEAF is an example of a BEV. Most advanced BEVs and PHEVs recapture energy through regenerative braking (put simply, converting the electric motor into 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. Solar photovoltaic (PV) panels on vehicles can also provide power to operate some small accessory loads and help charge the battery.

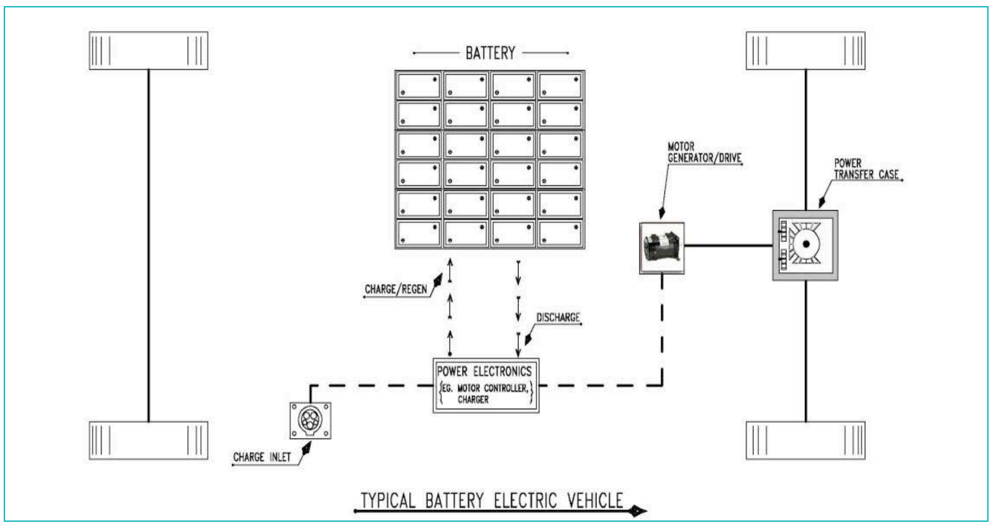


**Figure 2-1**
Battery Electric Vehicle

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 be sufficient to meet the BEV range and power requirements. EV batteries are typically more than ten times as powerful as batteries on conventional ICE vehicles.

### 2.1.2 Plug-In Hybrid Electric Vehicle (PHEV)

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

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

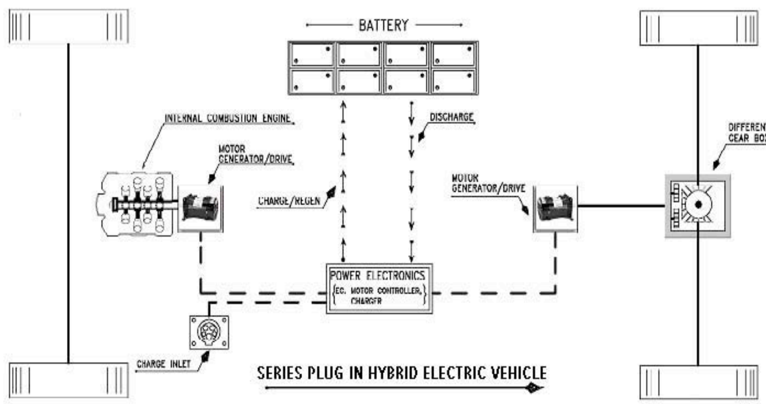


**Figure 2-2**
Series Plug-In Hybrid Vehicle Block Diagram

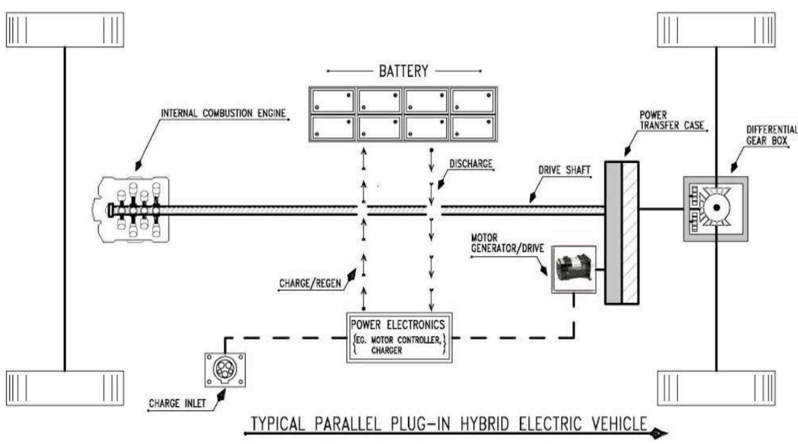


**Figure 2-3**
Parallel Plug-In Hybrid Electric Vehicle Block Diagram

Manufacturers of PHEVs use different strategies in combining the battery and ICE, and may utilize the battery only for the first several miles; an example of this strategy is the Chevrolet Volt, which has an ICE available to extend the vehicle range. Many vehicles use battery power for sustaining motion and the ICE specifically for acceleration or higher-energy demands at highway speeds. Frequently, the vehicles that employ the former strategy gain a designation such as PHEV-20 to indicate that the first 20 miles are battery only. Other terms related to PHEVs may include Range Extended Electric Vehicle (REEV) or Extended Range Electric Vehicle (EREV).

## 2.2 PLUG-IN VEHICLE TYPES

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

### 2.2.1 On-Road Highway Speed Vehicles

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

### 2.2.2 Limited Speed Electric Vehicles (LSEVs)

Limited Speed Electric Vehicles (LSEVs), are BEVs that are limited to operating at lower speeds of 40 km/h nationally, on specific highways provincially, and only permitted in some municipalities.

### 2.2.3 Commercial On-Road Highway Speed Vehicles

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

## 2.3 BATTERIES

### 2.3.1 Battery Technology

Today, most major car companies utilize lithium based batteries in their plug-in vehicles, both BEV and PHEV. Lithium provides 4x or more energy than lead-acid and 2x or more than that of Nickel-Metal-Hydride. The materials for Lithium based batteries are generally considered abundant, non-hazardous and lower cost than Nickel based technologies.

From an infrastructure standpoint, it is important to consider that as battery costs are driven down over time, auto companies may increase the size of the lithium-based battery packs. When planning for future infrastructure, this could be a consideration when sizing the charging circuits so that adequate power is available to recharge these future electric vehicles.

### 2.3.2 Relative Battery Sizes

Typically, PHEVs will have smaller battery packs because they have more than one energy 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.

Actual recharge times for PHEVs and BEVs vary depending on the state of charge of the battery at the start of the charge and the size of the battery. The range of an EV is influenced by:

- The weight of the vehicle, ambient temperature,
- Use of onboard electrical components (heat/air conditioning, lights, windshield wipers, radio, etc.), and
- The driving style/habits of the owner and the topography of the terrain driven.

The size of the battery, the existing state of charge of the battery and the distance needed before the next charge episode affect the calculations regarding achievable range of the vehicle and required recharge times. In general, Table 2-1 provides an outline of the different vehicle classes, their relative battery pack size ranges and relative charge times for each of the charger levels, assuming the battery pack is depleted.

Table 2-1 EV Charge Times with Depleted Battery

| CIRCUIT SIZE<br>Power in kW Delivered to Battery and Relative Charge Time (hours and minutes) | | | | | |
|---|---|---|---|---|---|
| EV Configuration | Usable Battery Capacity (kWh) | 120 VAC, 15 amp<br>1.2 kW | 120 VAC, 20 amp<br>1.6 kW | 240 VAC, 40 amp<br>3.3 kW | 240 VAC, 85 amp<br>6.6 kW |
| PHEV-10 Miles | 4 | 3 h 20 m | 2 h 30 m | 35 m | n/a |
| PHEV-20 Miles | 8 | 6 h 40 m | 5 h | 1 h 15m | n/a |
| PHEV-40 Miles | 16 | 13 h 20 m | 10 h | 2 h 30 m | 16 m |
| BEV | 24 | 20 h | 15 h | 3 h 40 m | 24 m |
| BEV | 35 | 29 h 10 m | 21 h 50 m | 5 h 20 m | 35 m |
| PHEV Bus | 50 | n/a | n/a | 7 h 40 m | 50 m |

Typical EV drivers do not completely deplete their batteries before recharging and auto manufacturers generally recommend against full battery depletion. Standard EV charge times and the required charging levels are directly influenced by the EV driver's need for range and the driver's availability to recharge.

Table 2-2 EV Range Delivered for 1 Hour Charge for Various Power Levels

| CHARGER LEVEL | POWER DELIVERED TO BATTERY | APPROXIMATE RANGE DELIVERED |
|---|---|---|
| Level 1 | 0.7 kW Auto Heater Circuit | 3 km |
| Level 1 | 1.2 kW | 8 km |
| Level 2 | 3.3 kW | 21 km |
| Level 2 | 6.6 kW | 42 km |

### 2.3.3 Cold Weather Considerations

The impact of cold weather on the operation of electric vehicle batteries could include reduced range. Vehicle cabin heating in a typical internal combustible engine vehicle is achieved from the excess heat from the engine. Use of the vehicle heater for cabin comfort can have a significant effect on vehicle range. Some auto manufacturers have addressed this issue by allowing vehicles to preheat and precool the vehicle while still plugged in. The preheat/precool feature significantly reduces the impact on range due to cabin temperature consideration.

# 3.0 APPLICABLE CANADIAN LEGISLATIVE CODES AND STANDARDS

## 3.1 REGULATORY AGENCIES

Electric Vehicles and electric vehicle technology, from vehicles to charging equipment, are regulated by many different organizations and agencies. There is not a single standards body that is responsible for all aspects of electric vehicles or electric vehicle charging stations. The Society of Automotive Engineers (SAE), CSA Group, Underwriters Laboratories (ULC), Institute of Electrical and Electronics Engineers (IEEE), the International Association of Electrical Inspectors (IAEI), the International Code Council (ICC), International Electrotechnical Commission (IEC) and the International Organization for Standardization (ISO) are among those actively engaged in the development of electric vehicle and EVSE technical and installation standards. All these bodies consider safety-related issues.

## 3.2 CANADIAN STANDARDS FOR THE ELECTRIC VEHICLE SUPPLY EQUIPMENT (EVSE)

On June 30, 2011, the CSA Group published Technical Information Letters (TIL's) that established interim Canadian requirements for EVSE products (Level I, II and III charging). These TIL's have been formally recognized by the provincial and territorial electrical safety regulators. Until such time North American harmonized standards are published for the EVSE, the TIL's, with or without additional referenced requirements, will form the basis for certification in Canada. The following is a list of the published TIL's:

- **TIL I-44** - Interim Certification Requirements for supply equipment for electric vehicles with inputs and outputs rated 600 V or less.
- **TIL A-35** - Interim Certification Requirements for Electric Vehicle cord sets and power supply cords
- **TIL D-33** - Interim Certification Requirements for Charging Circuit Interrupting Devices/Line Isolation Monitors rated up to 600V for use in EVSE.
- **TIL A-34** - Interim Certification Requirements of Electric Vehicle connectors/couplers and receptacles/plugs for use in a conductive charging system.
- **TIL J-39** - Interim Certification Requirements for Electric Vehicle Cables rated 600 V maximum and intended for use in accordance with CSA C22.1, Canadian Electrical Code (CEC), Part I and CAN/CSA-C22.2 No. 0.

The following alignment table lists the proposed standard number designation of the harmonized document for Canada (CSA), Mexico (ANCE) and the U.S. (UL).

Table 3-1 Proposed Standards for the Electrical Safety of the EVSEs

| NO. | CSA | UL | ANCE* |
|---|---|---|---|
| 1 | **CSA C22.2 No. 280** Electric Vehicle Supply Equipment (based on TIL I-44 and A-35) | **UL 2594** Electric Vehicle Supply Equipment | **ANCE NMX-J-XXX** Electric Vehicle Supply Equipment |
| 2 | **CSA C22.2 No. 281.1** Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits: General Requirements (based on TIL D-33) | **UL 2231-1** Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits: General Requirements | **ANCE NMX-J-XXX** Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits: General Requirements |
| 3 | **CSA C22.2 No. 281.2** Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits: Particular Requirements for Protective Devices for Use in Charging Systems (based on TIL D-33) | **UL 2231-2** Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits: Particular Requirements for Protective Devices for Use in Charging Systems | **ANCE NMX-J-XXX** Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits: Particular Requirements for Protective Devices for Use in Charging Systems |
| 4 | **CSA C22.2 No. 282** Safety of Plugs, Receptacles and Couplers for Electric Vehicles (based on TIL A-34) | **UL 2251** Safety of Plugs, Receptacles and Couplers for Electric Vehicles | **ANCE NMX-J-XXX** Safety of Plugs, Receptacles and Couplers for Electric Vehicles |

*At the time of publication of this Deployment Guideline, ANCE had not designated standard numbers for the respective standards listed in the table.*

With the publication of harmonized standards, the certification process for EVSE manufacturers will be simplified. These products would only require one certification from an accredited test agency such as CSA Group for use in all of North America.

## 3.3 CANADIAN NATIONAL AND LOCAL BUILDING CODE

The CEC is a model code only and has authority when it is adopted at a local jurisdiction, typically at the Provincial level. A few cities have their own local Building Code. At least one local Building Code (Vancouver) has requirements specifically for EV Infrastructure. Provincial Green Building Codes or local Zoning by-laws may add similar requirements in future for residential and commercial EV infrastructure.

## 3.4 CANADIAN ELECTRICAL CODES

The Canadian Electrical Code, CE Code, or CSA C22.1 is published by CSA Group for addressing the installation and maintenance of electrical equipment in Canada. In the current edition, the Code recognizes that other methods can be used to assure safe installations, but these methods must be acceptable to the authority enforcing the Code in a particular jurisdiction.

Legislation generally adopts the code by reference, usually with a schedule of changes that amends the code for local conditions. These amendments may be administrative in nature or may have technical content particular to the region.

In each province an Electrical Safety Regulation[3], or similar, which falls under the province's Safety Standards Act or similar[4], adopts the safety standards for electrical installations, (CSA C22.1-12) in Part I of the Canadian Electrical Code as the Provincial Electrical Code Regulation 2012[5] with amendments as referenced in the Schedule[6] to the regulation. Each province's Safety Authority's Electrical Safety Program[7] has been responsible for regulating electrical safety in each province, including all types of electrical equipment and installation.

The CEC provides the standards to which EVSE equipment is designed and electrical contractors must follow when installing electrical components. CEC-2012 provides:

- **Branch Circuit:** The EVSE branch circuit must be a dedicated circuit and sized for continuous duty of the EVSE and related ventilation equipment. (CEC 86-300, 302)
- **Disconnect Means:** A separate disconnecting means shall be provided for each installation of EVSE rated at 60 amps or more than 150 volts – to-ground. This disconnect must be on the electrical supply side to the EVSE, within sight of and accessible to the EVSE and capable of being locked in the open position. (CEC 86-304).This is applicable to Level 2 DC and Level 3 Fast Charging.
- **Receptacle and Wall Plug:** Level 1: A single, not duplex, 20 amp residential wall plug and receptacle are acceptable for Level 1 charging (CEC 86-306 1 (a)). More common 15 Amp shared circuits with duplex receptacles are not permitted to be installed for EV Charging.
- **Receptacle and Plug:** Level 2: Receptacles identified in the CEC will be acceptable (CEC 86-306 1 (b)). These are 208/240 V and minimum 20 Amp on dedicated circuits.
- **Warning Sign:** A permanent sign shall be installed at the connection of the EVSE to the branch circuit warning against operation of the equipment without sufficient ventilation (as recommended by the manufacturer's installation instructions). (CEC 86-200).
- **Ground Fault Interrupter:** The receptacle for Level 1 shall be protected with a ground fault circuit interrupter when the receptacle is installed outdoors and within 2.5 m of finished grade (CEC 86-306 (2)). As EV Supply Equipment also contains GFCIs nuisance tripping may be experienced by the two GFCIs interacting. Permanently connected EVSEs outdoors avoid this problem.
- **Hazardous Locations:** When EVSE is installed in hazardous locations as defined elsewhere in the Code, those sections apply. (CE 86-102)

## 3.5 SIGNAGE

The sign shown in figure 3-1 has been adopted by the Ministry of Transportation in the province of British Columbia as the symbol for identifying electric vehicle charging stations. The "DC" lettering shown in figure 3-2 is placed underneath figure 3-1 to specify a DC fast charging station as opposed to level 1 or 2 station. These sign images together represent the standard for highway traffic information signs, directing EV motorists to nearby DC fast charging stations or level 1 or 2 when used without the "DC" sign. Additional words may be added below the sign for specific details such as "Please allow electric vehicles to park here". A directional arrow might be added below it to indicate where EV charging is located coupled with the distance to the station. Other parking regulations might also be indicated, such as time limits or cost information. Please visit the BC Government website for signage resources for electric vehicle infrastructure: http://www.livesmartbc.ca/incentives/transportation/EV-toolkit.html.

[3] *http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/12_100_2004*
[4] *http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/00_03039_01*
[5] *http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/12_100_2004#schedule*
[6] *http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/12_100_2004#schedule*
[7] *http://safetyauthority.ca/safety-info-training/electrical-contractor-safety-information*


Figure 3-1
Sign for Electric
Vehicle Parking


Figure 3-2
Sign Indicating DC
Fast Charger Station

## 3.6 BLOCK HEATER CIRCUITS

A Block Heater is an electric heater that warms the engine block of an internal combustion engine to ease starting in cold weather. It is typically installed in the coolant system of the vehicle and the heater causes the coolant to circulate by natural convection. The block heater cord extends through the vehicle grill to connect to the receptacle. A typical block heater with cord can be seen in figure 3-3.

**Figure 3-3**
Typical Block Heater with Cord

At this writing, automotive manufacturers developing PHEVs are planning only one power inlet to the vehicle; a separate block heater circuit will not be required. The power provided by the cord set or the Level 2 EVSE will be utilized in the vehicle thermal preconditioning cycles as required by the vehicle.

There is a high degree of variability in regards to the types of block heater circuits available from one parking lot to the next. These variables could lead to confusion amongst EV users as they will directly impact whether a parking lot receptacle is suitable for EV charging or not. Table 3-2 identifies potential parking lot scenarios:

Table 3-2 EV and its Compatibility

| CIRCUIT TYPE | DESCRIPTION | EV COMPATIBLE |
|---|---|---|
| Single Circuit (always on) | Duplex Receptacle – Dedicated Single 20A (minimum) Circuit | Yes |
| Double Circuit (always on) | Split Duplex Receptacle – Two 15A Circuits | No |
| Cycled | Single/Double Circuits - Cycled On/Off | No |
| Temp. Controlled | Single/Double Circuits – Temperature Controlled | No |

Parking lots will have to be reviewed on a case-by-case basis by their owners to evaluate whether or not they can support EV charging systems. If possible, signage indicating potential EV incompatibilities may help to alleviate problems associated with overloaded circuits and circuit cycling. In accordance with Section 86 of the Canadian Electrical Code, many block heater circuits will not be able to be labeled as "designated" charge points as they will not meet the minimum 20Amps criteria.

Repurposing block heater circuits may be possible in some instances if the wire gauge that was used initially was oversized to carry 20 Amps continuously. In this case it might also be possible to re-distribute power on 208/240 Volts to increase the power availability. Care must be taken to ensure that the existing panels, transformers, main supply, etc. are sized accordingly to handle the increased load. Using these circuits for EV charging may overload the circuits or the supply service. If used not as intended for heaters, but for charging then the demand load must be recalculated to prevent overloading transformers and the supply service.

## 3.7 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. For EVSE components, the two primary ways to minimize flood damage are elevation and component protection. These methods prevent water from entering or accumulating by the equipment.

Elevation refers to the location of a component above the Design Flood Elevation (DFE). That is the primary protection for EVSE. All locations approved for EVSE installation should be above the DFE. It may mean that an EVSE is located outside a parking garage if locating it inside would put it below the DFE. It may mean that certain areas of a parking garage would not contain any EVSE, if that elevation is not achievable. It may require EVSE charging stations on the third level of a parking garage instead of the first.

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

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

Dry flood proofing refers to the elimination or minimization of the potential for flood damage by implementing a combination of waterproofing features designed to keep floodwaters completely outside of a structure[8]. If the entire building is protected from flood water, the EVSE is also protected.

## 3.8 INSTALLATIONS LOCATED IN SNOW ZONES

Snow may cover charging equipment making it invisible to snow plows operators. Clearing snow around EVSEs may be made more difficult. Cords may also be covered in a snow fall and become iced in during freeze-thaw cycles. Cords that cross sidewalks or walkways should be mounted overhead to prevent a tripping hazard or being cut with snow shovels. There is no standard for where on a vehicle the charging outlet may be. As such the cord must be able to reach to any corner of the space.

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

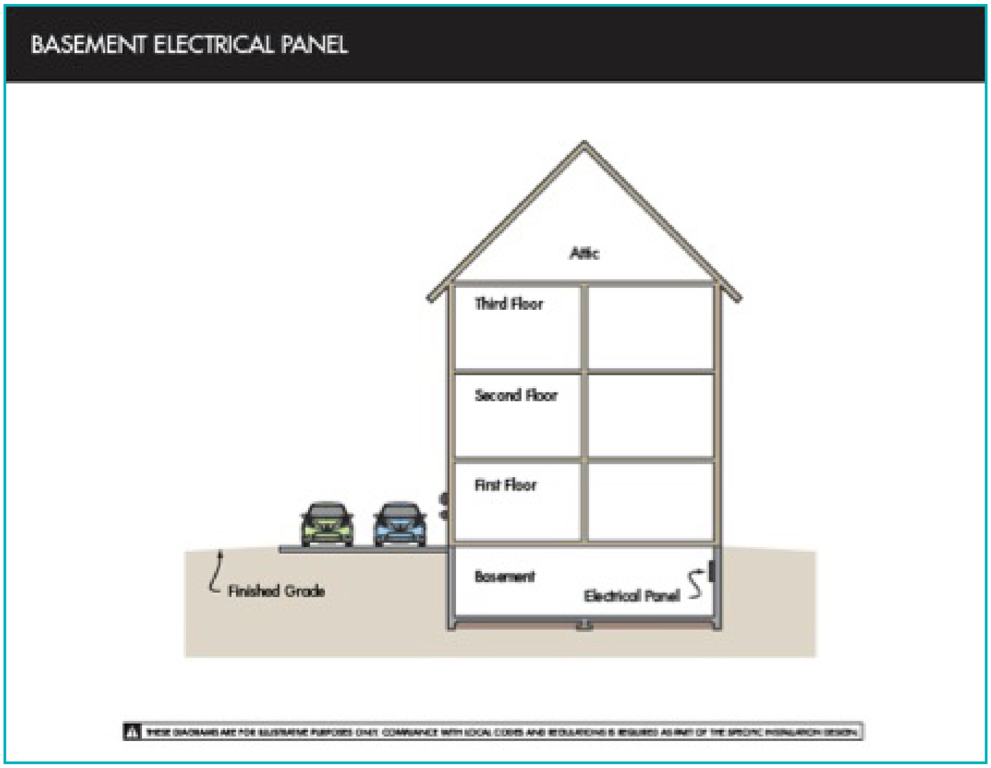


**Figure 3-4**
Basement
Electrical Panel

# 4.0 RESIDENTIAL CHARGING

## 4.1 PLANNING

Planning specifics will differ for different users of this guide as local electrical codes and regulations vary across the nation. For example installations for Level 2 EVSE require the use of a certified electrician; whereas Level 1 charging may simply require a dedicated available 125 VAC outlet.

The planning for a residential installation involves:

- Choosing an Electric Vehicle
- Choosing a Charging Strategy
- Selecting a Contractor who will assess the EVSE installation site
    - Determine voltage and amperage requirements of selected EVSE
    - Verify electrical capacity for additional load, recommending any necessary property or electricity service upgrade
    - Determine if communication to EVSE is required
    - Estimate installation cost for installing EVSE per Manufacture Guidelines
    - Obtain local permit for installation
    - Schedule the installation
    - Coordinate with local inspector to validate installation
- Communication Requirement
- Contact the local utility for EVSE installation notification
    - Determine if there are special electric vehicle charging rates available

The residential building owner, manager, or strata council have different planning considerations than a single EV owner in his own home, as does an EV owner in a Multi-Unit Residential Building (MURB). Consumers living in a multi-unit dwelling will have to secure permission to install a charging station and determine the particulars for such installations. Issues of insurance, damage liability, common property use, and operating and installation costs may be of factor. This section will outline the overall planning considerations for both the single family home and the MURB, including multiple charging scenarios.

### 4.1.1 Choosing an EV

Every major auto manufacturer is expected to market a vehicle that uses electricity for energy within the next 5 years. Whether to choose a BEV, PHEV or HEV will be the consumer's choice based upon their preference or driving patterns. Consumers may begin to decide on which type of electric vehicle to choose by analyzing some of the following:

- Primary use of vehicle
    - Commuter Use
    - Primary Transportation
    - Secondary Vehicle
- Average distance of daily drive
    - Availability of Workplace Charging
    - Availability of Publicly Available charging stations
- Area Topography
- Frequency of Long Trips

- Ease of installation needed charge infrastructure
- Aesthetics
- Purchase Price
- Available Electric Vehicle Incentives or electric utility rates

### 4.1.2 Choosing a Charging Strategy

Once a vehicle is selected, the owner's next step is to define the specific users of the charge infrastructure. The users of the charge infrastructure will help determine which charging level will suit their needs. Charging stations may be used for:

- A single vehicle
- Multiple vehicles within one residence
- Electric vehicle driving visitors

Residential charging station owners may decide to use a single charging option such as the Level 1 cordset or to purchase a Level 2 EVSE direct or from a car dealership. Drivers may decide to install both Level 1 and Level 2 charging options, using the charging option they need depending on their daily driving habits. Several factors affect the choice of the appropriate electric vehicle charging solution, which include:

- Type of vehicle
- Size of vehicle
- Size of battery
- Expected driving habits with the vehicle
- Cost
- Climate
- Parking site specifics
- Workplace charging availability
- Availability of publicly available chargers

The issues to be considered for a PHEV include:

- A PHEV generally has a smaller battery and shorter charge time requirements. Level 1 may be sufficient for all charging needs whereas BEV owners may consider Level 1 to be a back-up strategy only, relying on Level 2 for primary charging.
- Larger, heavier EVs will consume more power than smaller, lighter ones. An owner who plans on using the EV for local, short trips may find Level 1 to be sufficient whereas an owner who plans longer trips or more frequent trips even within the local area may find it inadequate.
- Owners desiring Level 2 equipment will need to consider the cost of the Level 2 EVSE and its installation whereas a suitable Level 1 circuit may already be present in their garage. EV owners who have the opportunity for Level 2 charging at work or in public areas may find the vehicle battery remains at a higher charge and thus the home charging time is not a concern. If available, EV owners who elect local time of use options with the utility (i.e. off-peak charging) may find that the reduced charge time is insufficient for Level 1 charging.

### 4.1.3 Level 2 AC

Power Requirement: Dedicated branch circuit hardwired to a permanently connected EVSE with the following specifications:

- 240VAC/Single Phase, or 208VAC Three Phase Y supply with a 4-wire (2 Hot, GND, Neutral), 20, 30 or 40Amp Breaker. 277VAC, 347VAC, 480VAC are also possible but not common.
- Power Requirement: Dedicated branch circuit cord and plug connected movable EVSE with the following specifications:

240VAC/Single Phase, 3 or 4-wire (2 Hot, GND, neutral), 20, 30 or 40Amp Breaker with the appropriate blade or twist lock receptacle such as a 6-20R, 14-30R or L6-50R.

208VAC/Three Phase, 4 wire 20, 30 or 40 Amp Breaker with an L21 receptacle.

- Level 2 notes:
  - The breaker size recommended will meet the requirements of most BEVs and PHEVs. Some PHEVs with small battery packs or EVs that are not used on long trips regularly may only require a 20 or 30Amp breaker for their recommended EVSE in which case the breaker can be easily changed.
  - The Neutral may not be required by some EVSE but may be required at some point in the future if a different vehicle is purchased.
  - For new construction, bring the circuit to a dual gang box with a cover plate for future installation of permanently connected EVSE or terminate with a receptacle to avoid the need for getting another permit at a later date.
  - In Planning the Level 2 of Charging, a major cost issue is the capacity of the existing electrical supply to the premises. Older homes often have a 100 Amp supply. Newer homes may have 200 Amp supply or even a 400 Amp supply in larger new homes. If you plan to add a 40 Amp circuit, there may be insufficient capacity in the electrical supply. This is known as the demand load calculation. Even if there is room in the panel, there may be insufficient supply. An electrician can help calculate the demand load available. If there is sufficient supply but the panel is full, a sub-panel may be added. An alternative is to consider demand load sharing. Another example is to put a transfer switch on a dryer outlet so that only the dryer or EVSE may be used at one time. Nevertheless, because the dryer is rated at just 25% of the peak power draw versus the EVSE rated at 100% of peak power, a new demand load must still be calculated.

### 4.1.4 Selecting a Contractor

The installation of an EVSE requires that a certified electrician install the charging station in a residential home, highrise or on public property. The contractor will need to perform a site visit to estimate the cost of installation. CEC covers the technical requirements for the installation of an EVSE. The placement of the equipment, the location of the electric supply and the installation manual for the EVSE will impact the cost of the installation along with additional cost factors.

### 4.1.5 Communication Requirement

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

## 4.2 GENERAL REQUIREMENTS AND DESIGN CONSIDERATIONS

### 4.2.1 Certification

It is assumed that the EVSE provided has met the appropriate codes and standards, is certified and is so marked. Owners should be cautioned against using equipment that has not been certified for this use.

### 4.2.2 Cord Length and Tripping Hazard

The EVSE have varying lengths of cords. The EV inlet location on electric vehicles vary by auto manufacturer. When selecting a location for an EVSE, cord length and inlet location should be considered in an effort to avoid tripping hazards and to allow vehicles to park forwards or backwards in the parking space.

### 4.2.3 Ventilation Requirements

If there are ventilation requirements, the EVSE will be required to energize a properly sized ventilation system. Such a requirement is expected to be rare, since automobile manufacturers are expected to use non-gassing batteries. Older lead acid wet cells batteries give off explosive hydrogen gas whereas newer lithium batteries do not. Some EV owners who convert their own vehicles to electric or purchase conversion vehicles may use gassing batteries. Certified EVSE will communicate with the vehicle, and if ventilation is required but no ventilation system exists, the EVSE will not charge the vehicle. In multi-family or parking garage situations that may already have ventilation systems for exhaust of normal vehicle emissions, such a system may be sufficient. However, 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 single vehicle charging. In these cases, it may be prudent to identify that the chargers are intended for non-gassing batteries only.

### 4.2.4 Energized Equipment

Unless de-energized by the local disconnect, the EVSE is considered electrically energized equipment. Because it operates above 50 volts, Part 19 Electrical Safety of the Occupational Health and Safety (OHS) Regulation requires guarding of live parts. The requirements for accessibility to the connector may require positioning the EVSE so that physical means may be required for electrical protection. If the EVSE is mounted in front of the vehicle, wheel stops, as referred in figures 4-1 and 4-2 or bollards may be recommended to prevent a vehicle from contacting the EVSE. Wheel stops also help position the EV for the optimum location for charging.

**Figure 4-1**
Wheel Stop[9]

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

Figure 4-2
Garage Wheel Stop[10]

## 4.3 SINGLE DETACHED DWELLINGS

### 4.3.1 Siting requirements

An indoor rated EVSE is acceptable for an enclosed garage. Best examples are shown in figures 4-3 and 4-4. Please note that the transfer switch shown in figure 4-3 between dryer and Level 2 EVSE is currently under study and approval process. Each site will vary in terms of design as well as the needs/preferences of the owners. It is important that the installer work closely with the owner to choose a location that suits their needs, is safe and meets the local building and electric codes. Special attention should be paid to the potential tripping hazard of the EVSE cord when choosing a location. One method of mitigating this risk is through the use of an overhead support or trolley system to allow the cord to hang above the vehicle.

The EVSE must be connected to the wall outlet at a height sufficient to avoid water or fumes on the floor. An EVSE that is shared by two vehicles in a double garage must be able to reach both vehicles' inlet connector. The inlet connection and storage height of the EVSE are governed by electrical standard (UL2594).

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

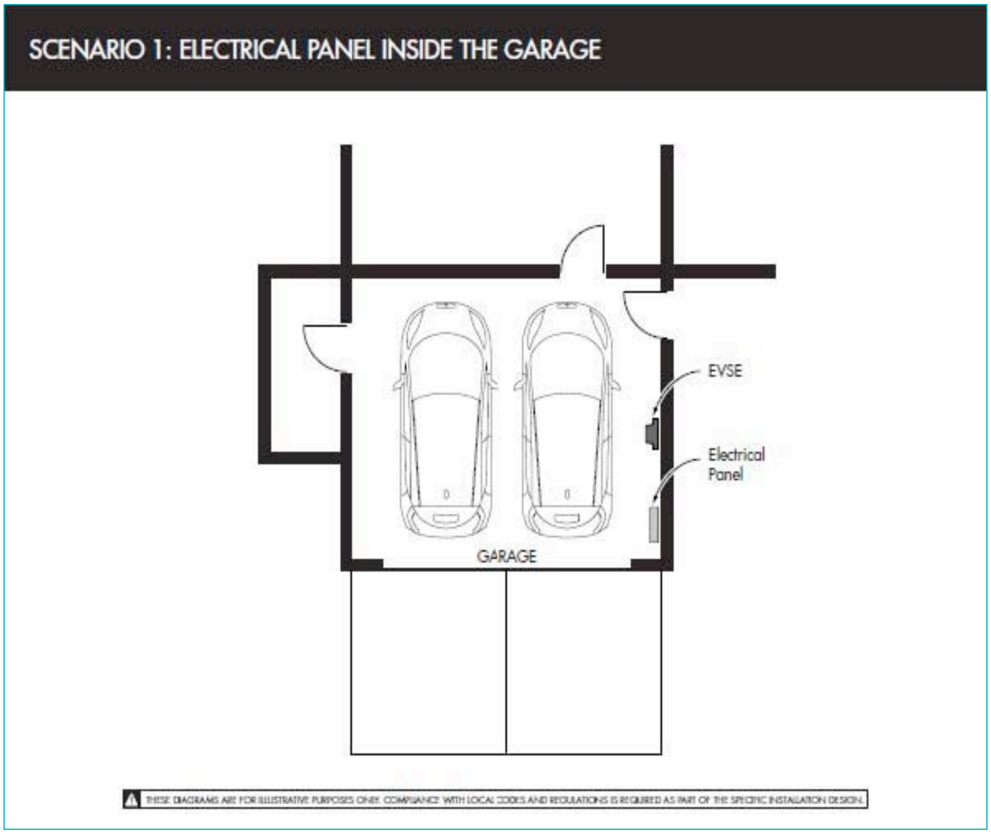


**Figure 4-3**
Garage Existing Panel

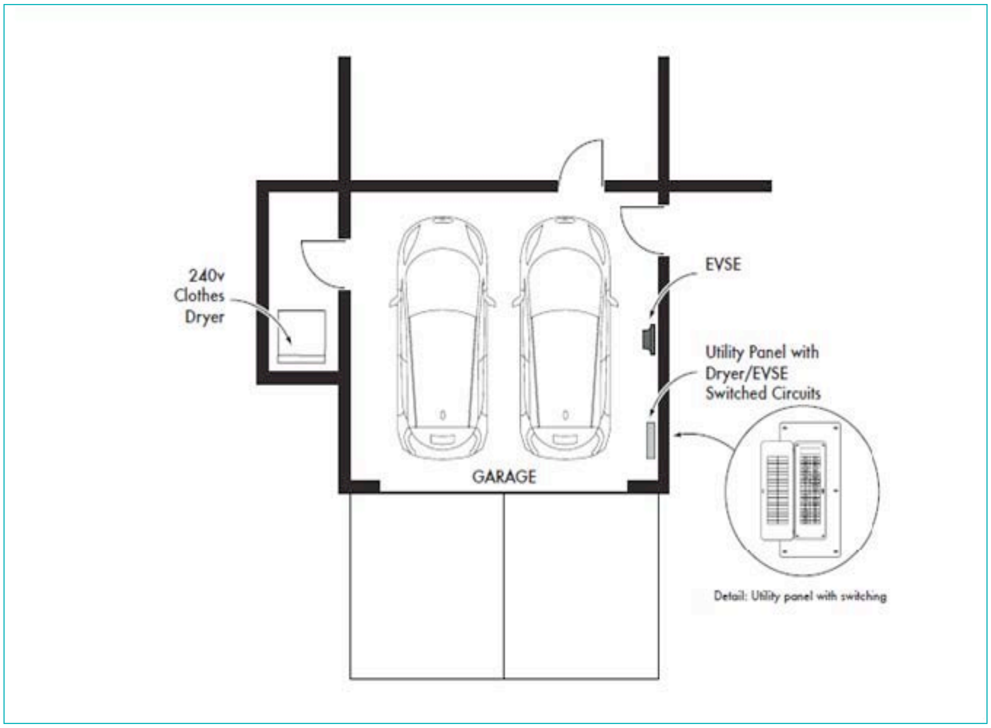


**Figure 4-4**
Garage—Switched (Dryer)—Suggested

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

Detached garages will require routing the electrical supply to the garage. Landscaping may be disrupted during the installation process. This may be of great significance to the owner and should be thoroughly planned in advance.

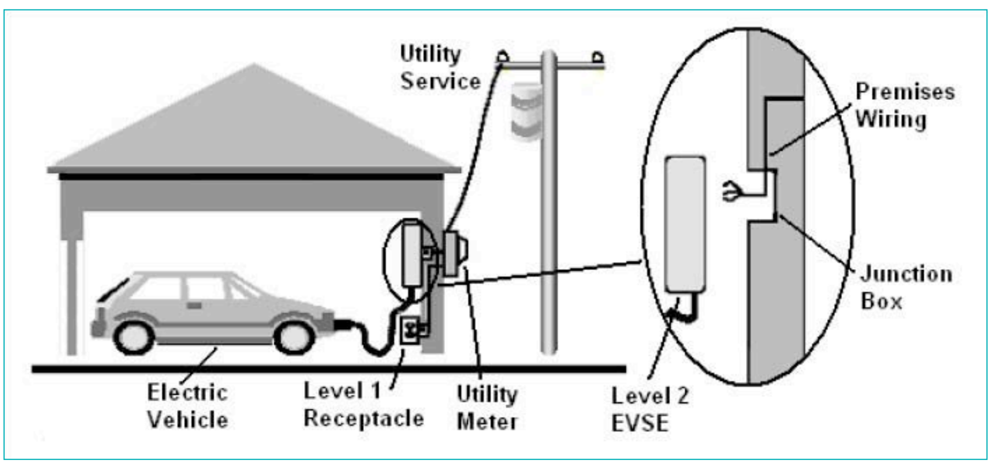


**Figure 4-5**
Typical Level 1 and Level 2 Installation for a Residential Charge

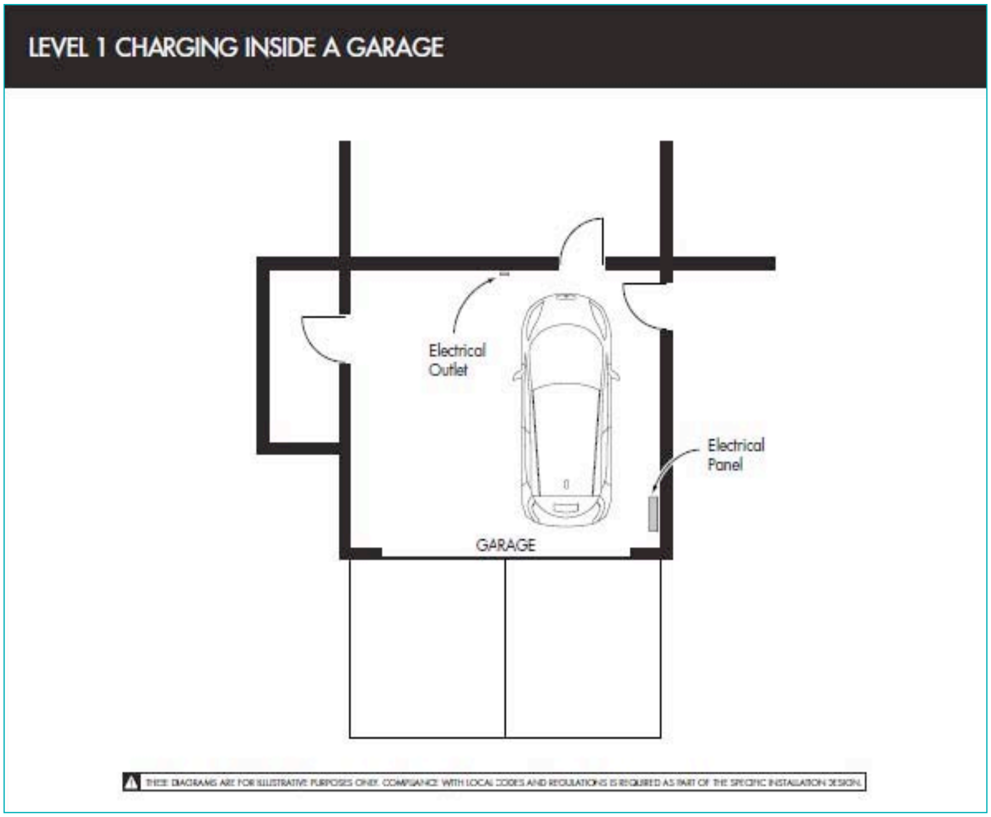


**Figure 4-6**
Level 1 Charging Inside the Garage

### 4.3.2 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 and single receptacle (125 VAC, 20 A) in the case of Level 1 charging or an EVSE (operating at 240 VAC, 20- 40 A) for Level 2 charging. If the garage is built with the conduit or raceway already installed from the panel to the garage, the task is greatly simplified. Ideally, the EVSE will be placed near to the panel as reasonably possible, as shown in figures 4-3, 4-4 and 4-6. Typically, the best placement of the EVSE will be at the front of the garage in the middle.

The specific steps involved in this process are shown in the flowchart in figure 4-7. In general they include:

- Consultation with the EV supplier to determine whether Level 1 or Level 2 EVSE (or both) is desired, whether ventilation will be required and the EVSE to purchase;
- Consultation with the electric utility to determine rate structure, requirements for a special or second meter which may be allowed in some provinces;
- Consultation with a licensed electrical contractor to plan the installation effort including location of EVSE, routing of raceway from utility service panel to EVSE, Level 1 or Level 2 requirements, ventilation requirements, adequacy of current utility service, and the obtaining of an installation quote;
- Submission of required permitting documents and plans;
- Completion of EVSE installation and utility service components, if required;
- Inspection of final installation.

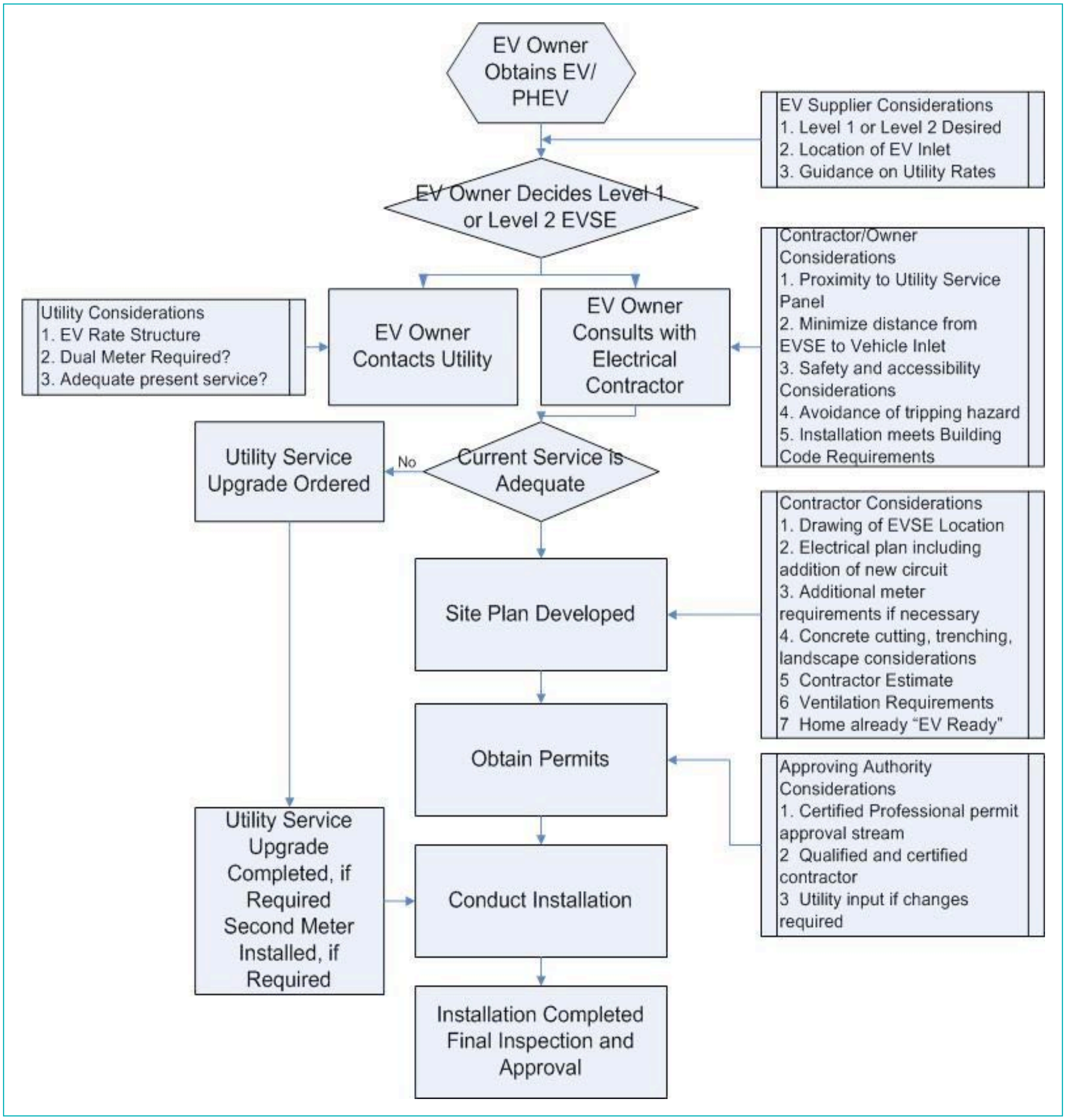


**Figure 4-7**
Installation Process for a Residential Garage/Carport

If the garage has a pre-existing raceway, the EV owner can determine whether this will be a 125 VAC, 20 amp circuit or a 240 VAC, 20, 30 or 40 amp circuit. Some homes may not have sufficient utility electrical service to install a 40 amp dedicated circuit. In that case, a lower power circuit is possible or a larger service may be added as noted. Another potential option would be to install an approved load control device that would 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 is required. In some jurisdictions, building standards are directing that a raceway for EVSE wiring is to be installed in all new home construction. The conductors may or may not be included at the time of construction. If included, consideration should be given to sizing the conductors for the 240 v, 20-40 amp circuit required for Level 2 charging. If a 125v, 20 amp Level 1 breaker and receptacle is installed, the home owner might have a functional circuit that could be upgraded easily to Level 2 240V 20 amp if desired.

## 4.4 CARPORT AND DRIVEWAY

### 4.4.1 Siting Requirements

The siting requirements for the carport or driveway installation scenario will include those identified above for the garage. Examples of carport and driveway are shown in figures 4-8, 4-9 and 4-10. Some owners may elect to place the EVSE in the garage but charge the vehicle outdoors. This is similar to the carport requirements. A carport is considered an outdoor area and the EVSE should be approved for exterior use. Consideration must be given to precipitation and temperature extremes. In geographic areas that experience high precipitation, snow and ice, pooling of water in the carport or driveway may be a concern.

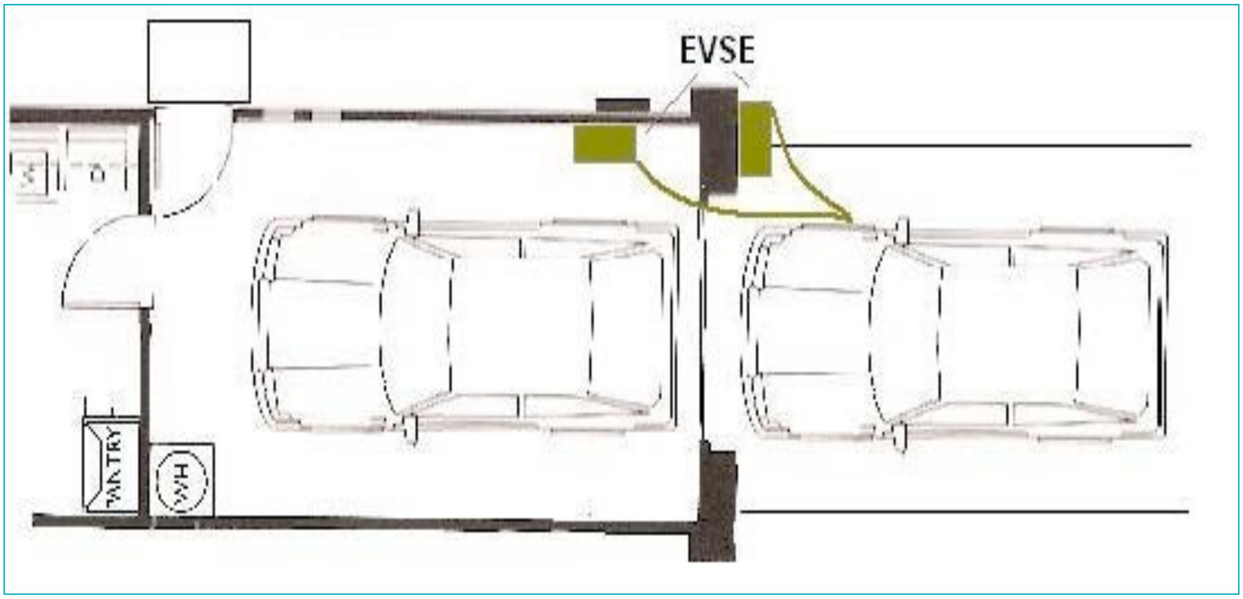


**Figure 4-8**
Installation Considerations for Outdoor Parking

Freezing temperatures can create an issue for cords freezing 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 7.3.3. The installation process is similar to the garage process outlined above.

The CEC requires that the outdoor receptacle have ground fault interrupt protection. This may be an issue when using a cord set which contains its own GFCI. Past experience has shown some nuisance tripping occurs when two GFCI's are located in the same circuit. New cord sets will use a CCID which performs a similar function but helps eliminate the nuisance tripping. A permanently connected EVSE avoids this concern, as well as deterring theft.

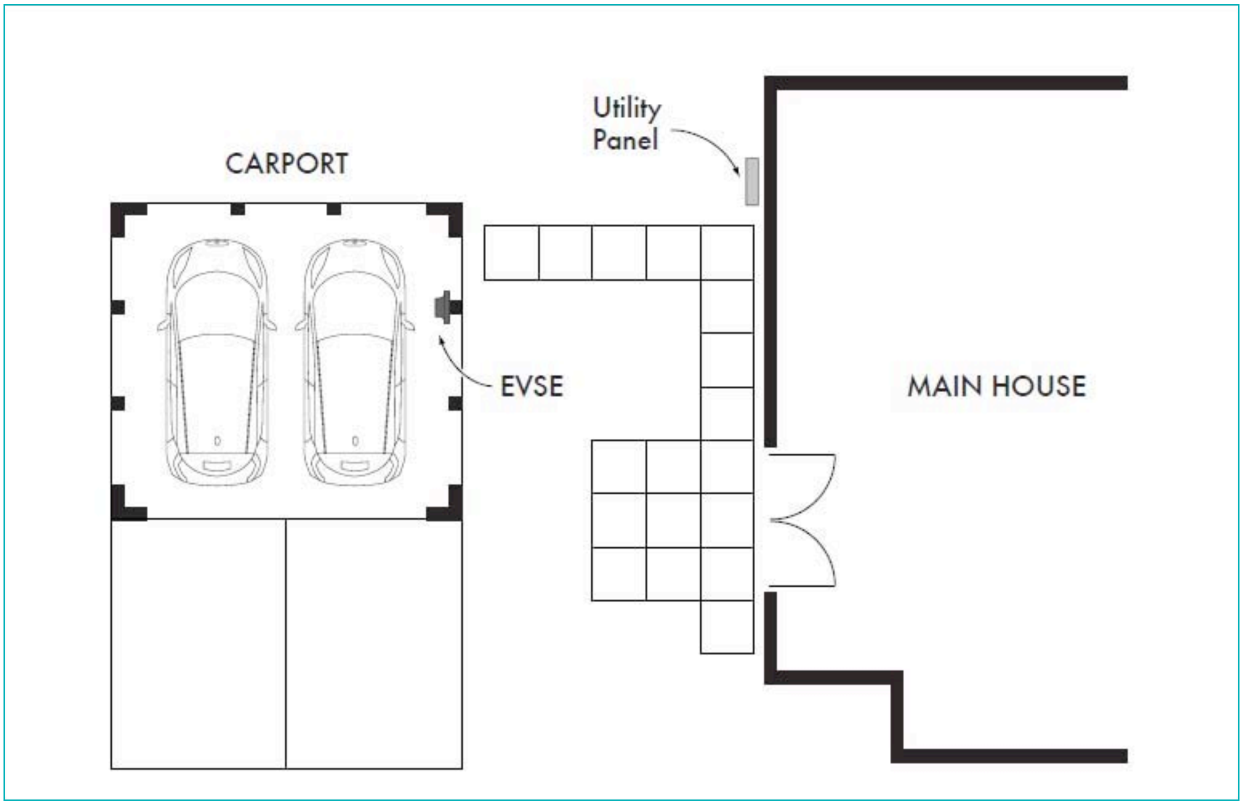


**Figure 4-9**
Carport

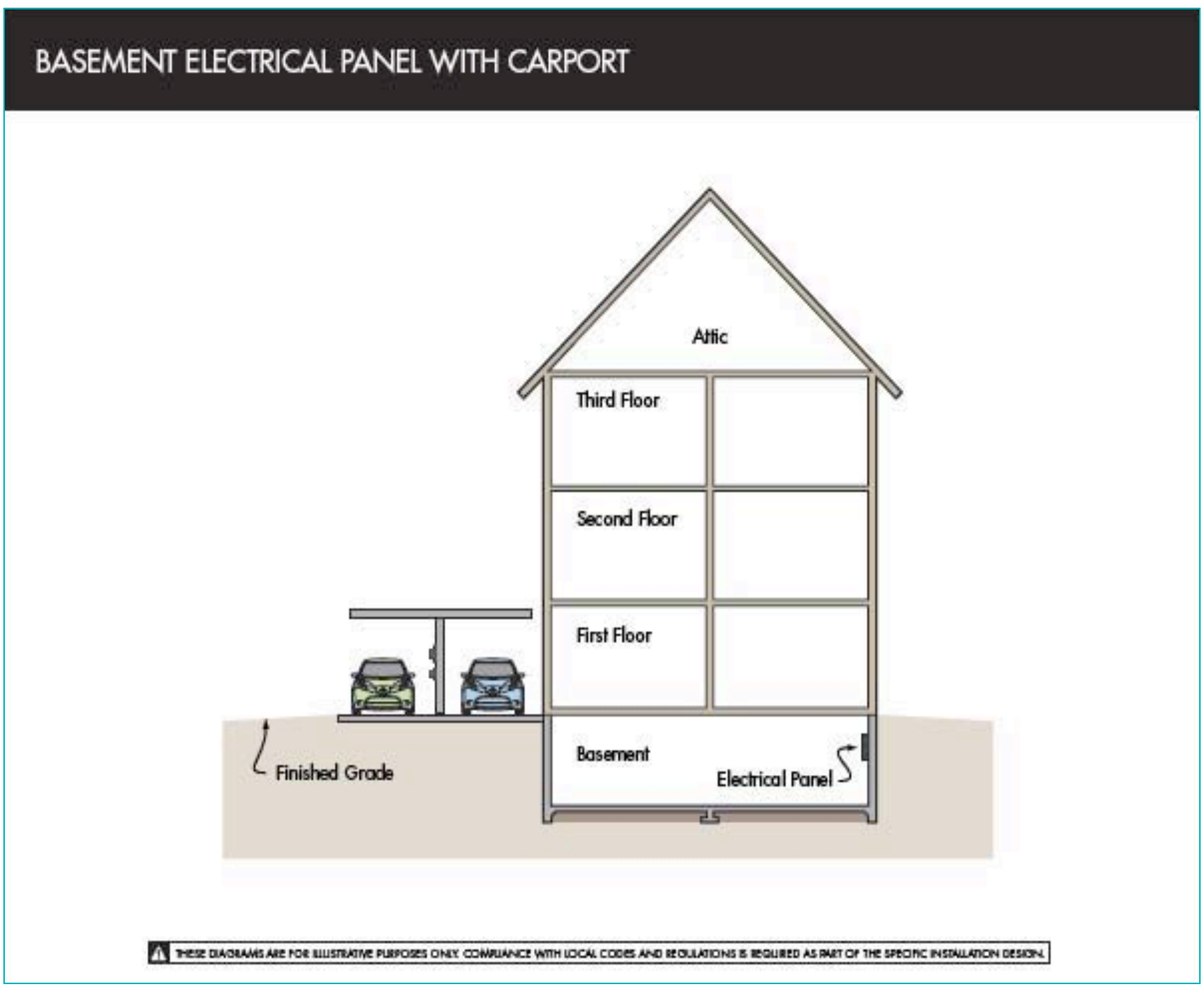


**Figure 4-10**
Basement Electrical Panel with Carport

## 4.5 MULTI FAMILY DWELLINGS

### 4.5.1 Siting Requirements

In multi-family dwellings, there will be additional considerations to those described above for single family residences because the apartment or condominium owner may also be involved in the siting decisions. Examples of this type of dwelling can be seen in figures 4-11 and 4-12.

It is recommended that the potential EV owner work through the following details with the building owner prior to purchasing an EV:

- Determination of who will pay for installation and any needed infrastructure upgrades
- Proximity to the EV owner's dwelling.
- Potential for water damage.
- Potential interference with snow removal operations.
- Lighting, insurance, liability, and vandalism concerns.
- Metering and payment methods for the electrical usage.
- Determination of who will purchase/own the EVSE.
- Details of what would happen should the EV owner leave the residence.

In condominiums, the Home Owners Association (HOA) will most likely be involved to approve EVSE additions. In addition to the details listed above, HOAs will likely need to consider drafting by-laws to establish the right to install EVSEs by unit owners. Developing an EV infrastructure plan that takes the details listed above into account is recommended. For new construction of Multi Family Dwellings, the allocation of physical space for all future electrical equipment and raceway sizing to accommodate the electrical capacity is fundamental at an early stage.

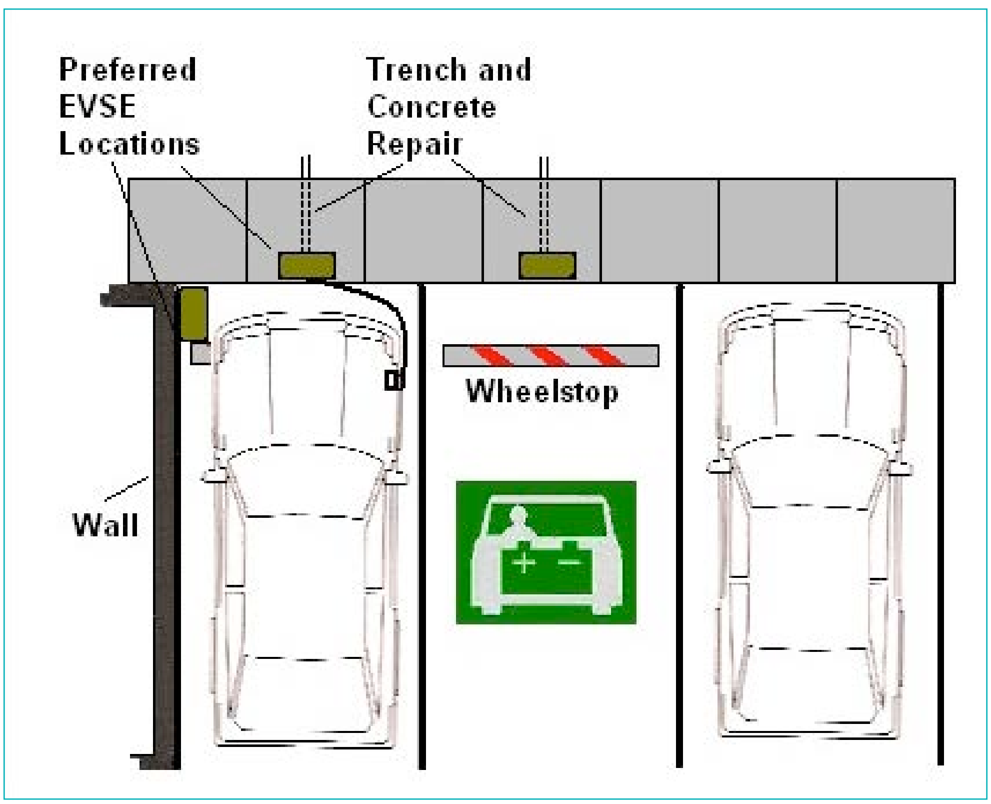


**Figure 4-11**
Typical EVSE Installation in Multi-Family Lot

In general, the EVSE will need to be approved for outdoor use unless the location is well protected from the environment. The installation of the EVSE at the front of the vehicle may be the only choice unless an adjacent wall is available. If located at the front of the parking stall, the

EVSE should be located on the vehicle side of any walkway to minimize the cord becoming a tripping hazard. The walkway for pedestrians would be on the back side of the EVSE. If a wheel stop is 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.

A major difference from single family homes with multi-family units is the location and ownership of transformers. For single family homes, the transformer is typically in an alley, on a power pole or on the ground with underground wiring. In larger multi-family units it is usually in the building in the electrical room. The added load of EVs may require an upgrade to the transformer and associated cost. Associated with this will be additions to the distribution center, and panels. These are all costly and require space.

A demand load management system that shares power with existing infrastructure may significantly reduce cost. An electrical engineering firm may be consulted to review the existing facilities electrical capacity and to recommend potential upgrades such as a demand load management system.

One multi-family installation scenario consideration may be to install both Level 1 charging in mass with Level 2 or DC Fast Charge stations available on a reservation or temporary basis such as in a loading zone or visitor parking area. In this configuration, drivers would utilize the charging level needed for their specific driving pattern.

A low rise multi-family condominium will differ from a high rise configuration in the electrical plan and layout. In some low rise townhome complexes, power is run to each unit with attached parking. This may allow for the electrical infrastructure to be extended from the unit directly. In high rise and other parking lot configurations, the power would come from a common electrical room and through common property.

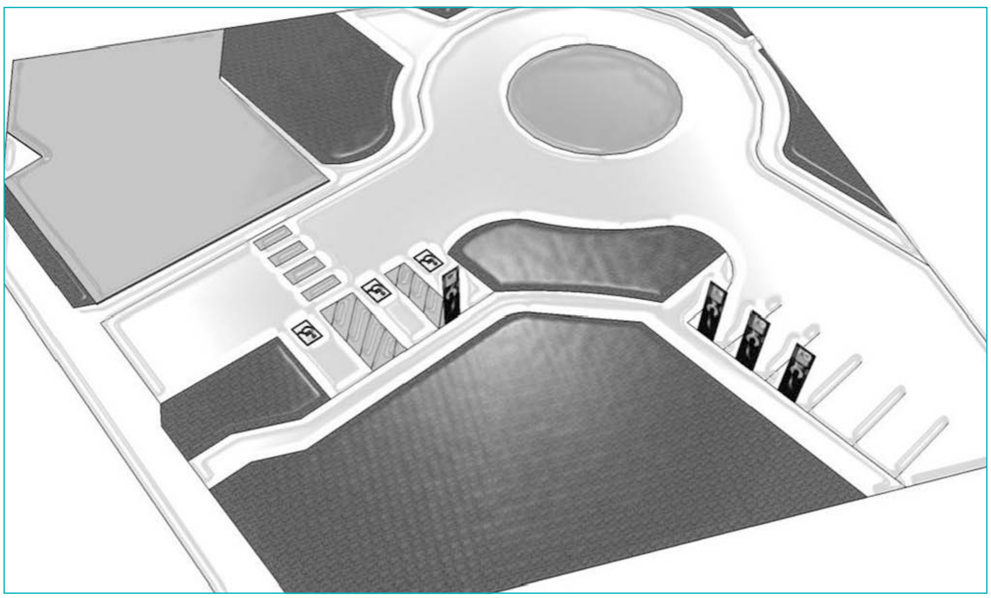

Figure 4-12
Multi Family—Large Building (High Rise)

If power can be shared with existing supplies on a load managed basis, then expensive equipment installation may be avoided. This however would require control of when EV charging could occur, such as at night only, depending on the peak power periods in your province. This peak power timing may shift from afternoon peaks in the summer for air conditioning to evening and overnight peaks in winter for heating. Each region is different. A localized load management design may be possible. This requires measuring current loads and switching or enabling charging only when sufficient power is available.

Power distribution may be on individual circuits at 120 V or 208V/240V or power may be distributed at higher voltages (600V) to localized small transformers in the parkade to minimize wire size due to the cost of copper wire. Each building and parkade configuration is different.

It may also be possible to provide DC Fast Charging with a shared charger amongst nearby parking stalls. Although the charger is more expensive, the cost may be shared amongst users.

### 4.5.2 Installation Process

Figure 4-12 below highlights the steps needed for the installation process for multi-family dwellings.

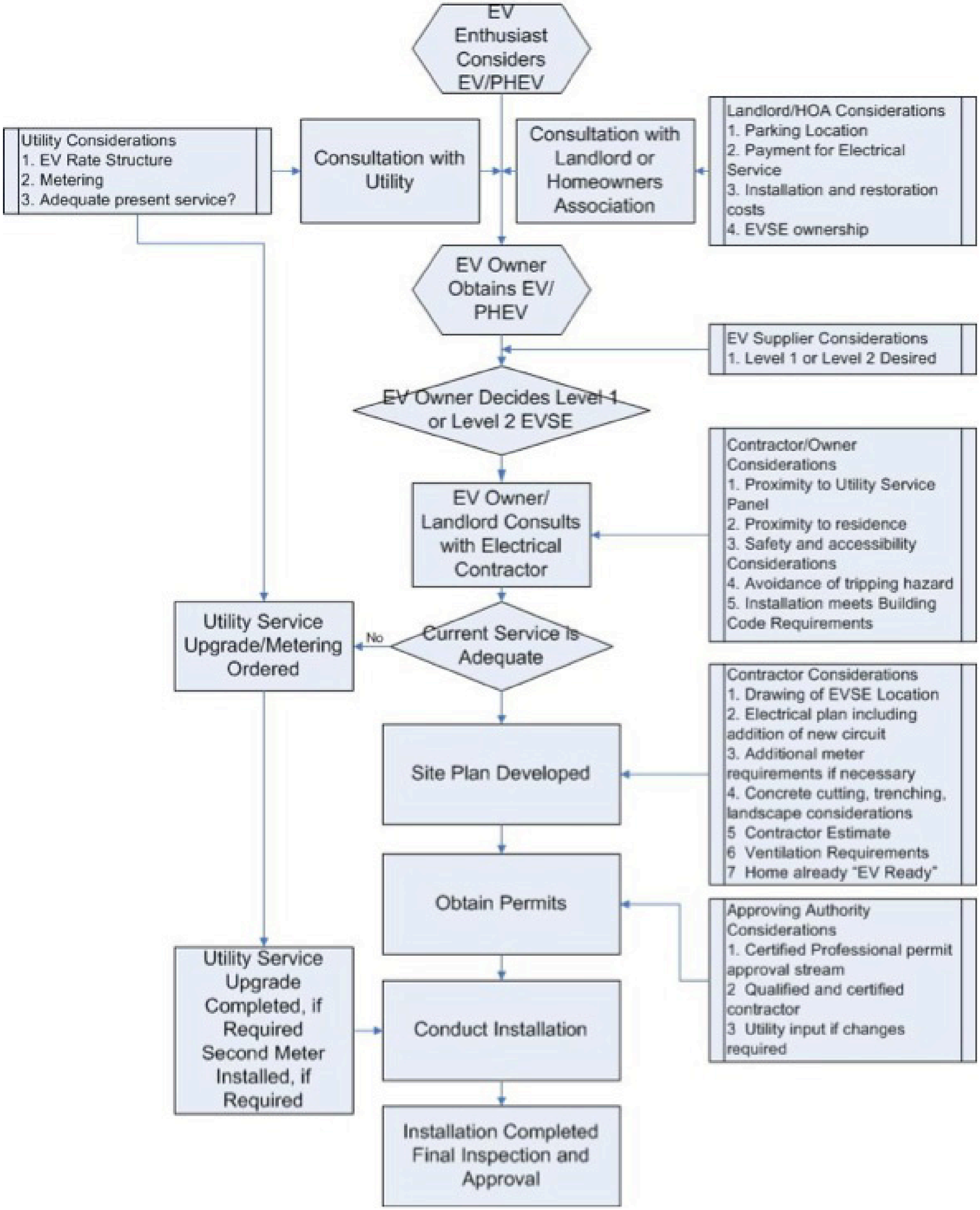


**Figure 4-13**
Installation Process for Multi-Family

## 5.0 COMMERCIAL CHARGING

## 5.1 COMMERCIAL CHARGING

Commercial applications for electric vehicle charge infrastructure may include fleet charging stations. Chargers for public use on private or public property (e.g. at a retailer or public park) can consist of Level 1, Level 2 or DCFCs. Site owners will decide on the type of charging equipment to install depending on the expected users and use of the charge infrastructure. Examples of commercial charging are shown in figure 5-1 through figure 5-7.

EVSE installations should be treated the same as similar electric loads and equipment. Commercial locations will plan for the installation of charge infrastructure using the same process outlined for residential installation planning; however, they will not necessarily be planning for the charging of a specific vehicle, unless the charge infrastructure is for a fleet of electric vehicles.

It is recommended that the commercial site owner work through the following details:

- Choose a Charging Strategy: Level 1, Level 2 or DCFC
- Select a Contractor who will assess the EVSE installation site
    - Determine voltage and amperage requirements of selected EVSE
    - Verify electrical capacity for additional load, recommending any necessary property or electricity service upgrade
    - Determine if communication to EVSE is required
    - Estimate installation cost for installing EVSE per Manufacturer Guidelines
    - Obtain local permit for installation
    - Schedule the installation
    - Coordinate with local inspector to validate installation
- Contact the local utility for EVSE installation notification
    - Determine if there are special electric vehicle charging rates available
- Determine if the parking stall needs universal access. For more information, please see section 7.2.

There are many different configurations for the installation of charge infrastructure. Charging stations can be installed in parking garages, in surface parking lots, row parking, head to head parking or street side, to name a few. The site owner/manager will need to assess the best installation scenario for their specific application.

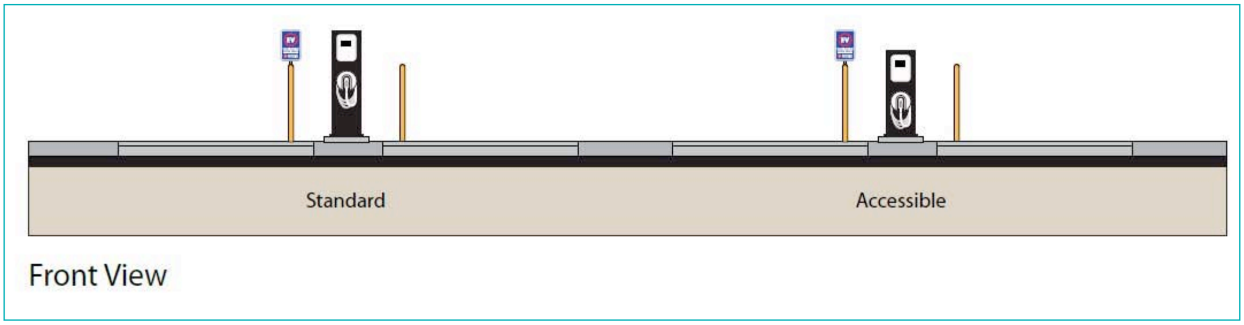


**Figure 5-1**
Commercial Row Parking Front Placement

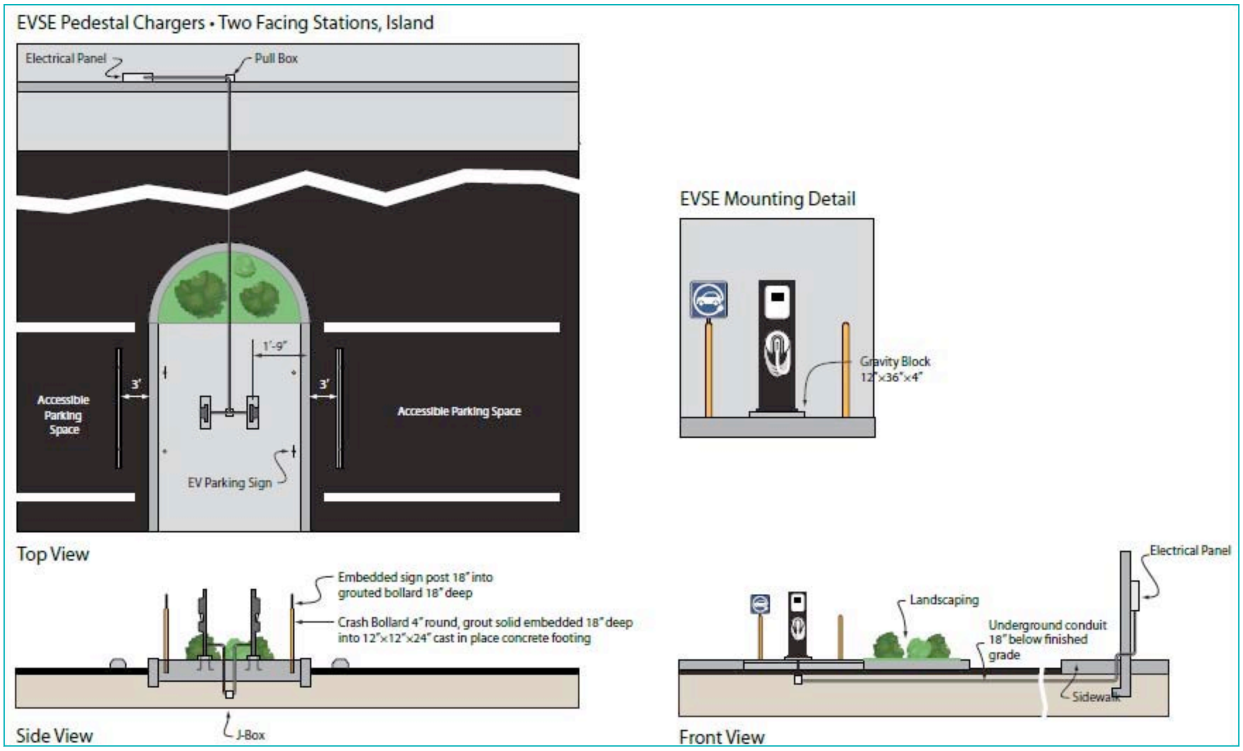


Figure 5-2
Commercial
—Head to Head
Parking

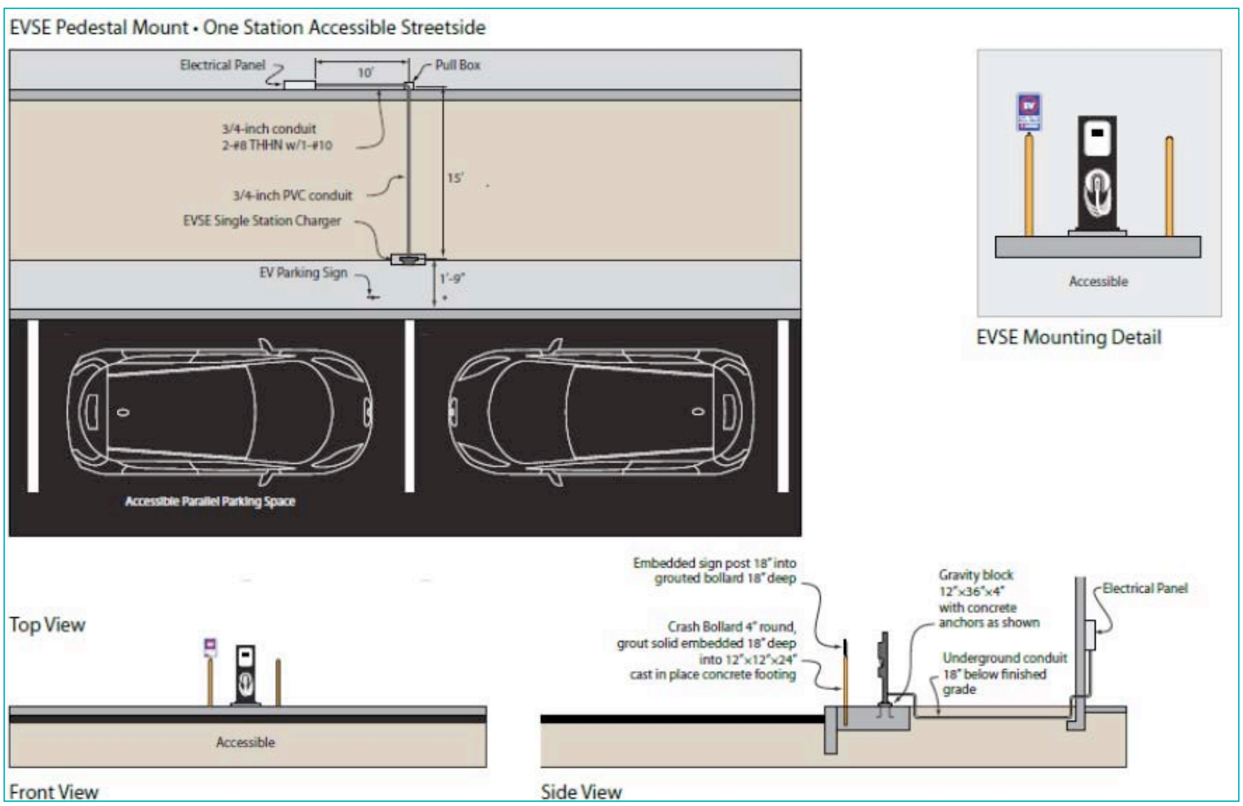


Figure 5-3
Commercial
—Street Side

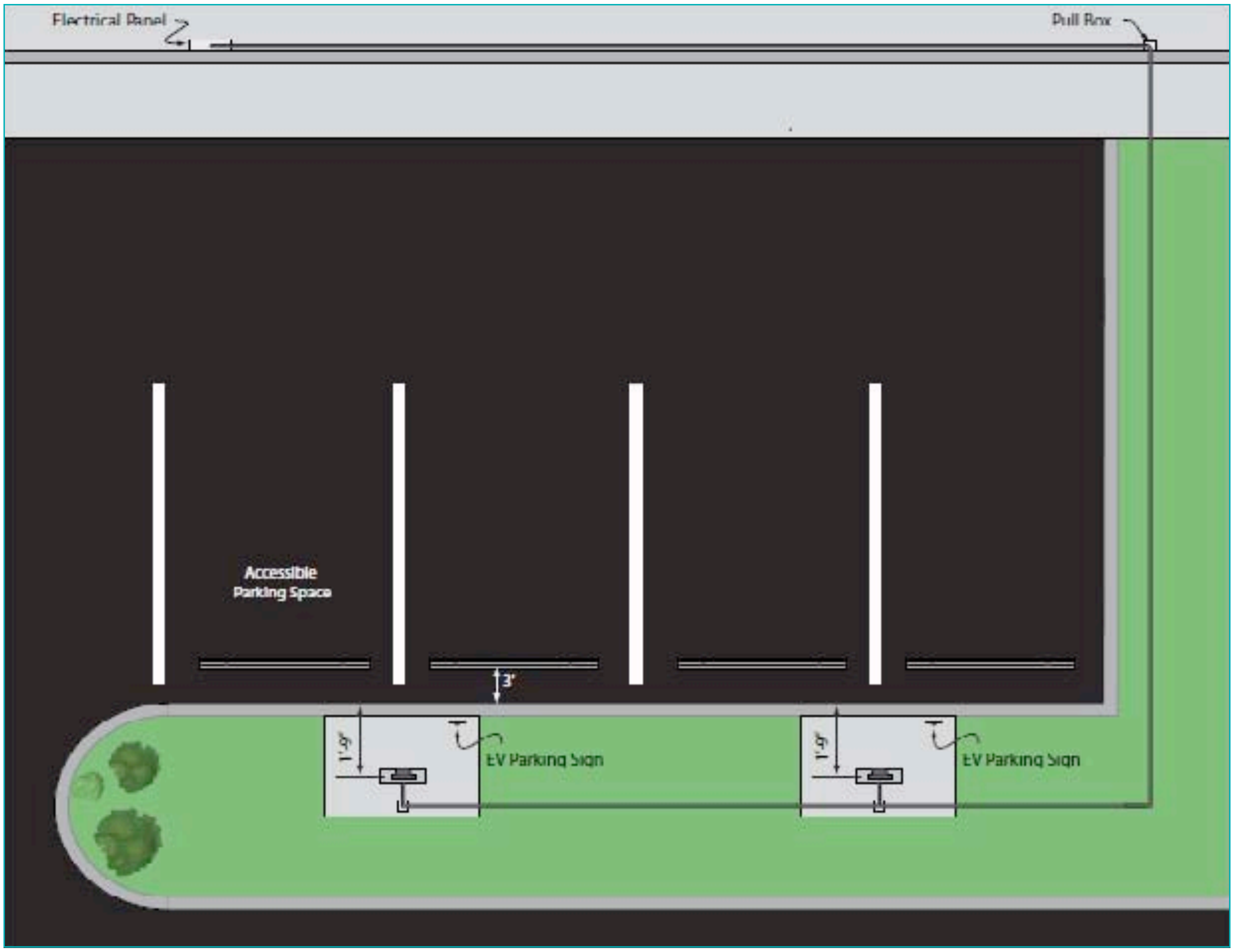


**Figure 5-4**
Commercial (Pedestal) — Avoid Trenching Diagonal across a Parking Lot

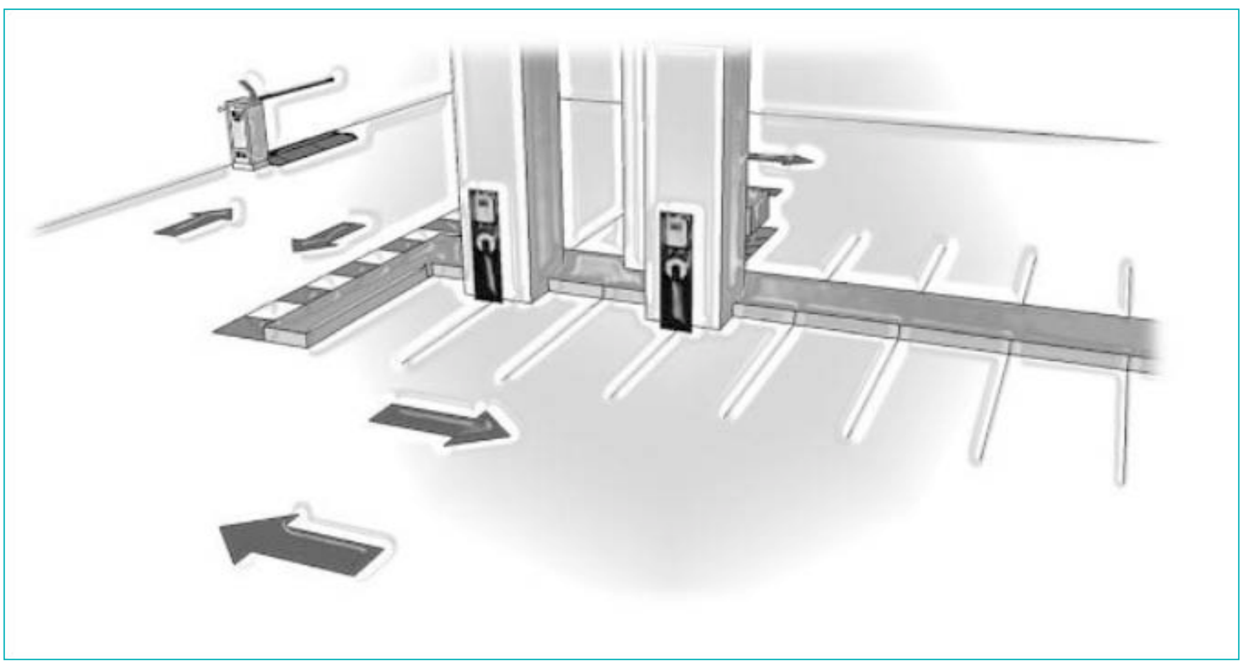

**Figure 5-5**
Commercial —Row Parking Middle Placement

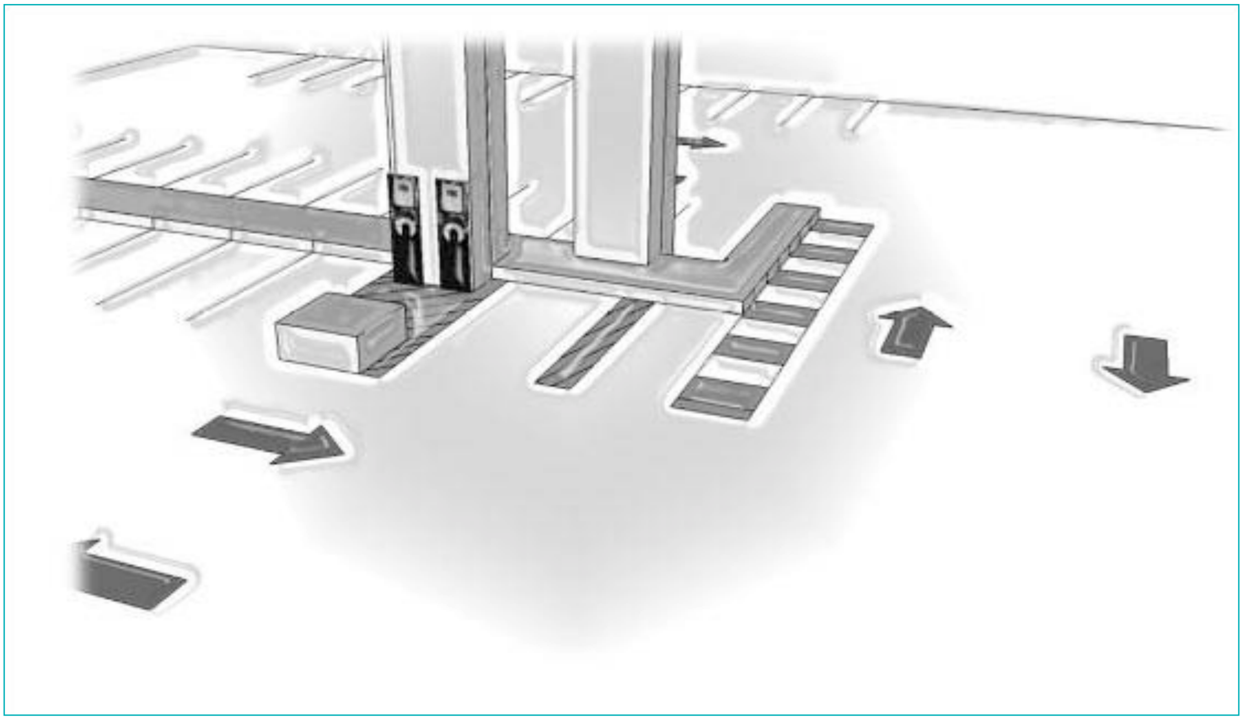

**Figure 5-6**
Commercial—
Row Parking Middle Placement

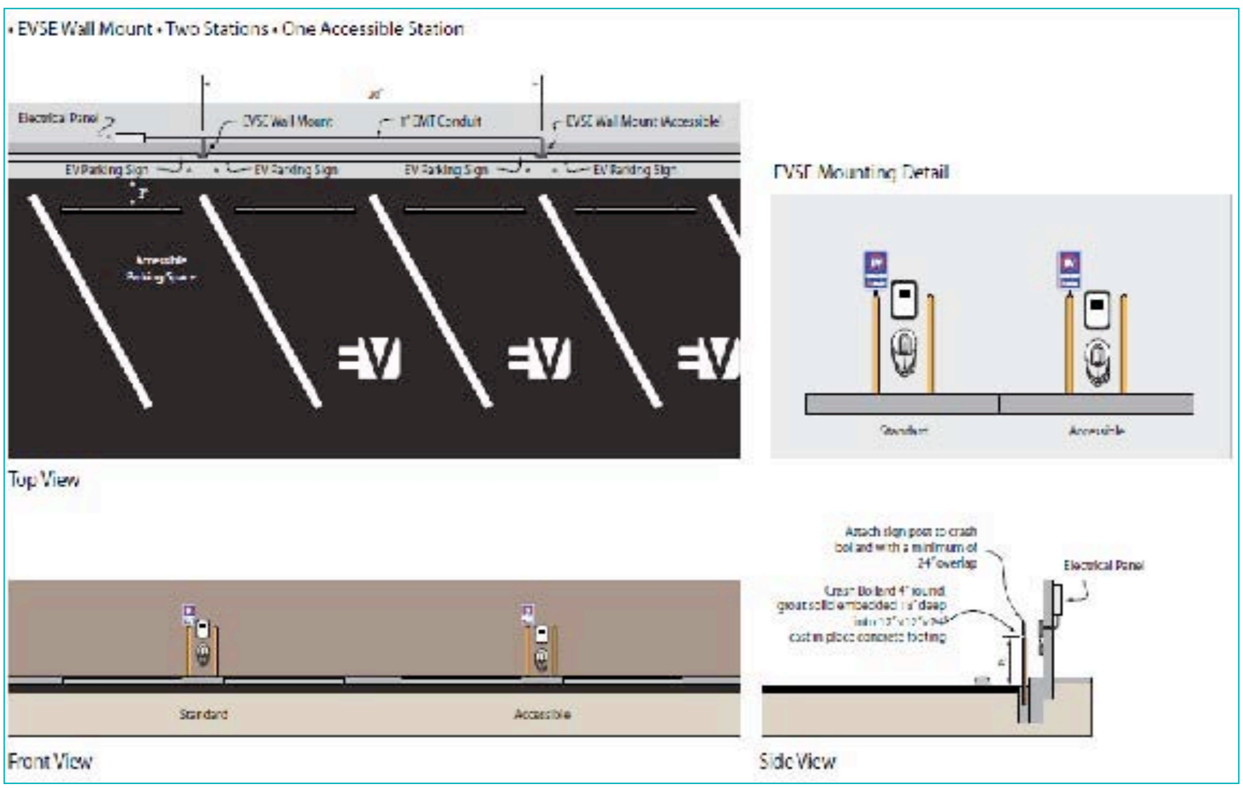


**Figure 5-7**
Commercial—
Wall Mount

### 5.1.1 Installation Process

The commercial installation process (figure 5-7) is similar to the processes shown in figure 4-13. More detailed planning is required prior to submittal of plans for obtaining permits.

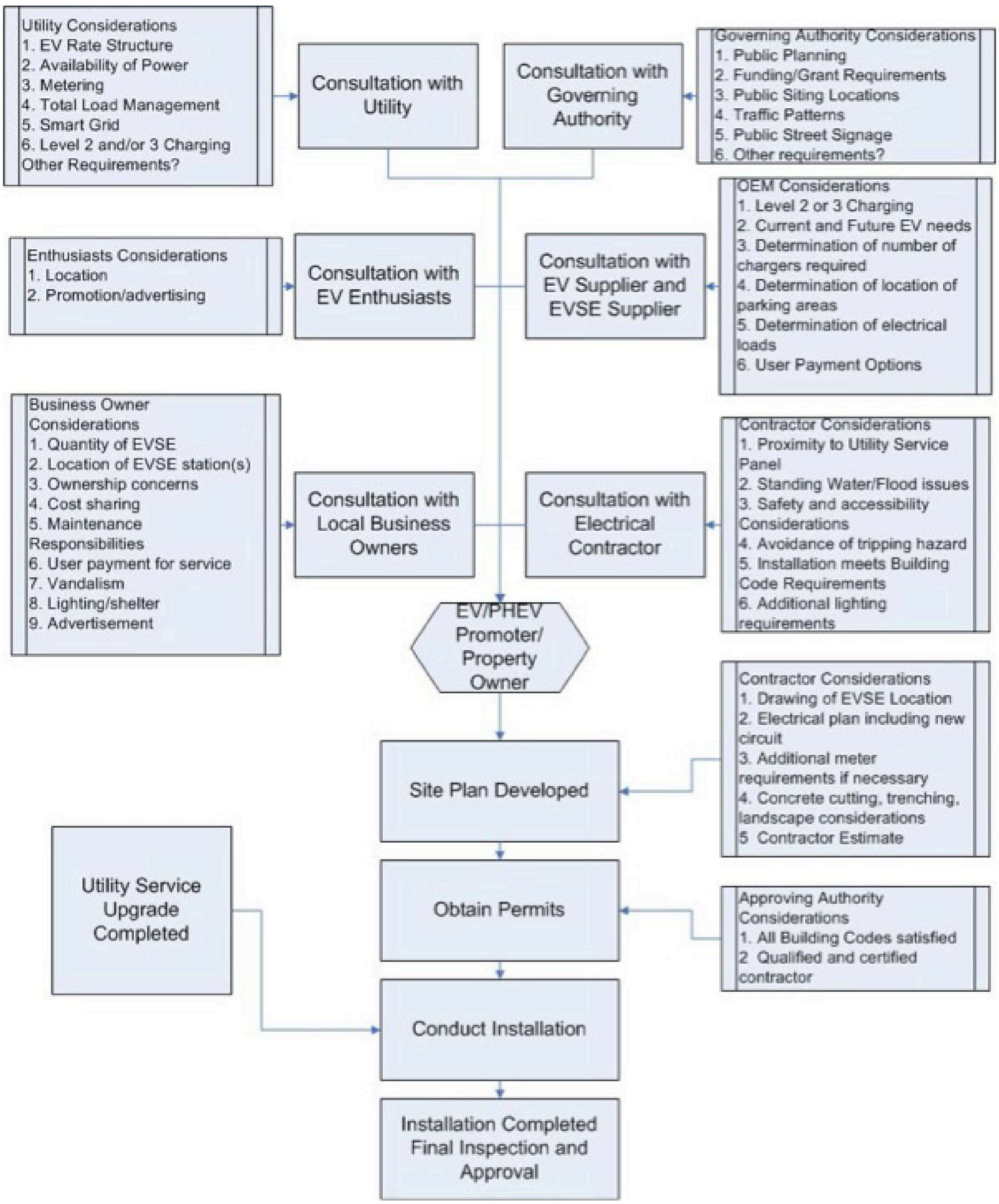


**Figure 5-8**
Installation Flowchart for Commercial Charging

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

## 5.2 COMMERCIAL FLEET

Commercial fleets make up the highest population of EVs at the present time. Utilities, governmental agencies and other private fleets have been encouraged and are encouraging the private adoption of EVs. A significant amount of planning is required to correctly size the EV parking and charging area for commercial fleet applications. Consideration is given to the current requirements as well as anticipated future requirements. Electrical service requirements will be much higher than residential or multi-family installations and can have a significant impact on electrical usage and on the utility. For that reason, electrical utility planners need to be involved early on in the fleet planning process.

Installation of EVSE at 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 quantity will have a significant impact on the cost.

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

Fleet managers must also be aware of other equipment to be stored in the vicinity of the EVSE. It is important that a hazardous environment does not already exist in the area planned. Fleet manager interests and priorities can also stimulate the development of DC Charging. The higher recharge rate means a shorter turn-around for each vehicle and maximizes on-road time. The 480/600 VAC is generally available in commercial facilities.

### 5.2.1 Installation Process

The commercial installation process (refer to figure 5-11) is similar to the processes shown in figure 5-8. Detailed planning is involved prior to the owner's final decision and obtaining permits.

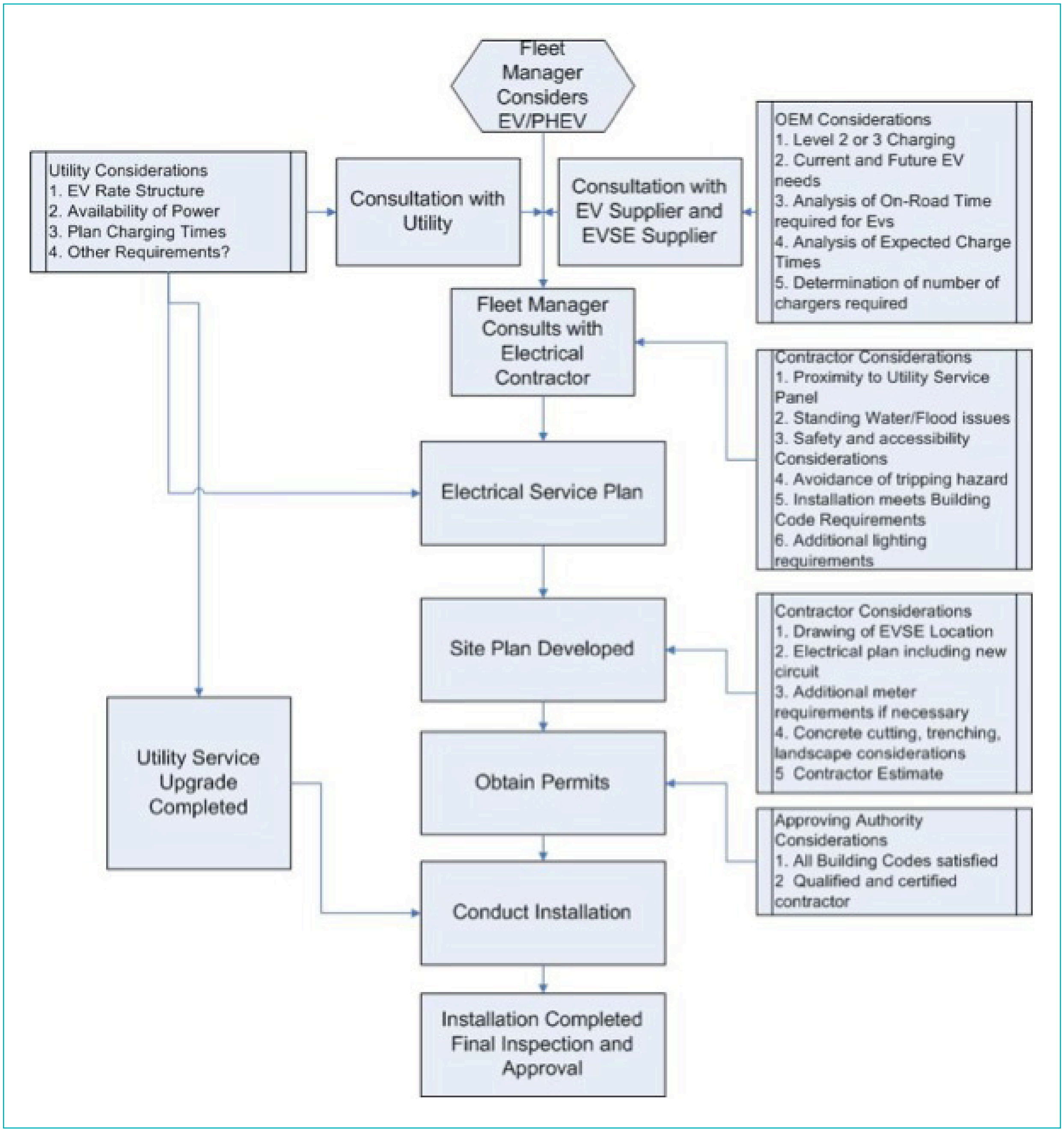


Figure 5-11
Installation Process for Commercial Fleet Operations

## 5.3 SMART EVSE AND DATA COLLECTION

In general, AC Level 2 and DC Level 2 equipment is manufactured as either basic or "smart" equipment. That is, equipment that meets the functions of recharging a vehicle only is considered basic equipment. EVSE that has the capability of collecting, storing and transmitting usage and other information is considered smart. There are several suppliers of both types of EVSE, however, most suppliers of basic equipment have or are considering adding smart capabilities to their product lines.

Smart equipment can be designed to interface with the electric utility service provider to assist in a variety of electrical load management strategies. For example, if the overall electrical load is too high, the electric utility may desire to reduce or stop EV charging at select locations. Such systems would require EV driver participation and notification.

Smart equipment can also be designed to measure, collect, store and transmit usage information. Such information can be useful for electrical utilities in monitoring and planning their grid reliability and generation strategies. Owners of publicly available EVSE may find this useful in determining when and how long users stay at the units and compare the data with in-store traffic.

Some suppliers of smart equipment can also provide other services to the EV driver such as providing reservation services and notifications related to the status of their vehicle's charge. Charging site hosts should consider their options in this regard prior to the purchase of the equipment. In addition, the electrical utility may recommend smart over basic equipment in their service territory.

# 6.0 DC FAST CHARGING

## 6.1 PLANNING

DCFC consumes the most electricity of all the electric vehicle charging options available. The installation of DCFC equipment is typically the most expensive of the three electric vehicle charging options. The operating costs, frequency of use and market acceptance of DCFC is yet unknown. Manufacturers of DCFC equipment offer varying services and configurations. Site owners should evaluate the site specifics and user need against the features and benefits of the available equipment. The installation of DCFC equipment requires an electrical contractor and coordination with the local utility; and most often requires a separate electric service. Different sites for the DCFC installation are shown in figures 6-1 through figure 6-3. The installation process for DCFC equipment includes the following:

- Contact the Local Utility
    - Ensure grid reliability
    - Verify local transformer capacity is available
- Select a DCFC equipment vendor
- Select a Contractor who will assess the DCFC installation site
    - Determine voltage and amperage requirements of selected EVSE
    - Verify electrical capacity for additional load, recommending any necessary property or electricity service upgrade
    - Determine if communication to the DCFC equipment is required
    - Estimate installation cost for installing DCFC equipment per manufacturer guidelines
    - Obtain local permit for installation
    - Schedule the installation
    - Coordinate with local inspector to validate installation

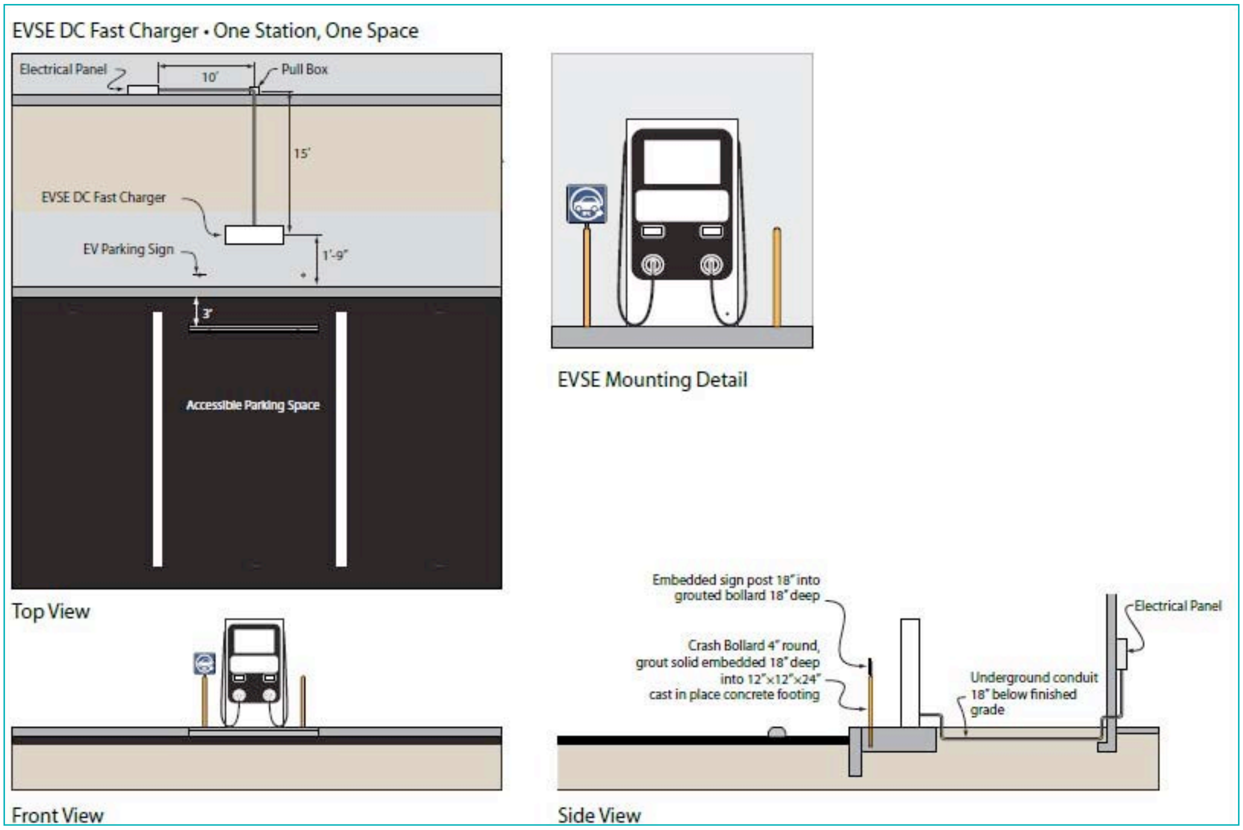


Figure 6-1
DCFC for One Space

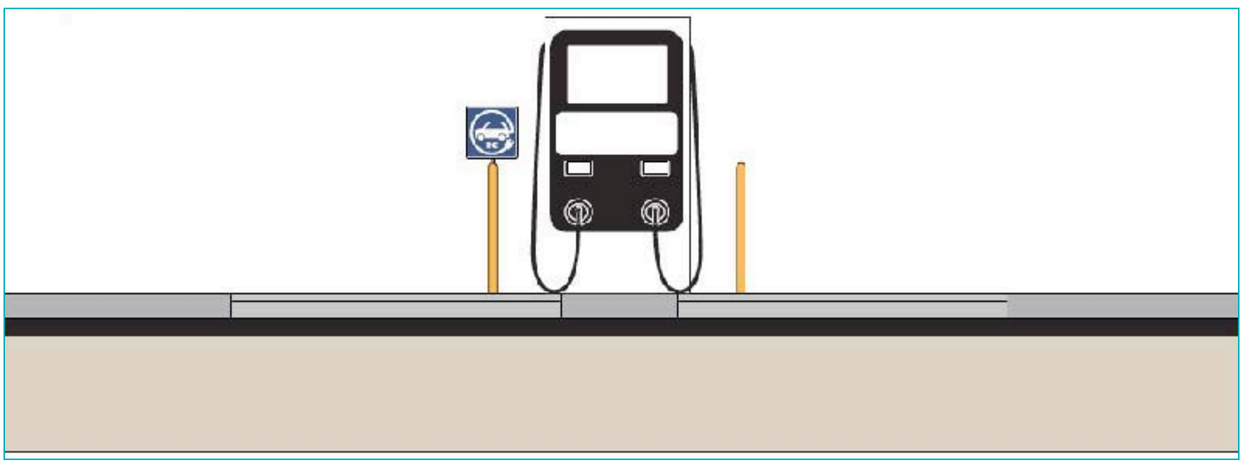

Figure 6-2
DCFC for 2 Spaces
—Front

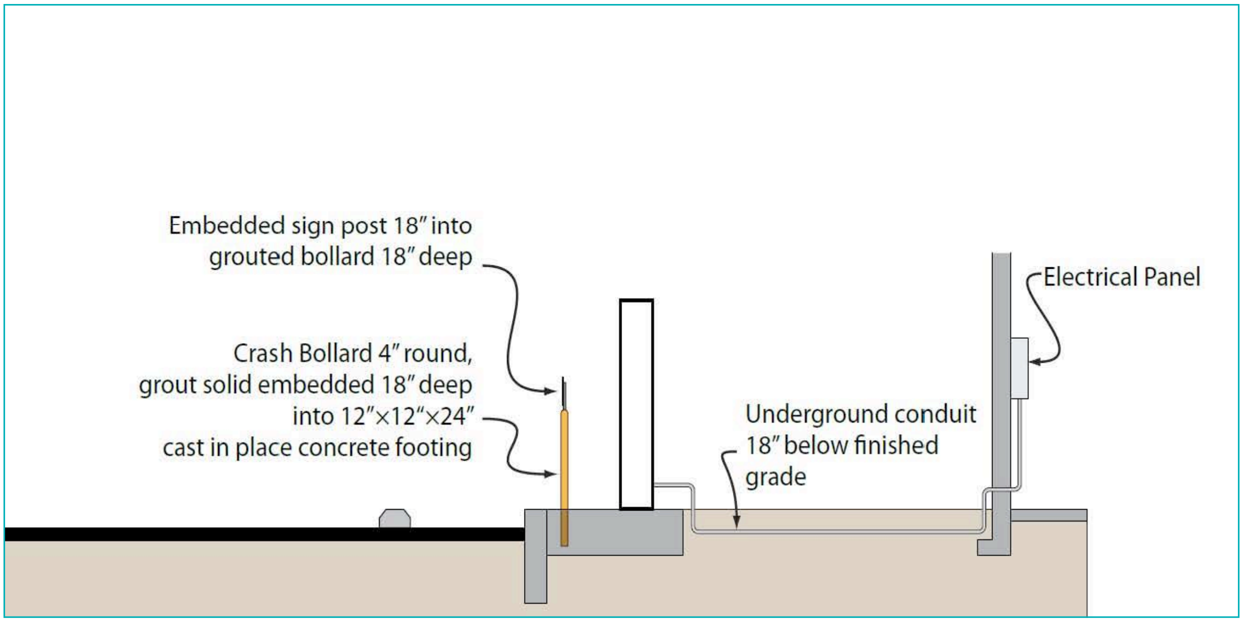


**Figure 6-3**
DCFC for 2 Spaces —Side

## 6.2 INSTALLATION PROCESS FOR DC FAST CHARGERS

The installation process for DCFC (Figure 6-4) is similar to the commercial process but involves higher construction and equipment costs. More detailed planning is required prior to the submittal of plans for obtaining permits. Greater coordination with the electric utility will be required because of the higher power levels required. Frequently, more detailed construction drawings are required. Site selection on the property is more involved and careful consideration for the unit placement is recommended.

In the United States, DCFC circuits are typically rated at less than 600 VAC and EVs typically operate at less than 600 VDC. Certified electrical contractors are generally qualified to work on these DCFC circuits without the additional certification and training that may be required if the circuit was rated "high voltage." In the United States, that rating occurs for voltages over 600 V[11]. In Canada, the "high voltage" rating occurs for voltages above 750 V[12]. Each province has a Safety Authority's Electrical Safety Program that is responsible for regulating electrical safety, including all types of electrical equipment and installation and should be consulted to determine appropriate contractor qualifications.

[11] NEC Article 490.2
[12] CEC Section 36-000

## 6.3 DC FAST CHARGING CHARACTERISTICS

DC Fast Charging is relatively new to EV infrastructure planning. While it is available on certain automobiles using the CHAdeMO standard, many automotive manufacturers are waiting for the SAE to complete their standards work. DCFC has certain advantages in being able to recharge vehicles in much shorter times than AC Level 2 charging as noted in Table 2-1. A **trade-off** for this recharge convenience comes through power requirements that are much higher than Level 1 and Level 2 AC, which complicates installation and increases costs. Deployment of DCFC has recently commenced and it is too early to evaluate their effectiveness. Nevertheless, it is thought that DCFC will have three primary applications.

- **Enhancing Range Confidence:** For BEV drivers or those considering the purchase of a BEV, depleting the battery while still away from a recharge location ("range anxiety") can be a negative motivator. Level 2 AC EVSE commonly found in public locations can provide the recharge capabilities to allow BEV drivers to charge sufficiently to return to their home base. For the person anxious to get home however, the recharge at AC Level 2 may be prolonged. Thus the availability of DC Level 2 will be of interest. The short duration of the charge necessary to substantially increase range makes these chargers particularly attractive. In this role, DC Level 2 EVSE may be found at convenience stores, fast food restaurants, gasoline stations, and other places where people typically stay for short durations. It is also likely that these locations will be near major street intersections or freeway interchanges to provide these services for the greatest number of people. These stations then become a backup safety net for publicly available infrastructure. The initial deployments of DCFC are including this factor in their location planning.
- **Transportation Corridors:** BEVs rely entirely on their battery's electrical storage for the vehicle range. Traveling between metropolitan areas or from locations remote from metropolitan areas will require recharge facilities along the way in order to enter the local EVSE infrastructure grid. DC Level 2 EVSEs are ideal for these transportation corridors. Drivers will want the shortest time to recharge while en route to their destination. The initial deployments of DCFC are including this factor in their location planning. In general, DCFC should be placed approximately 50 km apart for the convenience of BEV drivers. The initial deployments of DCFCs are including this factor in their location planning.
- **Mutual Family Dwelling Residents:** Some multi-family units are designed without assigned parking locations for the residents. Installation of Level 2 EVSE is not trivial in these locations as discussed previously. One potential solution for those interested in purchasing a BEV but who do not have a dedicated parking location at which to install an EVSE is to locate a DCFC in the vicinity. A parking garage that caters to these multi-family units could install a Level 2 AC EVSE, rotate cars at night and charge approximately 3 to 4 vehicles each night. A DCFC installed at the garage could recharge approximately 16 to 20 vehicles in the same time.

Many automobile manufacturers and their battery suppliers do not have significant history with DCFC and are cautious in their recommendations. However, as more experience is gained, more confidence and acceptance of DCFC is expected. The onboard BMS controls the recharge rate, even with DCFC, and current applications limit the recharge to 80% of the battery's capacity. For the Nissan LEAF, a recharge from 30% to 80% typically takes approximately 25 minutes.

## 6.4 UTILITY CONSIDERATIONS

It is very important to coordinate with the local authority or utility when installing a DCFC due to their intermittent use and large energy draw. Evaluation of the existing load profile shall be done to determine whether the addition of the DCFC will increase the overall rate structure or not. A new service drop should be considered if it can avoid an increase to the core facilities rate structure. Ask the utility provider for different energy cost quotes for light, medium and heavy usage. Ask your utility provider if the time of day has any effect on pricing. If it does, take into consideration the operation times to avoid higher cost power and also consider the equipment's business models to anticipate cost recovery from users. Certain sites may require step down transformers. These transformers can be installed either near to the building or near to the charging stations.

# 7.0 STATION OWNERSHIP, SAFETY ISSUES AND ACCESS

## 7.1 STATION OWNERSHIP

Ownership of the individual charging station will vary from location to location. A business owner may wish to host a public charging station, 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, to determine the necessary approvals required to obtain the permits and future plans for the removal of the equipment at the end of the product lifecycle.

For individual EV owners living in a single family dwelling, the ownership of the residential EVSE will most likely reside with the owner of the dwelling. In contrast, EVSEs installed for apartment and condominium complexes will likely be owned by the building owner.

For public charging, there may be a combination of owners. Utilities may wish to own and manage the public charging infrastructure in order to manage power requirements. In a successful EV market penetration, ownership of new public charging may shift to private ownership. Several businesses may join together to promote EV usage and may share in the EVSE ownership. However, there should be one individual business entity tasked with the responsibility of legal ownership along with proper contact information to be shared with the local utility. In all of the situations listed above, it is important for all of those involved to understand the legal responsibilities and liabilities associated with installing an EVSE on their premises.

### 7.1.1 Electrical Supply/Metering

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

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

A new utility service drop will typically require a new customer account be setup, which may include a credit evaluation of the entity applying for the meter, and a monthly meter charge in addition to the energy and demand charges. In addition, the local utility may require an analysis of the anticipated energy consumption in order to justify covering the cost of the new service drop.

### 7.1.2 Engineering, Permitting and Construction

The process flowcharts identified above all require the electrical permitting of the work. A typical permit application will include the name of the owner or agent, the physical address where the work will be conducted, the voltage and amperage of the system, the name, address and license number of the qualified contractor and whether additional trades will be involved.

Service load calculations may also be required. An electrical contractor may require a review of the current service load and consider the rating of the EVSE to be installed. A new load calculation will then determine whether the existing service panel is adequate or new service is required. Some jurisdictions will require the calculation to be submitted with the permit application.

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

For fleet and public charging installations, it is recommended that an engineering company prepares the detailed site plans for each installation. Several trades may be involved including general contracting, electrical, landscaping, paving, and concrete, masonry, and communications systems. As noted above, careful planning is required to coordinate this effort and an engineering company can provide the detailed set of drawings that will be required. In addition, there may be several permitting offices involved with the approval of these plans. Prior to any actual on-site work, the permit must be approved and posted at the site. The permit will identify periodic inspections and approvals of work if necessary.

## 7.2 DISABILITY REQUIREMENTS

It is important that persons with disabilities have access to the EV Coupler and access around the vehicle in order to connect with the vehicle inlet. Whether indoor or outdoor, this means that the EV Coupler should be stored or located at a height of not more than 1.2 m (4 ft) and not less than 0.6 m (2 ft.) above the parking surface. These requirements are similar to the building codes for elevator controls in that the maximum height is 1.37 m (4.5 ft) above the floor with 1.1 m (3.5 ft) being the preferred maximum and 0.89 m (3 ft) above the floor for the minimum height.

In addition, accessible parking stalls should be provided. An accessible stall is 3.7 m (12 ft) wide by 7.4 m (24 ft) deep as shown in figure 7-1, which includes an access aisle of 1.2 m (4 ft) on the passenger side. A van accessible space is the same size with a 2.2 m (7 ft) access aisle on the passenger side. Note that it is important that the placement of the EVSE should allow adequate space for a wheelchair to pass by the wheel stop.

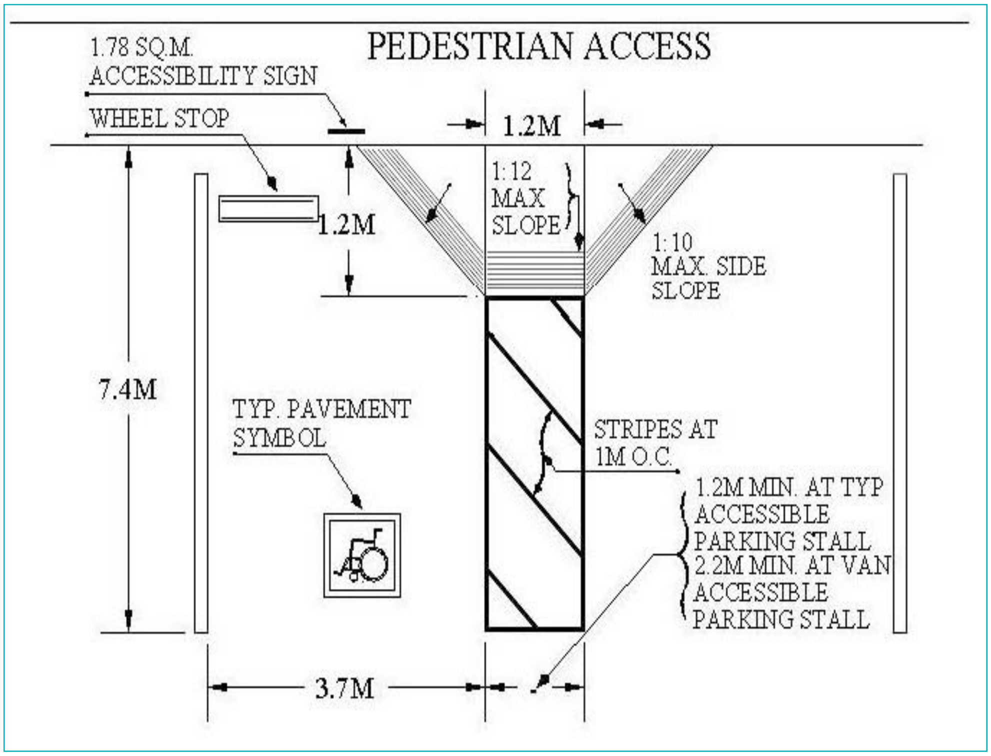


Figure 7-1
Parking Accessibility Requirements

According to building codes, parking lots with more than 50 stalls require parking for persons with disabilities (one for every 100 stalls). For lots with EV charging stations, the ratio should be one for every 25 stalls with EVSE. For every 10 accessible stalls, one should be van accessible.

Table 7-1 Accessibility Requirements

| EV PARKING STALLS | ACCESSIBLE STALLS | VAN ACCESSIBLE STALLS |
|---|---|---|
| 1 | 1 | 1 |
| 2-25 | 1 | 1 |
| 26-50 | 2 | 1 |
| 51-75 | 3 | 1 |
| 76-100 | 4 | 1 |

## 7.3 SAFETY PROTOCOLS

### 7.3.1 Occupational Health and Safety

The Canadian Centre for Occupational Health and Safety (CCOHS) is a Canadian federal government agency which serves to support the vision of eliminating all Canadian work-related illnesses and injuries. This agency develops and publishes the Canadian Occupational Health and Safety (COHS) Regulations.

The purpose of the OHS Regulation is to promote occupational health and safety and to protect workers and other persons present at workplaces from work-related risks to their health, safety, and well-being. Compliance with the requirements provides the basis on which workers and employers, in cooperation, can solve workplace health and safety problems. Specific parts related to EVSE include Part 19 Electrical Safety and Part 10 De-energization and Lockout. These parts will be important in the engineering and design of EVSE installations.

### 7.3.2 Indoor Charging

The possibility of invoking the ventilation requirements or hazardous environment requirements of the CEC exists when installing indoor charging. When the EVSE connector makes contact with the EV inlet, the pilot signal from the vehicle will identify that the battery requires ventilation. While most EV and PHEV batteries do not require ventilation systems, some batteries, such as lead acid or zinc air, emit hydrogen gas when charged. The EVSE contains controls to turn on the ventilation system when required and also to stop charging should that ventilation system fail. Alternatively, the EVSE will not charge the vehicle requiring ventilation, if a ventilation system does not exist.

The CEC identifies three classes of hazardous locations in Section 18. This Section of the CEC may impose restrictions or conditions under which EV charging may occur. Consult the CEC to determine the classification of an indoor space being considered for use for EV charging.

Section 20 of the CEC also identifies hazardous locations to include locations where flammable liquid or gas may be dispensed such as service stations and garages. Section 20-112 states that battery chargers and their control equipment shall not be located in hazardous areas as classified in Rule 20-102.

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

### 7.3.3 Vandalism

Public charging carries the possibility of vandalism and theft. Destruction of property through purposeful defacing of equipment is a possibility; however, such destruction has proven to be very minor to date. However, as public acceptance and the quantity of public 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 removal of graffiti can be accomplished. Careful planning on 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 desire to protect the equipment with a lockable secure cabinet to prevent unauthorized use and for vandalism protection.

### 7.3.4 Lighting and Shelter

For commercial, apartment, condo and fleet charging stations, adequate lighting is recommended for safety and convenience. Shelter is not typically required for out-door rated equipment. For geographic locations that have significant rainfall or snow, providing shelter over the charging equipment may provide added incentive to potential BEV or PHEV users (refer to figure 7-2). Locations within parking garages or private garages that are well protected from the environment may utilize EVSE that is not specifically outdoor rated.

Lighting should be sufficient to easily read associated signs, instructions, or controls on the EVSE and provide sufficient lighting around the vehicle for all possible EV inlet locations. Recommendations for lighting levels, including parking structures, can be found in the most current edition of the Illuminating Engineering Society of North America (IESNA) Lighting Handbook.

**Figure 7-2** Level 2 Public Charging Station with Shelter and Lighting

In residential garages or carports, lighting is also important to reduce the possibility of pedestrians tripping over extended charge cords while the EV is charging.

## 7.4 POINT OF SALE (POS) OPTIONS

Revenue models for EV charging stations will likely vary from region to region depending on the local regulations pertaining to who can and cannot offer electricity for resale. For example, Manitoba Hydro is currently the only entity that is legally allowed to resell electricity in Manitoba. Therefore, the Metered Charging model listed below would not be possible in Manitoba unless it was Manitoba Hydro offering the service. It is important to review your local regulations before setting up a commercial charging service.

Some of the common revenue models are explained below for commercial/public charging operations:

- Free parking. Free Charging. — In this scenario, the parking lot operator would install a charging station for the benefit of its customers. An example of this would be a store or hotel installing a charging station as a means to attract customers.
- Paid Parking. Free Charging. — In this scenario, the parking lot operator would charge a flat rate for the parking stall which would include power for PEV charging.
- Flat Rate Charging Fee. — Unlimited charging for a flat fee.
- Metered Charging — Users charged per kilowatt hour (kWh) of electricity supplied.

### 7.4.1 Card Readers

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

A smartcard is a card that is imbedded with a microprocessor or memory chip. It can more securely store more detailed information than a credit/debit card. The smartcard could be sold as a monthly subscription and imbedded with information on the user. That information could be captured in each transaction and used for data recording. The smartcard could be used for a pre-set number of charge opportunities or to bill a credit card number for each time of use.

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

### 7.4.2 Parking Area Meters

People are very familiar with 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 for public pay parking lots where a central kiosk is used for credit card purchases. The parking stall number is identified at the kiosk and a parking receipt issued that can be displayed in the vehicle. There is little cost for the meter and a single kiosk reduces the point of service cost for the whole parking lot. This system will require an attendant to periodically monitor the area for violations. Penalties for violators will need to be determined.

### 7.4.3 RFID Subscription Service

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

# 8.0 UTILITY PROGRAMS

## 8.1 BACKGROUND

Electric utilities are often mandated, regulated, or obligated to maintain a dependable, clean and low cost electrical supply to their customer base. In order to achieve these goals, utilities are evaluating and in some cases implementing "Smart-Grid" technologies that allow them to control various electrical loads on their system. Through these Smart-Grid technologies, utilities can potentially minimize new power plant, and electrical distribution and transmission investment by shifting and controlling load while minimizing the impact to the customer. Advanced Metering Infrastructure (AMI) or what is referred to as "Smart-Meters" are being deployed by utilities.

One of the immediate benefits is remote meter reading, eliminating the need to manually read thousands or in some cases millions of meters every month for billing purposes. These smart meters also have the capability to control various customer loads which is an important piece in implementing the overall Smart-Grid system. There have been significant advances in computer control of lighting, thermostat, appliances and energy management systems that make the communications with the smart meter possible.

Electric vehicles are one of the better loads to control for the utilities because EVs have an on-board storage system unlike lighting or air-conditioning load which can have an immediate impact on the customer when turned-off. For residential EV charging, the ability to move the charging times into the off-peak time of day could help delay costly infrastructure upgrades due to higher peak loads. Below is a list of various mechanisms that utilities can use to control EV loads. Note that the availability of these mechanisms varies from region to region.

There are various mechanisms for utilities to control EV load including;

### 8.1.1 Time of Use (TOU)

TOU is an incentive based electrical rate that allows the EV owner to save money by charging during a designated "off-peak" timeframe established by the utility. Typically, these off-peak times are in the late evenings through early mornings and/or weekends, during a timeframe where demand on the utility electrical grid is at its lowest point.

### 8.1.2 Demand Response

Demand response is a voluntary program that allows a utility to send out a signal to customers (typically large commercial customers) to cut back on loads during times the utility is experiencing a high demand. The customers are compensated when they participate in these programs to make it worth their while. EV owners may participate in such programs in the future as deployment of smart meters become more prevalent.

### 8.1.3 Real Time Pricing (RTP)

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

### 8.1.4 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 loads, in times of emergency such as grid voltage support, or based on pricing economics. V2G could also support vehicle-to-home whereby the energy stored in the vehicle battery could supplement the home electrical requirements. V2G requires that the on-board vehicle charger be bi-directional (energy can flow both directions) and that the EVSE at the premise also be bi-directional and accommodating of all the utility requirements related to flowing energy back into the electrical grid. Although there are various development efforts in V2G, this concept for on-road EVs is likely some years away from commercial implementation.

## 8.2 COMMERCIAL FLEET CHARGE STATIONS

**Power Requirement:** 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 will likely include multiple charge locations and therefore with new construction the additional load will need to be planned for when sizing the main SES. Since it is likely that most of the charging will occur during working hours, the additional load may require an upgrade or new SES and/or utility supply for existing buildings.

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

## 8.3 ELECTRIC GRID & ELECTRIC VEHICLE CHARGING

Emerging EVSE platforms are increasingly intelligent (i.e. capable of optimized charge activation/decisions) and networked (i.e. connected to broader energy management systems)

At the far end of capabilities, the most functional of these platforms exhibit fully integrated, smart charging capabilities with native functionality for advanced messaging, monitoring, demand response, and advanced analytic capabilities. As standards emerge that govern the interoperability of the infrastructure with Smart Grid deployments, this will enable efficient large scale, rapid build out of "communicating EVSE infrastructure" in support of the mass market EV deployments in the decades ahead.

The following applications/features are already a part of the leading advanced platforms or have priority for near term development and implementation as the competitive market for these solutions develops. The core function of these platforms are enabling an adaptive, intelligent and convenient system of EVSE charging stations, exposing intuitive applications for utilities and EV owners.

- Communication systems, multiple modes of communications including wireless, cellular, LAN and ZigBee that allow for flexible and ubiquitous network connection. The EVSE nodes may be inherently designed as a "smart" unit whose interactive features are fully enabled when activated with any IP based network connection.
- Notification systems for EV users of events and issues, such as when charging is complete or interrupted, via automatic text messages to a cell phone and/or email notification. Some of the more advanced capabilities allow bidirectional acknowledgement and potentially control commands.
- Enable EV users to use the internet or a smart phone to find network charging stations, inquire as to station availability (occupied/reserved/available), determine distance to and from available stations, and process EVSE transactions. Smart phone applications for status charges and notification of completion or interruption of charge.
- Provide utility system operators with real-time remote monitoring, control, diagnostics, and management tools to detect and correct problems, minimize station downtime, and enable remote start/stop or proportional scaling of charging sessions for demand response by EV end users via the internet or a smart phone.
- Present integrated web portals connecting to the platform (including through mobile apps for handheld devices) with features for accessing applications by both EV owner and the utility. This will be critical for maintaining the communication and transaction efficiency that is needed for effective "smart charging" workflow.
- Generate defined and on-demand reports on consumer profiles, charging behavior, charging history, revenue and expenditure streams, faults and incidents, etc., for information and planning purposes.
- Upgrade all software and firmware remotely via the EVSE management platform as new capabilities and functionality become available.
- Where applicable, enable a secure interface with utility and third-party demand-side management systems to provide real-time load shedding of any group of charging stations.

- The EVSE nodes may be configured with hardware circuits (and related management software) that support proportionally controlled output power levels to support utility demand response requests. The very advanced systems will work in conjunction with the vehicle's BMS (or adjacent energy storage systems) to allow bidirectional power flow between the battery and the grid, although this capability is farther from general market acceptance and availability.

## 8.4 UTILITY TARIFFS & INCENTIVES

### 8.4.1 RESIDENTIAL

Traditional demand response measures are possible for all classes of residential customers, with the ability for utilities to implement a "Load Shed" command for specific customers enrolled in that utility-sponsored program.

The process is typically accomplished as follows:

- Customer subscribes to utility service program through a Curtailment Service Provider (CSP) which authorizes the utility to send periodic "proportional charge control" signals in return for nominal cash compensation shared between the CSP and the demand response customer.
- Curtailment strategy is executed as required, which triggers an alert to the customer informing them of their EVSE participation.
- Curtailment strategy involves full or partial power transfer limitation for a predetermined period of time.
- On board interval meter captures reduced energy transfer and sends back 15 minute interval confirmation.
- Event is completed (or customer override is received) and full recharge rate is restored to EVSE. Appropriate notification messaging made to customer.

The opportunity to implement residential price responsive programs is also supported by more advanced platforms and programs. Depending on prevailing electric service rate structures in the different regulated markets, the Residential service applications that enable price responsive operation can be seen as follows:

#### *8.4.1.1 Areas without TOU Rates*

Unlike the commercial sector, most utility service areas offer flat rate (i.e. time invariant) electricity rates to residential customers. Although this is slowly changing, as regulators and policy makers see the conservation and load management potential of variable rates, there will be many early adopters of EVs that will not be exposed to a variable price signal to directly or indirectly influence their charging behavior. In this case, customer education is critical (which can be delivered through "multi-channel" methods, including streaming media to the interactive LCD panel on the EVSE) to drive them toward voluntary best-practice charging behavior. This behavior is essentially to program the on-board (either EV or EVSE) charge activation timer to manually delay recharging until late evening hours.

#### *8.4.1.2 Areas with Whole House TOU Rates*

Some of the more progressive utilities have experimented with Time of Use (TOU) (i.e. time variant) electricity rates for their residential class customer accounts. Where this exists, the EV customer can be directly motivated through cost saving opportunities to shift their vehicle recharging activity to the overnight period, where system loads (and corresponding wholesale prices) are likely low. Customer education remains a critical part of achieving best practices here, and at a minimum would require manual programming of the EVSE / EV to activate the deferred charging profile.

The availability of more granular variable rates – for example Day Ahead, or Hour Ahead, hourly market prices – allows a more interesting (and automated) – response to capitalize on lower off-peak rates. In this case, advanced EVSE with more computational and storage power can be programmed to receive and store these changing price tables, and the EV owner can establish specific price thresholds that will trigger the recharging process. EV State of Charge (when this communication standard is approved) will be incorporated into the EVSE in the future, allowing override rules to these charge control settings based on unique user requirements for minimum range and vehicle availability time.

The Whole House rate structures do not allow for differential treatment of the EV recharging process from that of other energy consumption within the home. The EVSE sub meter will still permit data to be integrated by the homeowner to reconcile the portion of their bill associated with the EV. The standards and legislation associated with utility meter data would not allow for the EVSE sub meter to be used in any way for reconciliation of incentives or to reimburse, or even apply specific taxes on, owners of EVs for that portion of their bill related to vehicle refueling.

##### *8.4.1.3 Areas with Separate EV TOU Rates*

Some of the most progressive utilities are currently experimenting with TOU (i.e. time variant) electricity rates that apply only for the EV recharging process. By its nature, this approach requires separate Revenue-Grade metering (or sub-metering) that can isolate this consumption portion for different billing treatment. As with Whole House TOU rates, the EVSE can be automatically configured to respond to live (and changing) price signals delivered by the utility (or a regional power market authority), that will select appropriate price thresholds to activate or inhibit power flow to the EV batteries.

### 8.4.2 Commercial

For the Commercial application, Demand Response takes on a different approach. The traditional "load shed" techniques do not apply, because of the use profile that the commercial recharge session entails. Customers that have engaged their EVs at a commercial recharge station generally cannot be "interrupted" in the traditional sense, because they depend on the added energy to return them home, or to the next destination point. There is also limited ability to "turn down" the recharge rate since there may be subsequent scheduled (or reserved) charging sessions that are coming up next. Note that this is where the behavior will likely deviate between the full BEV owners and the PHEV owners, since the latter could safely resort to gasoline operation as a fallback.

There is however, a much higher "willingness to pay" by the EV owners for the convenience of recharging away from their home or workplace. Therefore, a price recovery mechanism would be the most likely implementation of a Demand Response capability for commercial charging.

This capability may be implemented through the interactive touch screen (and remote consumer messaging) features that the Blink Network enables. If the commercial host is enrolled in a Time of Use electric service plan, their EV recharging service offer can be configured in several ways as follows to pass along the higher rate structures of on-peak charging.

- A Peak Time surcharge can be added to the parking/charging fee for those periods of high electric rates.
- A tiered pricing can be implemented where shorter/faster charge sessions are priced higher than longer/slower charge rates.
- Messaging can be sent to the customer during a recharge session that alerts to a higher rate being invoked, and allows accept (continue charge) or decline (stop charge).

A unique issue with commercial host-based charging arises from the general utilization of utility Demand Charge fees for peak loads that exceed predetermined thresholds. This is particularly acute for the DCFC stations with their high power draw however; it can also arise with the coincident use of multiple Level 2 AC chargers in a concentrated parking area.

With a highly informed consumer market, participant connection at commercial charging locations may take on a more significant role than simply recharging the vehicle for the trip home. Participants may find the benefits of being part of the connected load/supply could encourage the commercial EVSE connection even though battery state of charge is high and the recharge may be more convenient than necessary.

##### *8.4.2.1 Additional Signals Influencing Charging Behavior*

Sophisticated interactive displays, remote monitoring and configuration applications, and robust messaging systems all lay the foundation for some game changing operating and business models. For example, screens that display information on "off peak" charging goals and monthly budget information could well lead to modified behavior based on this information being made highly visible. Another innovative item that is provided is a carbon reduction monitor, which keeps track of the cumulative offset from shifting away from petroleum for electric transportation. Additionally, a continuous cost savings calculation is provided for avoided gasoline expenditures.

In the future, non-price signals will be incorporated that will drive active modification of the EV charging process. For example, if there is surplus wind energy available overnight, this could be signaled to trigger recharging based on that "green" source of power availability. Local distribution equipment signals may be provided as a Smart Grid capability that would coordinate and modify charging rates behind a secondary transformer, mitigating the impact of EV "clustering".

At the extreme of this type of non-price signaling is the near-real-time connection to the Ancillary Services market, through an aggregation service, where the charge (or discharge) rate is continuously adjusted based on frequency regulation signals. Several EVSE vendors and EV Service Providers are actively testing bi-direction power flow through the EVSE and are also directly involved in the communications standards development work that will support this emerging capability.

## 9.0 COST FACTORS

The installation of electric vehicle charge infrastructure requires planning on the macro scale, such as throughout a province, or a large city, and on the micro level, such as a major employer, retailer or residence. The costs associated with installing charge infrastructure can, likewise, be categorized.

This section outlines the key cost factors that are considered when deploying charge infrastructure in a large geographic area or at a residential location. These factors are categorized and outlined below for large-scale deployment programs, Level 1 and Level 2 Residential, Commercial and DCFC installation scenarios.

## 9.1 GEOGRAPHICAL COST FACTORS

EVSE investment made into electric vehicle charge infrastructure deployment across large geographic areas requires planning and data analysis. Deployment across a large city, a large employer or university campus or across a region involves multiple stakeholders.

The key factors to be considered in large scale deployment projects are:

- Consumer Interest
- Employment Density
- Security and Vandalism Risk
- Retail Density
- Traffic Corridors
- Hills/Level Parking for Accessibility
- Proximity to Destinations
- Even Distribution
- Visibility
- Residential Population Density
- Future Growth Areas
- Demographics Ownership Models
- Availability to Drivers
- Reserved Parking
- Level 1, Level 2 or DCFC
- Space Signage

## 9.2 LEVEL 1 AND LEVEL 2 COST FACTORS

Drilled down to the individual charger in a home or small building residential installation scenario, the cost factors involved relate to equipment, labor and ongoing operation of the charging stations. Variables such as whether the installation is a new installation or renovation, Level 1 AC charging, Level 2 AC EVSE or both, the electric panel's location and size, underground conduit and wire, fluctuate the price of the installation for both residential and commercial installation. Other costs like service upgrades, wiring costs, and permit fees also add to the installation price.

The key cost factors that are shared with publicly available charging stations, large building residential, fleet and commercial charging station locations are:

- Appropriate Voltage and Amperage
- Electric Rates/TOU
- Use of Existing Receptacles
- Spare Capacity or Electric Service Upgrades
- EVSE Features and Equipment Costs
- Nearby Power Access
- Concrete/Asphalt – patchwork for trenching
- Transformer Upgrade
- Panelboards – possible subpanels, panel upgrades and additional circuits
- Presence of Spare Capacity
- Above Ground vs. Trenching
- Access – shared or single user
- Shelter
- Lighting
- Barriers/Bollards/Wheel Stops
- Ventilation Requirements
- Distance from EVSE to car plug
- Trenching or Boring
- Lighting

## 9.3 DC FAST CHARGE STATION INSTALLATION COST FACTORS

Many of the same cost factors exist for the installation of DCFC Station. The Voltage and Amperage of the DCFC may require a new electrical service and additional coordination with the local utility company. Factors are the same as Level 1 AC and Level 2 AC installations as listed above in addition to Electric Demand Rates

# 10.0 REGIONAL RESOURCES

## 10.1 CANADIAN UTILITY LINKS

Electric utility companies in Canada are in various states of readiness for the introduction of EVs. Major utilities are listed below, in addition to links that document EV adoption progress, EV factsheets, and associated goals, where available. Links pertaining to green energy developments, smart grid studies and related press releases are also included. Select the link that applies to the electric utility in your area to better understand their EVSE installation policies. In circumstances where there is no current infrastructure development, use the links to contact your utility directly for further information on how to proceed.

**Table 10-1 Canadian Utility Links**

| | |
|---|---|
| Alberta Power Limited | No website |
| Antigonish Electric Utility | http://www.townofantigonish.ca/elec.html |
| ATCO Electric | http://www.atcoelectric.com/ |
| BC Hydro | http://www.bchydro.com/ev<br>http://www.bchydro.com/about/our_commitment/sustainability/plugin_vehicles.html |
| Berwick Electric Light Commission | http://www.berwickelectric.com/ |
| Bruce Power | http://www.brucepower.com/ |
| Bullfrog Power | http://www.bullfrogpower.com/<br>https://www.bullfrogpower.com/business/factsheets/EV_fact_sheet.pdf<br>http://www.bullfrogpower.com/about/vision.cfm |
| Burlington Hydro | http://www.burlingtonhydro.com/<br>http://www.burlingtonhydro.com/your-community/projects.html |
| Canso Electric Light Commission | No website |
| Churchill Falls(Labrador) Corporation Limited | http://www.cflco.nf.ca/ |
| Cooperative Regionale d'electricite de Saint-Jean-Baptiste de Rouville | http://www.coopsjb.com/ |
| Emera | http://www.emera.com/en/home/default.aspx |
| Enersource Hydro Mississauga | http://www.enersource.com/Pages/index.aspx<br>http://www.enersource.com/about-enersource/MediaRoom/Enersource Drives into the Future.pdf |
| ENMAX | http://www.enmax.com/home.html |
| ENWIN Utilities | http://www.enwin.com/ |
| EPCOR | http://www.epcor.ca/en-ca/Pages/default.aspx |
| FortisAlberta | http://www.fortisalberta.com/ |
| Fortis BC | http://www.fortisbc.com/Pages/default.aspx |
| Greater Sudbury Hydro Inc | http://www.sudburyhydro.com/index.htm |
| Green Programs | http://www.sudburyhydro.com/green_room_programs.htm |

| | |
|---|---|
| Guelph Hydro | http://www.guelphhydro.com/ |
| Horizon Utilities | http://www.horizonutilities.com/HHSC/html/includes/default.jsp |
| Hydro Ottawa | https://www.hydroottawa.com/<br>http://www.hydroottawa.com/residential/saveonenergy/community/chevy-volt/ |
| Hydro-Quebec | https://www.hydroottawa.com/<br>http://www.hydroquebec.com/transportation-electrification/ |
| Lake Front Utilities | http://www.lakefrontutilities.on.ca/ |
| Lower Churchill Project | http://www.nalcorenergy.com/lower-churchill-project.asp |
| Lunenburg Electric Utility | http://www.explorelunenburg.ca/electricity.html |
| Mahone Bay Electric Utility | http://www.townofmahonebay.ca/town-services/electric-utility.html |
| Manitoba Hydro | http://www.hydro.mb.ca/<br>http://www.hydro.mb.ca/environment/electric_vehicles.shtml |
| Maritime Electric | http://www.maritimeelectric.com/ |
| NB Power | http://www.nbpower.com/Welcome.aspx?lang=en |
| Newfoundland and Labrador Hydro | http://www.nlh.nl.ca/ |
| Nefoundland Power Inc. | https://secure.newfoundlandpower.com/ |
| Northanland Utilities (NWT) Limited | http://www.northlandutilities.com/ |
| Northanland Utilities (Yellowknife) | http://www.northlandutilities.com/ |
| NorthWest Territories Power Corporation | http://www.ntpc.com/ |
| Nova Scotia Power | https://www.nspower.ca/en/home/default.aspx<br>http://shareready.nspower.ca/ |
| Nunavut Power | http://www.nunavutpower.com/home/ |
| Oakville Hydro | http://www.oakvillehydro.com/<br>http://www.oakvillehydro.com/ohesi/green_power_program.aspx |
| Ontario Power Generation | http://www.opg.com/index.asp |
| Power Stream | http://www.powerstream.ca/app/pages/HOME.jsp<br>http://www.powerstream.ca/app/pages/news110728.jsp |
| Qulliq Energy | http://www.nunavutpower.com/home/ |
| Rideau St-Laurence Power Distribution | No Website |
| Riverport Electric Light Commission | http://www.riverport.org/businesses/riverportelectric/riverportelectric.html |
| Saint John Energy | http://www.sjenergy.com/cms/ |

| | |
|---|---|
| Saskatoon Light & Power | http://www.saskatoon.ca/DEPARTMENTS/Utility Services/Saskatoon Light and Power/Pages/default.aspx<br>http://www.saskatoon.ca/DEPARTMENTS/Utility Services/Environmental Services/climatechange/Pages/default.aspx |
| SaskPower | http://www.saskpower.com/ |
| Thunder Bay Hydro | http://www.tbhydro.on.ca/ |
| Toronto Electric Light Company | http://www.hydroone.com/Pages/Default.aspx |
| Toronto Hydro | http://www.tbhydro.on.ca/ |
| TransAlta Corporation | http://www.transalta.com/<br>http://www.transalta.com/sustainability/environment/greenhouse-gas-rfps |
| Veridian Connections | http://www.veridian.on.ca/ |
| Waterloo North Hydro, Inc | http://www.wnhydro.com/ |
| Yukon Electrical Company | http://www.yukonelectrical.com/ |
| Yukon Energy Corporation | http://www.yukonenergy.ca/ |

## 10.2 CANADIAN PROVINCIAL LINKS

Canadian Provinces are in varying degrees of readiness for EV and EV Infrastructure deployment. Listed below are links to each Provincial Government. These websites (where available) inform about the EV policies, factsheets, Smart Grid developments, and related progress. To gather information regarding the EV policies in a particular province, click on the link provided next to the province name. In cases where EV information is currently unavailable, please use the links provided to contact your Province directly with how to proceed with EVSE installation, and further EV inquiries. As the adoption of EV technology increases over time, additional policies and developments will occur in areas that do not currently have these programs in place.

**Table 10-2 Canadian Provincial Links**

| | |
|---|---|
| Alberta | http://alberta.ca/index.cfm<br>http://www.energy.alberta.ca/Electricity/pdfs/SmartGrid.pdf |
| British Columbia | http://www2.gov.bc.ca/http://www2.gov.bc.ca/<br>http://www.empr.gov.bc.ca/RET/TransportationPolicyPrograms/plug-in/Pages/default.aspx<br>http://www.livesmartbc.ca/incentives/transportation/index.html |
| Vancouver Site | http://www.veva.bc.ca/home/index.php |
| Manitoba | http://www.gov.mb.ca/<br>http://www.gov.mb.ca/iem/energy/initiatives/hybridvehicles.html<br>http://www.gov.mb.ca/iem/energy/transportation/images/elec_vehicle_road_map.pdf |
| New Brunswick<br>Climate Change Policy | http://www2.gnb.ca/content/gnb/en.html<br>http://www.gnb.ca/0009/0369/0015/0002-e.asp |
| Newdoundland and Labrador | http://www.gov.nl.ca/ |
| Northwest Territories | http://www.gov.nt.ca/ |
| Nova Scotia | http://www.gov.ns.ca/ |
| Nunavut | http://www.gov.nu.ca/ |
| Ontario | http://www.ontario.ca/<br>http://www.mto.gov.on.ca/english/dandv/vehicle/electric/index.shtml |
| Ottawa | http://evco.ca/site/node |
| Durham Site | http://www.durhamelectricvehicles.com/ |
| Prince Edward Island | http://www.gov.pe.ca/ |
| Quebec | http://www.gouv.qc.ca/portail/quebec/pgs/commun/<br>http://www.vehiculeselectriques.gouv.qc.ca/<br>http://www.efficaciteenergetique.mrnf.gouv.qc.ca/en/my-driving/<br>http://www.communauto.com/electrique/index_ENG.html |
| Saskatchewan | http://www.gov.sk.ca/ |
| Yukon | http://www.gov.yk.ca/ |

## 10.3 CANADIAN NATIONAL LINKS

As implementation of EV technology in Canada is increasing, organizations dedicated to promotion and education are being established. Some of the examples of such organizations are listed below. Please refer to the links provided for general EV information, location of public infrastructure networks, and EV progress throughout Canada. As developments in EV technology and adoption rates increase, many new resources for prospective EV owners will become available.

**Table 10-3 Canadian National Links**

| | |
|---|---|
| Electric Vehicle Society | http://www.evsociety.ca/index.php<br>http://www.evsociety.ca/links.php |
| Electric Mobility Canada (EMC) | http://www.emc-mec.ca/eng/index.php |
| The Electric Circuit | http://www.theelectriccircuit.com |
| ecoTransport | http://www.ecoaction.gc.ca/ecotransport/index-eng.cfm |
| EV Canada | http://www.evcanada.org/ |
| Canada's Electric Vehicle Technology Roadmap | http://canmetenergy.nrcan.gc.ca/transportation/hybrid-electric/329 |
| Canadian Energy Efficiency Alliance (CEEA) | http://www.energyefficiency.org/index.html |
| Transport Canada: Electric Vehicle Primer | http://www.tc.gc.ca/eng/programs/environment-etv-evprimer-eng-1994.htm |

## 10.4 CANADIAN ELECTRIC CODES AND STANDARD LINKS

**Table 10-4 Canadian Electric Codes and Standard Links**

| | |
|---|---|
| CSA Group (CSA) | http://www.csa.ca/cm/ca/en/home |
| Institute of Electrical and Electronics Engineers (IEEE) Canada | http://www.ieee.ca/index.htm |
| National Building Code of Canada (NBC) | http://www.nationalcodes.nrc.gc.ca/eng/nbc/index.shtml |
| National Energy Code of Canada for Buildings (NECB) | http://www.nationalcodes.nrc.gc.ca/eng/necb/index.shtml |
| National Fire Code of Canada (NFC) | http://www.nationalcodes.nrc.gc.ca/eng/nfc/index.shtml |
| Society of Automotive Engineers (SAE) International | http://www.sae.org/ |
| Standards Council of Canada (SCC) | http://www.scc.ca/ |
| Underwriters Laboratory of Canada (ULC) | http://www.ul.com/canada/eng/pages/ |

## 10.5 CANADIAN EV OEM LINKS

The development and release of EVs in Canada is expected to increase significantly between 2012 and 2013. In 2012 the Nissan LEAF and the Chevrolet Volt will be released throughout North America. The next major release within the next year is the Toyota Prius PHEV. Listed below are links to the Original Equipment Manufacturers (OEMs) that are developing, testing, and studying EVs and PHEVs in Canada. These vehicles have either been released as of 2012, or are coming very soon.

**Table 10-5 Canadian EV OEM Links**

| | |
|---|---|
| Chevrolet Volt | http://www.gm.ca/gm/english/vehicles/chevrolet/volt/overview |
| Ford Focus Electric | http://www.ford.ca/app/en/fo/buildandprice.html |
| Mitsubishi i-MiEV | http://www.mitsubishi-motors.ca/en/i-miev/ |
| Nissan LEAF | http://www.nissan.ca/vehicles/ms/leaf/en/index.aspx |
| Smart fortwo | http://www.thesmart.ca/ |
| Tesla Roadster | http://www.teslamotors.com/canada |
| Toyota Prius PHEV | http://www.toyota.ca/cgi-bin/WebObjects/WWW.woa/28/wo/Home.Environment-xDw76uOHmqCAEMqLZ6BQ8w/5.9?e510000e%2ehtml |

## 10.6 CANADIAN EVSE LINKS

EV owners have a variety of charging needs. While some EVSE are designed to simply charge vehicles, others are developed for potential Smart Grid application integration. The EVSE listed below have been certified by the ULC, and more information is available at the links provided. With a variety of products being released, Canada has the potential for a diverse EV charging infrastructure network.

**Table 10-6 Canadian EVSE Links**

| | |
|---|---|
| Aerovironment EVSE-RS | http://evsolutions.avinc.com/ |
| Clipper Creek CS-40 | http://www.clippercreek.com/products.html |
| Coulomb CT500, CT2000, CT2021, CT2025, CT2100 | http://www.coulombtech.com/products-chargepoint-stations.php |
| Eaton EVSE | http://eatoncanada.ca/ResidentialProducts/ElectricVehicleChargingSolutions/ |
| ECOtality Blink EVSE | http://www.blinknetwork.com/ |
| GE Wattstation | http://www.geindustrial.com/products/static/ecomagination-electric-vehicles/index.html |
| Leviton EVR-Green Series | http://www.leviton.com/OA_HTML/SectionDisplay.jsp?section=37668&minisite=10251 |

## 10.7 UNITED STATES RESOURCE LINKS

There are many organizations established in the United States for the promotion and education of Electric Vehicles and related technology. Additionally, these U.S. organizations may have launched similar programs in Canada. Established EV charging networks and Government implemented programs supply interactive maps of EVSE locations. The links below are examples of resources commonly used in the U.S. for EV enthusiasts and individuals interested in learning more about EVs.

**Table 10-7 United States Resource Links**

| | |
|---|---|
| Alternative Fuels & Advanced Vehicles Data Center Map (AFDC) | http://www.afdc.energy.gov/afdc/locator/stations/ |
| Blink Network Map | http://www.blinknetwork.com/locator.html |
| ChargePoint Network | http://www.chargepoint.net/find-stations.php |
| Electric Auto Association | http://www.electricauto.org/ |
| Electric Drive Transportation Association | http://www.electricdrive.org/ |
| Electric Power Research Institute (EPRI) | http://et.epri.com/ |
| Electric Vehicle Safety Training | http://www.evsafetytraining.org/ |
| Go Electric Drive | http://goelectricdrive.com/ |
| Plug In America | http://www.pluginamerica.org/ |
| PlugShare | http://www.plugshare.com/ |
| Rocky Mountain Institute | http://www.rmi.org/ |
| Recargo | http://www.recargo.com/ |

## 11.0 LESSONS LEARNED

The deployment of EV charge infrastructure to date has been limited in Canada; however, there are large deployment projects underway in various countries from which preliminary lessons learned have been identified. As EV market penetration increases, best practices and lessons learned will continue to grow as users and implementers identify and address market conditions. This section will identify those lessons learned and identified for the deployment of charge infrastructure in the existing pilot projects, including The EV Project.

## 11.1 SITE SELECTION FOR THE CHARGING SITE HOST

Several factors need to be considered when placing an EVSE on retail or other publicly available sites. Those who are sincerely attempting to motivate the public to purchase EVs may wish to place the EVSE in preferred parking locations near the facility entrance. However, experience has shown that this can actually have a negative effect. In the early days of EV adoption, such EVSE locations may be frequently vacant giving the visible impression that EVs are not being adopted. Such locations may actually frustrate ICE drivers who note that they do not get the preferential treatment. In addition, placing the EVSE near the facility entrance often places it further from the electrical source which then increases the installation costs. Therefore, it is more desirable to place the EVSE at a location near an electrical source which may not necessarily be considered the preferred parking space.

When installing the EVSE, it is more cost efficient to use landscaped areas for the conduit routes where available. Coring between the levels in a parking garage can be avoided by using an electrical panel on the existing floor only. Installing wall mounts vs. pedestal EVSEs can also help to reduce the installation costs.

## 11.2 ACCESSIBILITY REQUIREMENTS

Section 7.2 addresses Accessibility Requirements. It was found when preparing for installations in the United States for The EV Project that there were no national guidelines for the installation of accessible equipment. Consequently, some EVSE suppliers and local jurisdictions approving permits ignored the subject. Others wishing to be fully compliant with strict interpretations of potential requirements, created conditions where the installation of EVSE would be impossible or so cost prohibitive that no host would agree to install. As a result, several organizations initiated studies to consider what recommendations should be presented for consideration. Most of these studies and recommendations did not consider the cost to the host for compliance. In most cases where a retrofit of existing facilities is undertaken, it is acceptable to forego improvements for accessibility if it can be shown that the cost of compliance would exceed 20% of the improvement project costs. Such consideration should be applied to help promote the availability of publicly available EVSE.

## 11.3 SIGNAGE

Encouraging the adoption of EVs can be added by the availability of publicly available EVSE. Publicly availability of the EVSE means that it should be available to the PEV driver when he/she is looking for a place to recharge. Signage should be used for "wayfinding" (locating) the EVSE and for usage regulation (controlling charging stall access). It was found that the selection of a common symbol is important for the public education and recognition both in wayfinding and in usage regulation. In the United States, an interim symbol has been selected by several states but not all states have concurred. Section 3.5 identifies the symbol that has been selected for Canada. This symbol should be used on streets and highways as well as at the parking stall where the EVSE is installed.

Next, it is important that the EVSE is available to the EV driver when searching for an available station. It has been found that without regulation, ICE vehicles will not recognize the EV symbol as restrictive and will park in the designated locations. This is particularly true when the parking location is near the facility entrance. Signs that indicate the parking stall is to be used for "EV charging only" should be considered to reduce non EV parking.

Note that the sign does not indicate EV Parking only, since providing a place for EVs to park is not the incentive. It is to provide a place for them to charge. An EV that is not charging should not be taking up the space.

This also brings up the question of how much regulation to provide. While no municipality is known to have implemented punitive measures for non-EV charging, some have considered penalties so severe as to be a disincentive for even EVs to park at these locations. This would guarantee that the space remains vacant which again is a deterrent to the adoption of EVs by the public.

## 11.4 INSTALLATION QUOTES

It has been found that requesting two quotes by the electrician/ contractor before installing electric vehicle charge infrastructure can be a benefit. Quotes should give the price estimation on the preferred location as well as a secondary location for the installation. Quotes should also cover the pricing for obtaining permits. When reviewing the quote ensure the project timeline considers the permitting and inspections required. Installation of residential EVSE is very similar to the installation of a household appliance. Electrical contractors should be well trained in the particular differences for the EVSE.

## 11.5 RETROFITTING EXISTING SITES

When retrofitting the existing sites, consider oversizing the conduit size and wire size to allow for additional charging stations. This will ease the cost of future infrastructure expansion.

## 11.6 ZONAL COMPLIANCE

Every province and their regions have different zoning requirement and regulations. Before installing charge infrastructure, check with the provincial government or local code authority for zoning considerations to ensure zoning compliance. Every part of the installation should meet the requirements of that particular zone or province.

## 11.7 PERMIT COSTS

The EV Project installed EVSE in many different jurisdictions around the United States. Each jurisdiction provided pricing for the electrical permit. In some locations the permit was reasonably based upon similar work such as household circuits for electrical clothes dryer. Other jurisdictions recognized that EVSE installation was a new source of revenue for the jurisdiction and charged fees that were up to 10 times as much as others. Such fees add to the cost of installations and may be a discouragement for potential EV adaptors.

## 11.8 EVSE INFRASTRUCTURE PLANNING

Various approaches to EVSE infrastructure planning are being developed. Some are using very rigorous geographic information systems (GIS) approach to finding the ideal locations based upon traffic flows, land use planning, employment locations, EV buyer demographics, etc. Others are simply looking to find charging site hosts willing to install an EVSE. Municipalities that are planning to install public infrastructure should consider hiring consultants to support this effort.

## 11.9 SITE SELECTION MOTIVATION

It has been found that selecting the locations for publicly available EVSE can be a point of disagreement among those desiring to encourage EV adoption. The motivation for the selection of a point needs to be considered. For example, if the motivation is to provide a highly visible public location that can be used as a public symbol, it may not be the best location for a highly utilized and accessible unit. If the motivation is to utilize access fees to assist in offsetting the costs of the equipment and installation, high utilization is desired and the long-term parking location at an airport is not a good selection. A park-and-ride location where residents park their vehicles to complete the commute on public transportation may also not be an ideal location if high utilization is required.

Generally such locations are relatively close to the residents' home so charging is not required and only one vehicle per day can access the EVSE. This may be a good site if the promotion of mixed transportation modes is being encouraged. This is not to say that any one motivation is more important than another but understanding the motivations can prevent disagreements.

Employers may wish to incentivize their employees to adopt EVs and provide free charging. However, they should review their personnel policies to ensure that they are not unfairly providing benefits to certain employees over others.

## 11.10 TIME OF USE INCENTIVES

It has been suggested that providing off-peak charging incentives through electric utility TOU tariffs can change PEV driver charging behavior. The EV Project specifically analyzed data from the project to check for this result. Evaluation required identification of two conditions: charging availability – that is, when is the EVSE available for charging and charging demand – that is, when available, it is used for charging.

Data from the fourth quarter, 2011 was selected and charge availability was graphed for two separate markets in the EV Project: San Francisco, California and Nashville, Tennessee. It was clear that weekend and weekday charging patterns are different but most TOU rates apply during the weekday so that criteria was selected.

For these two markets, the Daily Charging Availability of all EVSE was plotted on the same graph of the daily routine as a percentage of all residential EVSE in the market area.

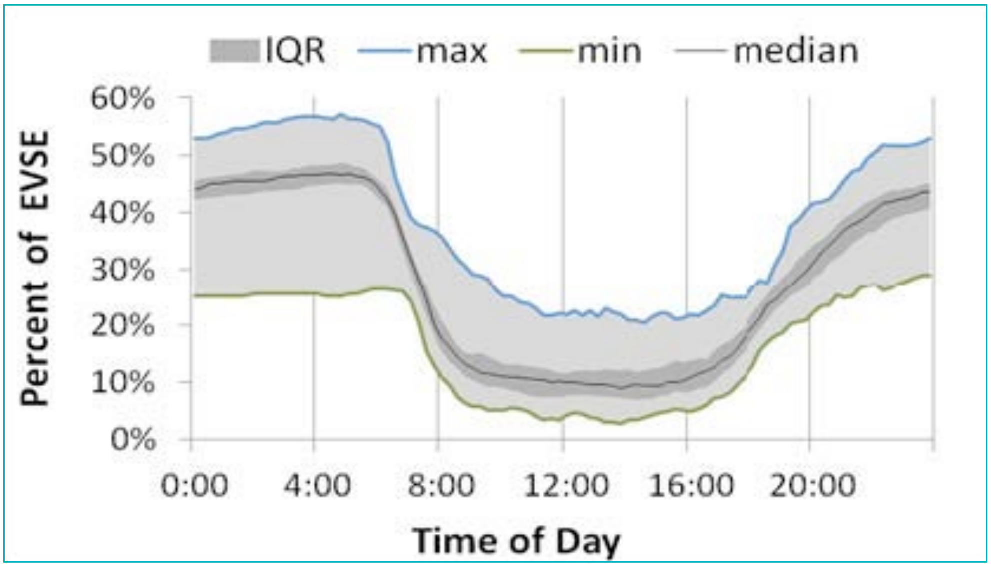


**Figure 11-1**
Weekday Residential EVSE Availability in Nashville, TN

Interpretation of figure 11-1 would show that at 4 a.m., at no time during the quarter were there less than approximately 25% of the residential EVSE in operation nor were there more than approximately 55% of the residential EVSE in operation. The median value was approximately 45%, meaning that there were the same numbers of data points above and below this median value. The Inner Quartile Region (IQR) would be the 25% to 75% of the variance. Presenting the median value is most descriptive because it can remove the highly variable points such as might occur as a result of the Thanksgiving or Christmas holidays.

Generally speaking, this graph (figure 11-1) shows the typical EV driver behavior in plugging in the EV when arriving home at night starting at about 5 p.m. and increasingly the number of plug-in events increases to about midnight. Then the unplug events begin about 6 a.m. as people go about their daily routine.

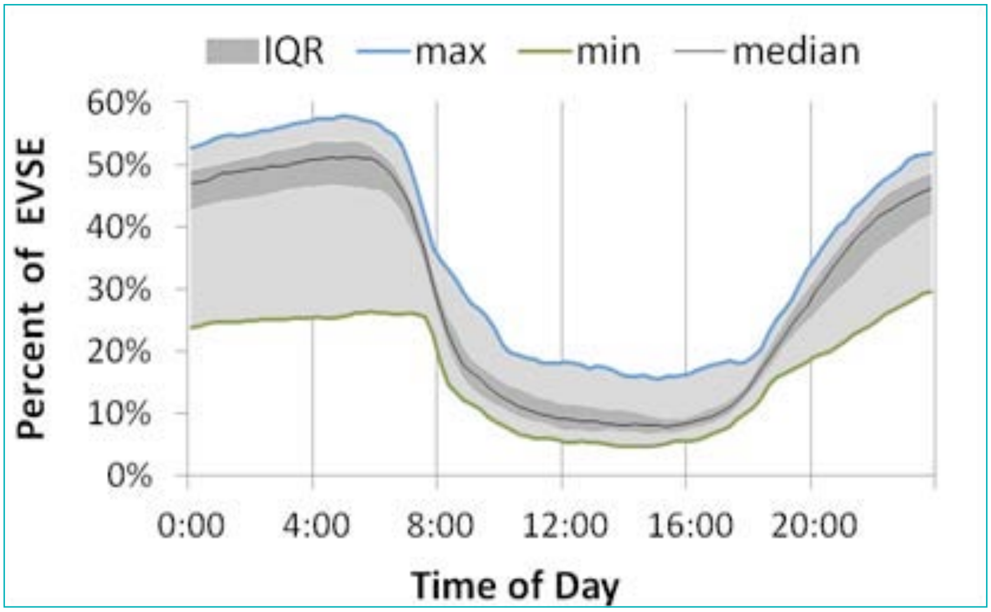


Figure 11-2
Weekday Residential EVSE Availability in San Francisco

The graph shown in figure 11-2 of San Francisco shows a consistent EV driver behavior with that of Nashville. In general, the EV is connected and the residential EVSE is available to provide power in both locations in the same manner.

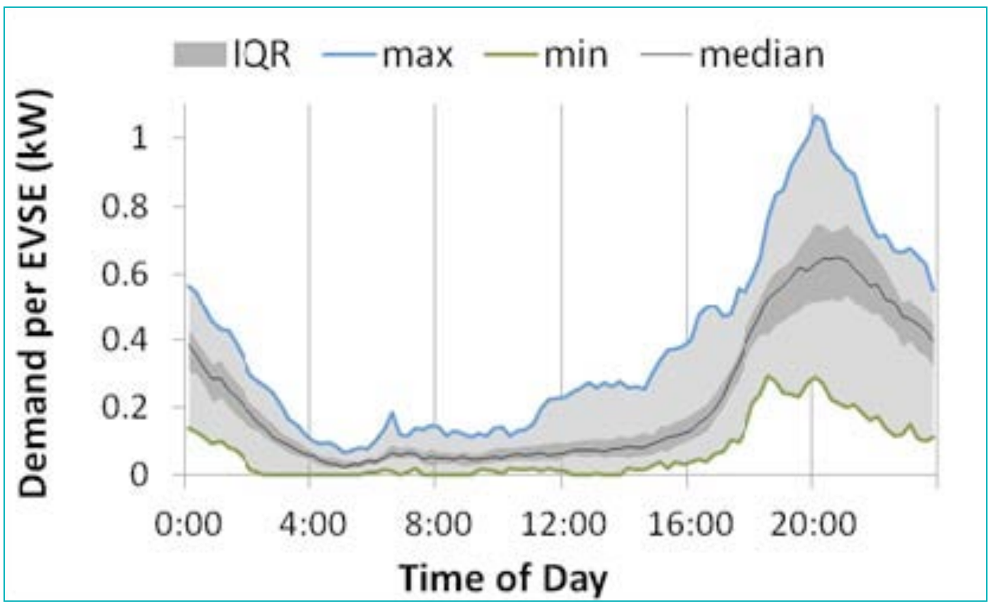


Figure 11-3
Weekday Residential EVSE Charging Demand Nashville

The charging demand curve follows very closely the availability curve in figure 11-3 indicating that for most EV drivers, the charge commences as soon as the vehicle is connected. Some of the first to connect have already completed their charge when the later vehicles connect.

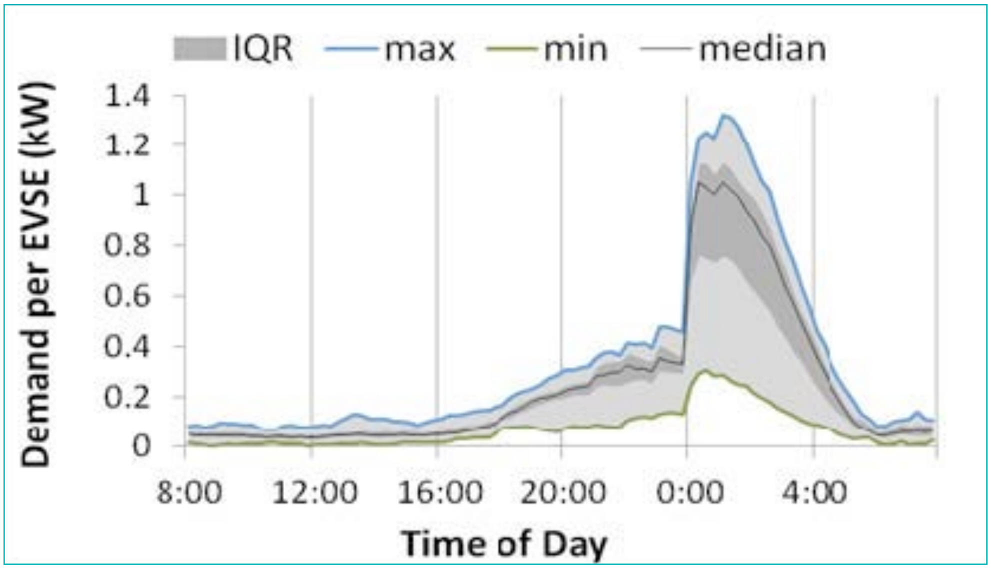


**Figure 11-4**
Weekday Residential EVSE Charging Demand San Francisco

Figure 11-4, the charging demand curve for San Francisco, has a dramatic increase at midnight so the scale was adjusted to more clearly see this effect. While the EVs were plugged in at the same time of the day as those in Nashville, the actual charge events didn't start until midnight. The significant difference between Nashville and San Francisco is that the electric utility in San Francisco has TOU rate that incentivizes people to charge after midnight. This preliminary information would imply that the TOU rate has a significant effect in driving EV driver behavior.

This also points out additional issues for consideration by the utilities who may have a desire to mitigate this significant peak during the off-peak times.

The EV Project is developing a significant amount of Lessons Learned papers. The Project completes in December 2013 so significant data on EV owner behavior is anticipated. Results will be posted at www.THEEVPROJECT.com.

## 11.11 DCFC POWER

One significant lesson learned in the United States from The EV Project is that there can be substantial differences between the rate structures of many electric utilities. Where there are local concerns over power production capabilities or costs, there are typically rate structures that seek to limit the peak demand that any user may have. That is, a separate charge may be assessed to a facility for the peak demand that it may draw above pre-set threshold. These demand charges are typically assessed for the entire month's billing based upon the peak in any 15 minute interval. A higher power DCFC (i.e. 50 kW) will likely trigger a peak demand charge for a facility that can cost the host hundreds of dollars for the month. If this fee can be absorbed across many charge events, the effect is not as significant as that experienced in the early adoption days when utilization is low. These demand charges can be a significant dis-incentive for would-be hosts. Consequently, EVSE suppliers and electric utilities are considering ways to mitigate this cost.

In the interest of increasing EV adoption, the regulatory authorities may consider providing special revisions for DCFC to exempt them from the demand charge. However other considerations are also possible. EVSE suppliers may revise the charge algorithms to limit the charge power to less than the threshold. Others may ensure that the peak demand does not average over the threshold during the 15 minute period by regulating how long the charge at the high level is sustained. Others are considering the addition of battery storage. The battery storage provides a source of energy to allow the demand from the utility to remain below the threshold during the charge and the battery is recharged after the EV charge event is completed. These remedies can result in longer recharge times and/or higher cost to the project.

## 11.12 DCFC INSTALLATION

While the process for installing a DCFC is similar to that of a Level 2 AC EVSE, in practice, the process is more time consuming and costs are higher. DC Level 1 Fast Chargers can vary in output power up to 40 kW. DC Level 2 Fast Chargers vary in output from 40 kW to 100 kW. In The EV Project, DCFC of 60 kW power are being installed. The equipment is required to have the power conversion equipment to convert the AC power to DC and also to dispense that DC energy to the vehicle. In general, the larger the output power, the larger and more costly the equipment. The Blink model used in The EV Project provides this in two separate units: Grid Power Unit (GPU) and Charger Dispenser Unit (CDU). An installation process for DCFC is shown in figure 11-5 below.

**Figure 11-5**
DCFC Installation

The two unit design was selected to separate the user interface in a method that allows for advertising revenue and two charge ports. (Advertising will be discussed in the DCFC Business model section.) This adds a marginal amount to the overall installation but all DCFCs will share similar installation requirements.

The typical power requirements of this charger are 200 Amps at 208 VAC to 71Amps at 600 VAC. More typically, the unit is installed with a maximum current of 89 Amps at 480 VAC. This service has not been found available in most EV Project host sites. A new separate electrical service has been required. This adds installation costs plus the new monthly costs associated with the new service. This may be the best choice however if the EVSE supplier or other third party is to retain ownership or operational control.

The trenching and recovery work is essentially the same for both Level 2 and DCFC. However, the site permitting requirements have generally required more Architect and Engineer (A&E) support with more detailed site drawings and calculations. In the case of the Blink DCFC, the advertising screen required another plan review with the Authority Having Jurisdiction (AHJ) for outdoor advertising.

Locating the DCFC in the parking lot is similar to that for AC Level 2. However there is a slight distinction when considering accessibility requirements. With AC Level 2 EVSE, it can be expected that the charging is provided as a convenience to the driver while they are visiting the site facility. That is, the primary purpose of the visit is for the facility; not to charge. Thus all the accessibility requirements are important: 1) being able to exit the vehicle and approach the EVSE; 2) use the accessibly designed EVSE; 3) complete the charger connection with the vehicle; 4) provide an accessible route to the facility. For DCFC, the primary purpose of the visit is for the charge since the rapid nature of the charge is desirable. While charging, the visit to the facility may be a convenience. Thus the fourth design consideration; the accessible route to the facility, may not be required. An accessible route that meets all the slope and obstacle requirements can add significant cost to the project.

The EV Project has found that costs associated with the installation of DCFC typically range from $15,000 to $25,000. As with Level 2 AC, costs can be reduced if trenching is done through landscaped areas rather than concrete or asphalt. Close proximity to the electrical source can also keep costs down.

## 11.13 AC LEVEL 2 WITH DCFC

The DCFC can serve several purposes including a backup to the local community AC Level 2 infrastructure grid as well as providing range extension along transportation corridors. The EV Project has found that at times, the site can support one of these objectives as well as support the local AC Level 2 grid with the presence of the AC Level 2 EVSE. Thus, placing an AC Level 2 EVSE near the DCFC on sites is becoming common. The costs for AC Level 2 installation are reduced when installed at the same time as the DCFC.

## 11.14 DCFC BUSINESS MODELS

Within the last year, several new models for DCFC have been announced and are in various stages of development and test. Most providers have not publicly announced the cost of the unit but costs can be significantly higher than the AC Level 2 EVSE. Consequently, new business models are in development for the ownership, operation and maintenance of DCFC. The EV Project has found that while charging site hosts may be motivated to have the unit on their property, they would prefer not to purchase or operate the unit. Consequently, ownership models are being developed around the EVSE supplier or other third party operator managing the DCFC.

As another potential revenue stream for the charging site host or managing third party, advertising is a common design feature for some DCFC. As seen in many gasoline stations, the advertising screen can run pre-set ads or be tailored for the host's own advertising. The charging unit itself can be wrapped in an advertising banner to help defray costs.