CANADIAN EV INFRASTRUCTURE DEPLOYMENT GUIDELINES 2013

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REPORT FOR

CEATI INTERNATIONAL Inc.
1010 Sherbrooke Street West, Suite 2500
Montreal, Quebec,
Canada H3A 2R7
Website: www.ceati.com

STRATEGIC OPTIONS FOR SUSTAINABLE POWER GENERATION INTEREST GROUP (SOIG)

CEATI REPORT No. T112700-0536

CANADIAN EV INFRASTRUCTURE DEPLOYMENT GUIDELINE

Prepared by
ECOtality North America
Phoenix, Arizona, USA

Principal Investigator
Stephen Schey

Sponsored by
BC Hydro Manitoba Hydro Hydro One
Natural Resources Canada

Technical Advisor Hal LaFlash, BSME, MBA

January 2013

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ABSTRACT

This report provides the essential information and resources required to implement EV charge infrastructure. The report touches various topics, e.g., different power requirements for Level 1 and Level 2 AC chargers, DC Fast Charging Equipment, EV 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 to be distributed as an online resource to aid in the proper deployment of EV charge infrastructure and 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 EV consumers and charge infrastructure users. Safety issues, disability requirements and station ownership topics have also been touched upon. An overview of the key cost factors for the installation of EV charge infrastructure and the lessons learned have also been provided in the guideline. The objective of the Canadian EV Charge Infrastructure Deployment Guideline is to educate the reader on installation considerations and provide the necessary information and resources to properly implement EV charge infrastructure.

ACKNOWLEDGEMENTS

This report was prepared under CEATI International Agreement No. T112700-0536 with the sponsorship of the following participants of CEATI's Strategic Options for Sustainable Power Generation Interest Group (SOIG):

BC Hydro	BC	Canada
Hydro One	ON	Canada
Manitoba Hydro	MH	Canada
Natural Resources Canada, CanmetENERGY	ON	Canada

The investigators are grateful to CEATI for the opportunity to work on this interesting issue. The constant support and guidance by the CEATI Technology Coordinator Hal LaFlash, as well as Project Monitors BC Hydro, Hydro One, Manitoba Hydro and Natural Resources Canada, CanmetENERGY, was greatly appreciated by the investigators.

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 comment 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.

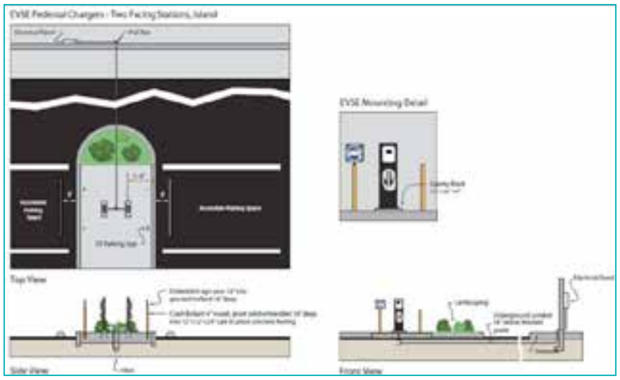

Figure 2
Sample AC Level 2
Installation Plan

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 well references the local codes and standards required during installation as well as providing 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.

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 Vehicl
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 increase 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 (EV) 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 in the planning effort behind the adoption of EV technology. An understanding of the terminology, the recharging types, the basic technology involved, the types of vehicles expected to require charging, the relevant electrical codes and related standards and the 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 EV 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 EV 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 EV charge infrastructure that incorporates the Lessons Learned from the several major projects underway in North America as well as the interactive stakeholder working sessions. The target audience in this report varies from civic and campus planners, facility engineers, architects, developers, operation personnel and large building owners to individual and fleet EV consumers and charge infrastructure users.

1.1 CHARGING POWER

EV 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.

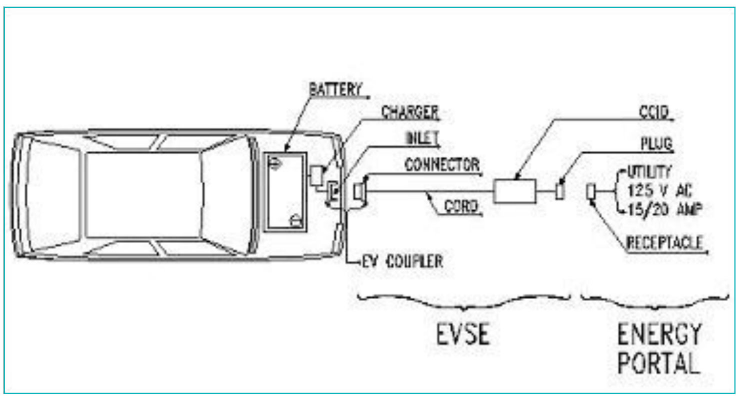

Figure 1-1
Charging diagram

The EV 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 EV 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 of cords, connector and attachment plugs, to all other fittings, devices, power outlets or apparatus that are installed specifically for the purpose of delivering energy to an EV. 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 EV charging. Level 1 AC, Level 2 AC, and DC Fast Charging (DCFC) 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]

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

- Battery size
- Charging option selected: Level 1 AC, 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 AC (120 V)

Level 1 AC charging uses a standard 120 VAC branch circuit that is the lowest common voltage level found in both residential and commercial buildings. Typical amperage ratings for these receptacles are 15A or 20A. A Level 1 AC cord set (120 VAC, 15/20A), as shown in Figure 1-2, is provided by many EV manufacturers with the sale or lease of an EV.

Figure 1-2
Level 1 Cord Set

[1] "EV 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
J1772 Connector
and Inlet

Level 1 AC charging typically uses a standard 3 prong electrical outlet (5-15R/20R) as shown below in Figure 1-4. The cord set has a standard 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 J1772 Standard shown in Figure 1-3 above.

Level 1 AC 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 20A circuit would be 16A.) The dedicated circuit requires the use of Single 5-20R receptacle shown as item number 3 in Figure 1-4 below.

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

1.1.2 Level 2 AC (Greater than 125V or greater than 20A)

Level 2 AC charging specifies a 240V, single phase branch circuit. The J1772 approved connector at the vehicle end allows for current as high as 80A AC (100A rated circuit). However, current levels that high are rare and a more typical rating would be 40A AC, which allows a maximum current of 32A. Figure 1-5 diagrams Level 2 AC 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 can plug into a 240V receptacle similar to a residential clothes dryer plug or alternatively be hard wired to the premises. Although Level 2 AC charging units typically feature cords that connect directly with the vehicle, as shown in Figure 1-2, work is underway to develop cordless charging systems to wirelessly deliver power to the vehicle. One example is a floor mounted transmission module that delivers power to a receiver mounted on the bottom of the vehicle chassis.

When connected to a Level 2 AC EVSE, 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, a vehicle that has a maximum charging capability of 3.3 kW will only receive 3.3 kW even though it may be connected to an EVSE capable of delivering 6.6 kW.

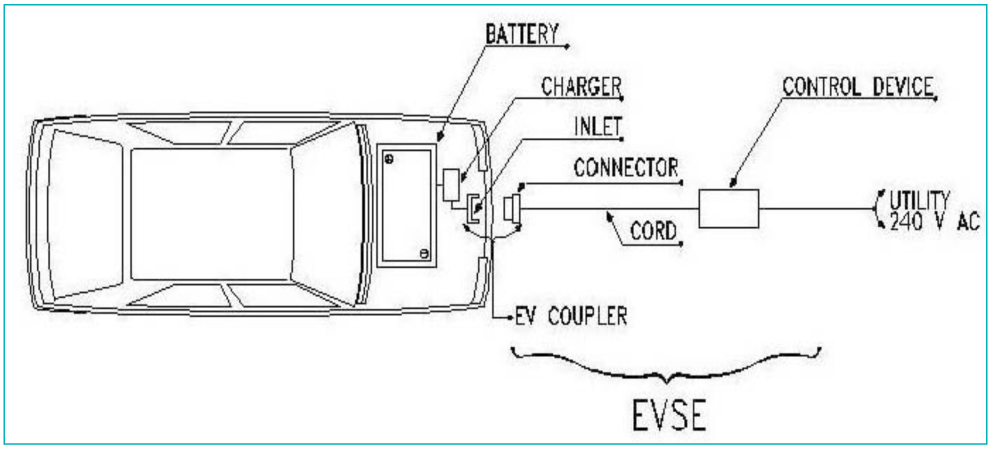

Figure 1-5
Level 2 Charging Diagram

Figure 1-6
Level 2 Charging

1.1.3 DC Fast Charging

DC Fast Chargers provide the fastest charging times and typically use an off-board charger to provide the AC to DC conversion. The vehicle's on-board battery management system (BMS) controls the off-board charger to deliver DC directly to the battery. Previously identified as Level 3 charging by the Infrastructure Working Council (IWC), The Society of Automotive Engineers (SAE) has redefined this as DC Level 2 charging. Figure 1-7 represents the components of DCFC.

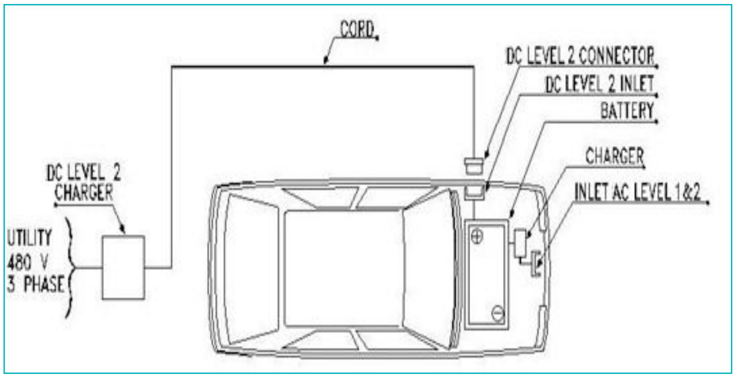

Figure 1-7
DC Charging

This off-board charger is serviced by a three phase circuit at 208, 480 or 600VAC. It requires a cord and connector 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 PEVs to be charged from either a conventional 15A AC wall outlet or a DC connection of up to 90 kW. The SAE J1772 combo connector standard under development is targeted for completion by the end of 2012. A preliminary design is shown in Figure 1-9 below.

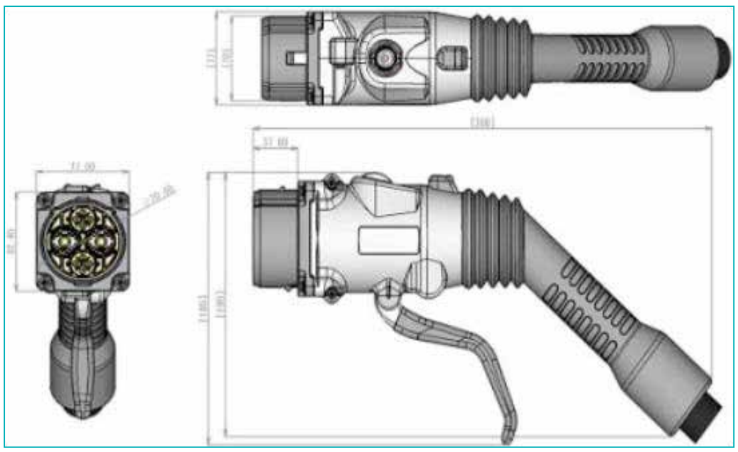

Figure 1-8
CHAdeMO
Standard Connector

Figure 1-9
SAE Recommended
J1772 Combo
Connector3

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 EV CONFIGURATIONS

There are two basic EV configurations at this point in time: battery electric vehicles (BEV) 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 EV (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% of the energy used to propel the vehicle to speed prior to braking. Solar photovoltaic panels on vehicles can also provide power to operate some small accessory loads.

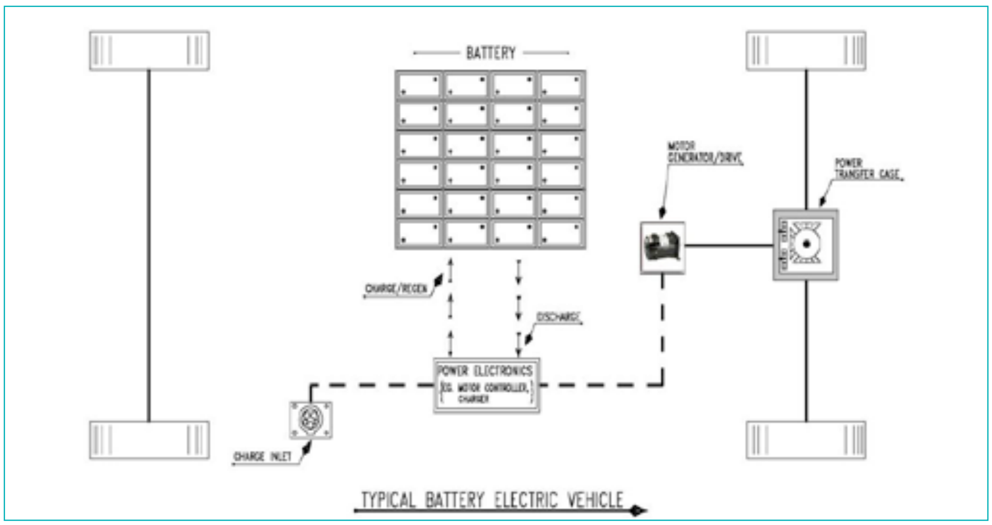

Figure 2-1
Battery EV

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.

2.1.2 Plug-In Hybrid EV (PHEV)

Like a typical hybrid EV (HEV), the PHEV configuration utilizes a battery and an ICE powered by gasoline, diesel or other liquid or gaseous fuels. PHEVs 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 electricity from the grid to charge the battery. The PHEV is able to run for an increased distance strictly on the electric motor without having to engage the onboard ICE, thus increasing fuel efficiency.

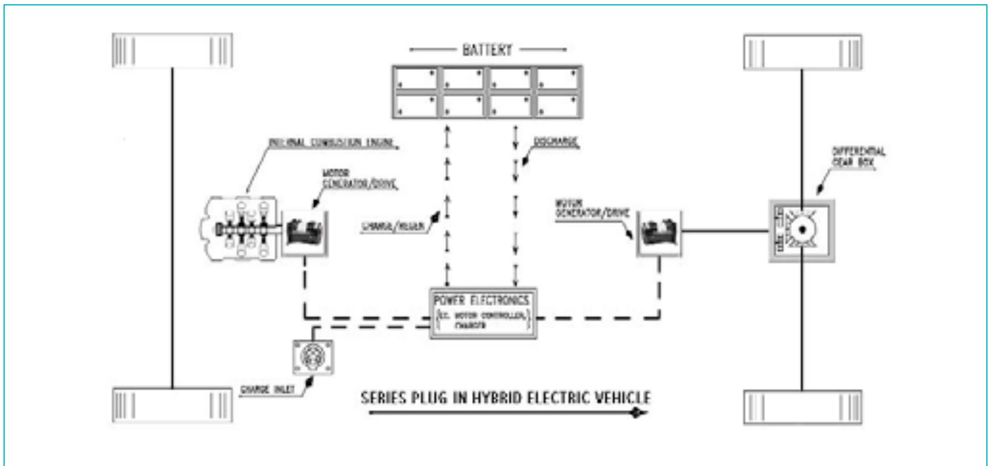

Figure 2-2
Series Plug-In Hybrid Vehicle Block Diagram

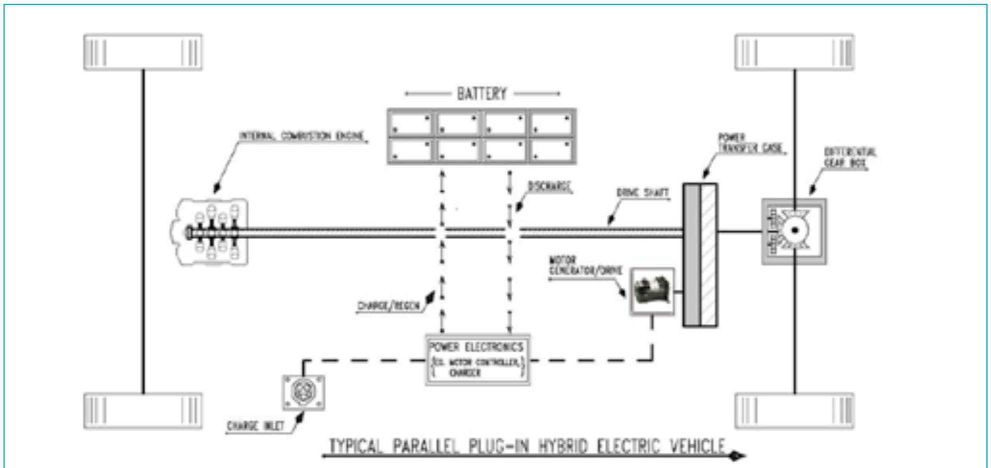

Figure 2-3
Parallel Plug-In Hybrid EV Block Diagram

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 EV (REEV) or Extended Range EV (EREV).

2.2 PLUG-IN VEHICLE TYPES

EVs 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 EVs (LSEVs)

Limited Speed EVs (LSEVs) are BEVs that are limited to operating at lower speeds of 40 km/h nationally; and 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.

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 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 EV charging infrastructure, this should be a consideration when sizing the charging circuits so that adequate power is available as charging demands increase.

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.)
- The driving style/habits of the owner
- 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 Power in kW Delivered to Battery and Relative Charge Time (hours and minutes)						
EV Configuration	Usable Battery Capacity (kWh)	120 VAC, 15A **1.2 kW**	120 VAC, 20A **1.6 kW**	240 VAC, 20A **3.3kW**	240 VAC, 40A **6.6 kW**	480 VAC, 85A **60 kW**
PHEV-10 Miles	4	3 h 20 m	2 h 30 m	1h 10 m	35 m	N/A
PHEV-20 Miles	8	6 h 40 m	5 h	2 h 30 m	1 h 15 m	N/A
PHEV-40 Miles	16	13 h 20 m	10 h	5h	2 h 30 m	16 m
BEV	24	20 h	15 h	7 h 20 m	3 h 40 m	24 m
BEV	35	29 h 10 m	21 h 50 m	10 h 40 m	5 h 20 m	35 m
PHEV Bus	50	N/A	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 (as shown in Table 2-2 below) 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	4 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 EVs typically results in reduced range. Vehicle cabin heating in a typical ICE vehicle is achieved from the excess heat from the engine. In a BEV, heating the cabin relies on using energy from the battery, which can have a significant effect on vehicle range. Some auto manufacturers have addressed this issue by allowing vehicles to preheat and pre-cool while still plugged in, thus reducing the heating/cooling load on the battery.

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 EVs or EV charging stations. The Society of Automotive Engineers (SAE), CSA Group (CSA), Underwriters Laboratories of Canada (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 EV and EVSE technical and installation standards. All these bodies consider safety-related issues.

3.2 CANADIAN STANDARDS FOR THE EV SUPPLY EQUIPMENT (EVSE)

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

- TIL I-44 - Interim Certification Requirements for supply equipment for EVs with inputs and outputs rated 600V or less.
- TIL A-35 - Interim Certification Requirements for EV 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 EV connectors/couplers and receptacles/plugs for use in a conductive charging system.
- TIL J-39 - Interim Certification Requirements for EV Cables rated 600V maximum and intended for use in accordance with CSA C22.1, Canadian Electrical Code (CEC), Part I and CAN/CSA-C22.2 No. 0.

Once published, the TILs provide the Canadian requirements for the four harmonized projects addressing electrical safety of the EVSE. The following alignment table lists the proposed standard number designation of the harmonized document for Canada (CSA), Mexico (ANCE) and the U.S. (UL). These standards are scheduled to be published in 2012.

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

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

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 the CSA 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 the 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 the CSA 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[4] (or similar regulation), which falls under the province's Safety Standards Act[5] (or similar Act), adopts the safety standards for electrical installations (CSA C22.1-12, in Part I of the Canadian Electrical Code). This becomes the Provincial Electrical Code regulation 2012[6] with amendments as referenced in the Schedule[7] to the regulation. Each province's Safety Authority's Electrical Safety Program[8] has been responsible for regulating electrical safety in that province, including all types of electrical equipment and installation.

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

- 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 60A or more, or more than 150V – to-ground. This disconnect means 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).
- Receptacle and Wall Plug: Level 1: A single, not duplex, 20A residential wall plug and receptacle are acceptable for Level 1 charging (CEC 86-306 1 (a)). More common 15A 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 208/240V and minimum 20A 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 Circuit Interrupter (GFCI): 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)). Some EVSE can contain GFCIs, thus nuisance tripping may be experienced when the two GFCIs interact with each other. A permanently connected outdoor EVSE avoids this problem.
- Hazardous Locations: When EVSE is installed in hazardous locations as defined elsewhere in the Code, those sections apply. (CE 86-102)

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

3.5 SIGNAGE

The sign shown in Figure 3-1 has been developed as a standard for Canada and has been submitted by Electric Mobility Canada for national approval in Canada and many other countries. The blue background on a rectangular shape with a white pictorial image and "DC" lettering, as shown in Figure 3-2, is a standard for highway traffic information signs, directing EV motorists to nearby DC fast charging stations. The pictorial image conveys the message without words. Additional words may be added below the sign for specific details such as "Please allow EVs 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.

Figure 3-1
Sign for EV 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 vehicleso that 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 – Single 15A Circuit	No
Double Circuit (always on)	Split Duplex Receptacle – Two 15A Circuits	Yes
Cycled	Single/Double Circuits - Cycled On/Off	No
Temp. Controlled	Single/Double Circuits – Temperature Controlled	No

As shown in Table 3-2, the only scenario suitable for EV charging is parking lots that feature dedicated, "always on" two-15A circuits for each duplex receptacle. Using the other types of circuits listed above could result in the user's vehicle receiving a reduced charge or none at all. 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 labelled as "designated" charge points as they will not meet the minimum 20A criteria.

Repurposing block heater circuits may be possible in some instances if the wire gauge that was used initially was oversized to carry 20A continuously. In this case it might also be possible to re-distribute power on 208/240V 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.

3.7 INSTALLATIONS LOCATED IN FLOOD ZONES

Permits for construction of facilities, including EV charging stations, include reviews to determine whether or not 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), which 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 also 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 to be on the third level of a parking garage instead of the first.

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

Wet flood proofing refers to the elimination or minimization of the potentiality 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 potentiality of flood damage by implementing a combination of waterproofing features designed to keep floodwaters completely outside of a structure.[9] If the entire building is protected from flood water, the EVSE is also protected.

3.8 INSTALLATIONS LOCATED IN SNOW ZONES

Snow may cover charging equipment making it invisible to snow plow 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 the charging outlet may be on a vehicle; as such, the cord must be able to reach to any corner of the space.

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

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 an available 125 VAC outlet.

The planning for a residential installation involves:

- Choosing an EV
- 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 as per manufacturer guidelines
    - Obtain local permit for installation
    - Schedule the installation
    - Coordinate with local inspector to validate installation
- Communication Requirement options for EVSE that connect to a network
- Contact the local utility for EVSE installation notification
    - Determine if there are special EV charging rates available

The residential building owner, manager or strata council has different planning considerations from a single EV owner in his own home, as does an EV owner in a Multi-Unit Residential Buildings (MURB). Consumers living in MURBs 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 are all factors that should be reviewed before starting the installation process. 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 EV to choose by analyzing some of the following factors:

- Use of vehicle
    - Commuter use
    - Primary transportation
    - Secondary vehicle
- Average distance of daily drive
    - Availability of workplace charging
    - Availability of public charging stations
- Area topography

- Frequency of long trips
- Aesthetics
- Ease of EVSE installation
- Purchase price
- Available EV 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
- EV driving visitors

Residential charging stations owners may decide to use a single charging option such as a Level 1 AC cord set or to upgrade to a Level 2 AC EVSE. 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 that affect the choice of the appropriate EV charging solution 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 AC may be sufficient for all charging needs, whereas BEV owners may consider Level 1 AC to be a back-up strategy only, relying on Level 2 AC for primary charging.
- Larger, heavier EVs will consume more power than smaller, lighter ones. An owner who plans on using the EV only for short trips may find Level 1 AC 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 AC equipment will need to consider the cost of the Level 2 AC EVSE and its installation given a scenario where a suitable Level 1 AC circuit may already be present in their garage. EV owners who have the opportunity for Level 2 AC charging at work or in public areas may find that the vehicle battery remains at a higher charge and as a result, 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 AC charging.

4.1.3 Level 2 AC

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

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

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

o 208V/Three Phase, 4 wire 20, 30 or 40A 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 30A breaker for their recommended EVSE, in which case the breaker can be easily changed.
    - A 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.
    - A major cost factor for Level 2 EVSE is the capacity of the existing electrical supply to the premises. Older homes often have a 100A supply. Newer homes may have 200A supply or even a 400A supply in larger homes. If you plan to add a 40A circuit, it is necessary to perform a demand load calculation as there may be insufficient capacity in the electrical supply. Even if there is room in the panel, there may be insufficient overall 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. For example a switch could be added to ensure that only the dryer or EVSE may be used at one time. Under this scenario, the demand load must still be calculated as the dryer is rated at just 25% while the EVSE is rated at 100%. This option may allow for a Level 2 AC 20A circuit with only a small increase in the calculated load.

4.1.4 Selecting a Contractor

The installation of an EVSE requires that a certified electrician install the charging station in a residential home, high rise or on public property. The contractor will need to perform a site visit to estimate the cost of installation. The 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

Several EVSE suppliers provide equipment that connects to their service network, which provides special features. These EVSE have communications requirements that may include a wireless internet connection as a preferred method. In some situations, the residence wireless network router may be too far removed from the EVSE to allow a sufficient signal. For new construction that incorporates an advanced internet network within the home or if the home design suggests that the router may be too distant from the expected EVSE location, providing an internet connection at the EVSE location would be advisable. A third option provided by some EVSE suppliers is the use of a cellular modem in the EVSE itself. However, this typically will incur monthly cellular costs.

4.2 GENERAL REQUIREMENTS AND DESIGN CONSIDERATIONS

4.2.1 Certification

The EVSE provided by the supplier has been certified to meet CSA and UL standards (Table 3-1 above) and is thus 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 charging inlet location on EVs varies by vehicle to vehicle and should be taken into consideration when selecting a location for an EVSE installation as well as the EVSE cord length in an effort to avoiding tripping hazards and to allow vehicles to park forwards or backwards in the parking space.

4.2.3 Ventilation Requirements

Certain battery chemistries, such as lead-acid, will off-gas during the charging process. If so, ventilation systems will be required to clear the atmosphere around these EVs while charging. EVs provided by the automotive companies currently use non-gassing batteries so this situation will be rare and mostly limited to "do-it-yourself" hobbyists. If gassing batteries are used, the EVSE will need to communicate with the vehicle, and if ventilation is required but no ventilation system exists, the EVSE will not charge the vehicle. In MURBs or parking garage situations that may already have ventilation systems for exhaust of normal vehicle emissions, such a system may be sufficient.. It may be impractical to wire the charger to the ventilation controls or it may be costly to run the system for a single gassing vehicle. In these cases, it may be prudent to identify that the chargers are intended for non-gassing batteries only. However, due to the rarity of gassing-batteries, this is a non-issue in most circumstances.

4.2.4 Energized Equipment

Unless de-energized by the local disconnect, the EVSE is considered electrically energized equipment. Because it operates above 50V, 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 shown 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 in the optimum location for charging.

Figure 4-1
Wheel Stop10

Figure 4-2
Garage Wheel Stop11

[10] Rubberform Recycled Products LLC, www.rubberform.com
[11] ProPark Garage Wheel Stop, www.organizeit.com

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. Each site will vary in terms of design as well as the needs/preferences of the owners. It is important that the installer works 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).

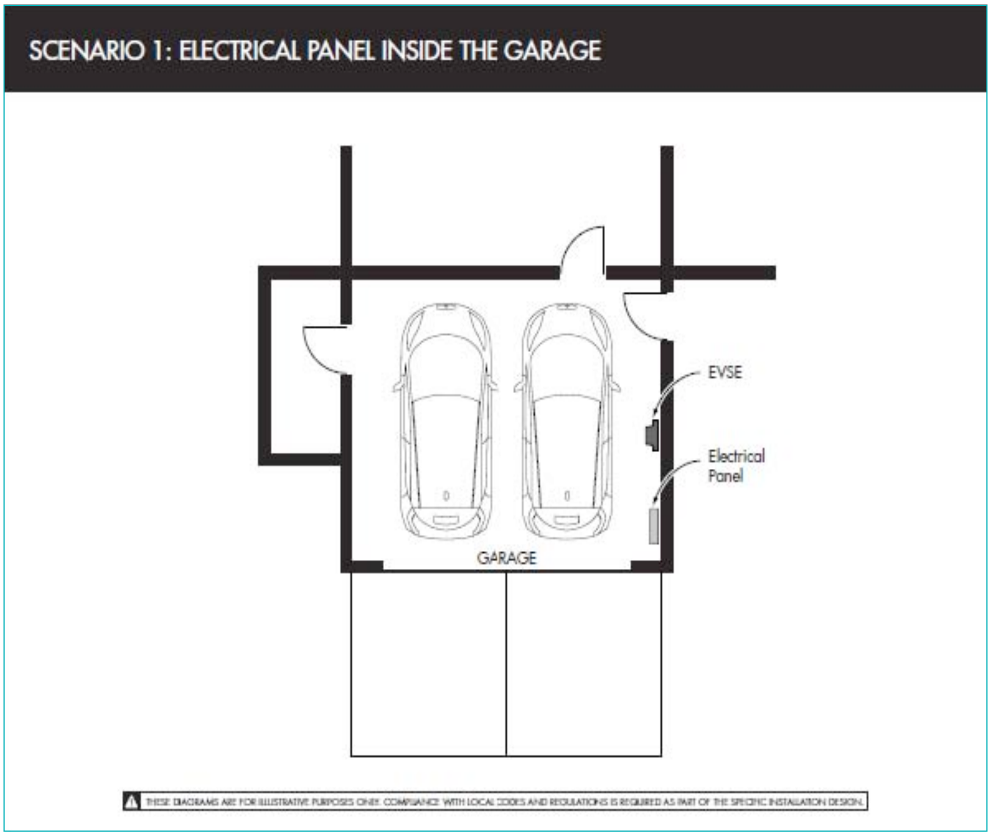

Figure 4-3
Garage Existing Panel

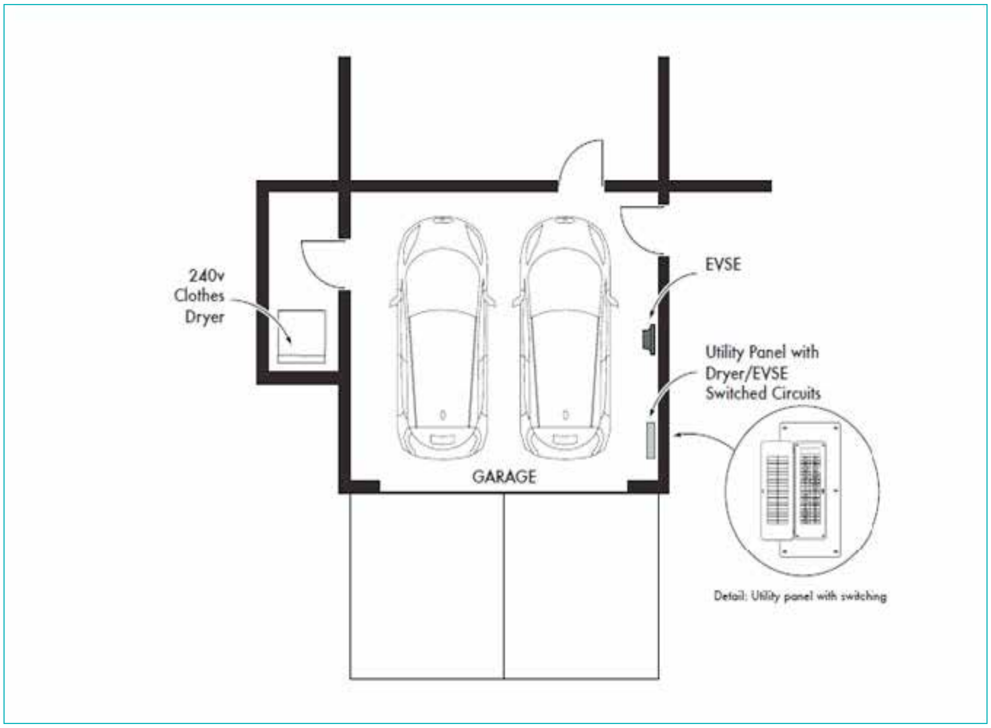

Figure 4-4
Garage—Switched (Dryer)—Suggested

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 a routing of the electrical supply to the garage. Landscaping may be disrupted during the installation process, which may be of great significance to the owner and should be thoroughly planned in advance.

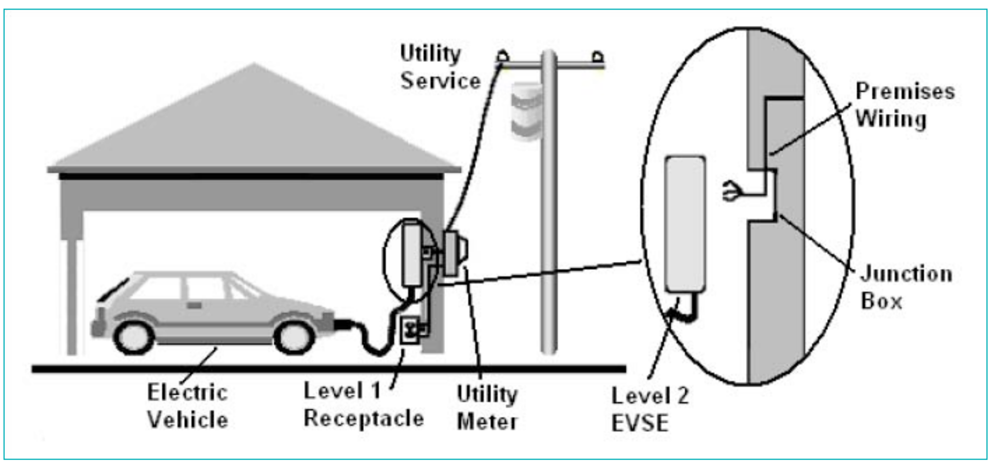

Figure 4-5
Typical Level 1 and Level 2 Installation for a Residential Charge

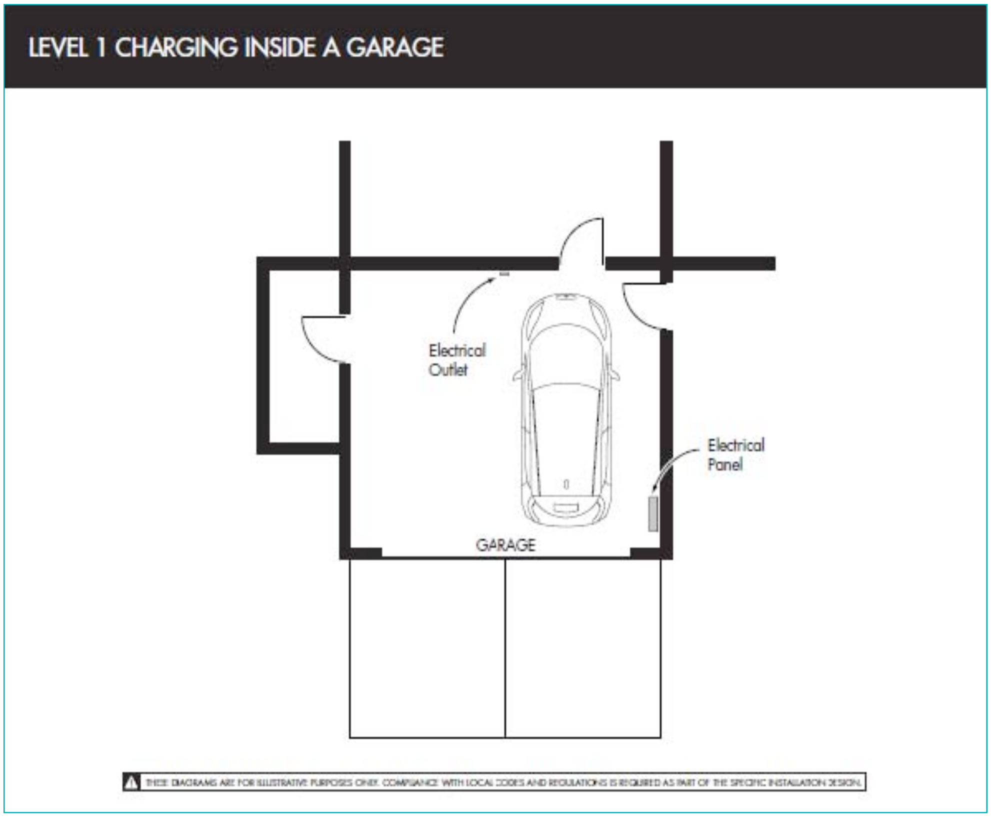

Figure 4-6
Level 1 Charging Inside the Garage

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 (125V, 20A) in the case of Level 1 charging or an EVSE (operating at 240 VAC, 20-40A) for Level 2 charging. The general layout is shown in Figure 4-5. 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.

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 and whether ventilation will be required and which 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 the location of EVSE, the routing of raceway from utility service panel to EVSE, the Level 1 or Level 2 requirements, the ventilation requirements, the 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

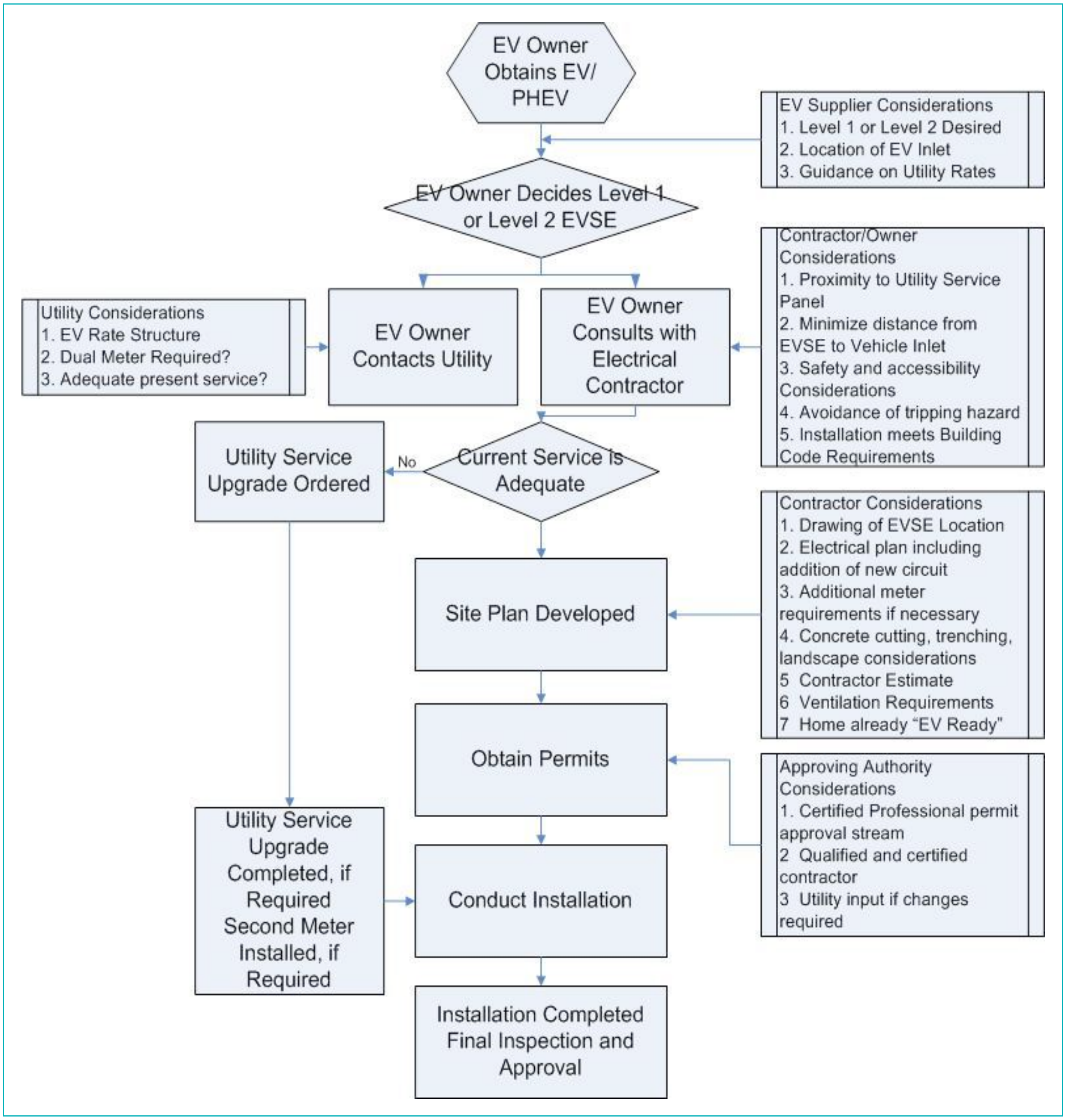

Figure 4-7
Installation Process for a Residential Garage/Car Port

If the garage has a pre-existing raceway, the EV owner can determine whether this will be a 125 VAC, 20A circuits or a 240 VAC, 20, 30 or 40A circuits. Some homes may not have sufficient utility electrical service to install a 40A dedicated circuit. In that case, a lower power circuit is possible or a larger service may be added. 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 demanding that a raceway for EVSE wiring 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 VAC, 20-40A circuit required for Level 2 charging. If a 125 VAC, 20A Level 1 breaker and receptacle is installed, the home owner might have a functional circuit that could be upgraded easily to Level 2 240 VAC 20A, if desired.

4.4 CAR PORT 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 car port requirements. A car port 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, efforts should be made to ensure proper drainage from the charging site.

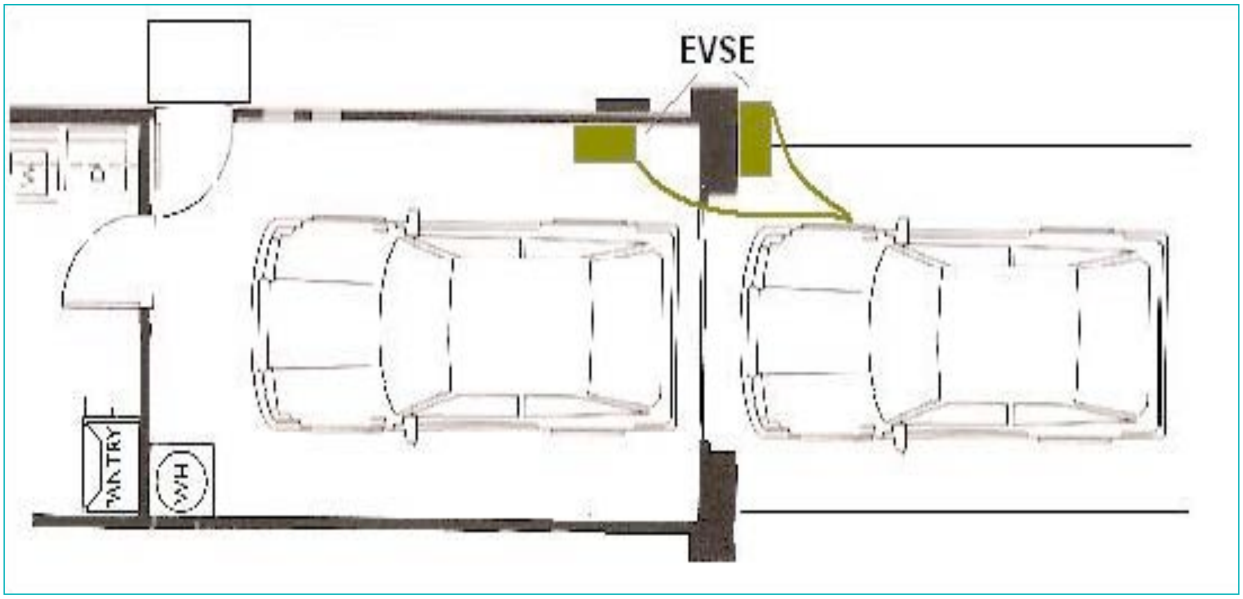

Figure 4-8
Installation Considerations for Outdoor Parking

Freezing temperatures can create an issue for cords freezing to the parking surface and so 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 in Figure 4-7 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 that nuisance tripping can occur when two GFCIs 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 deters theft.

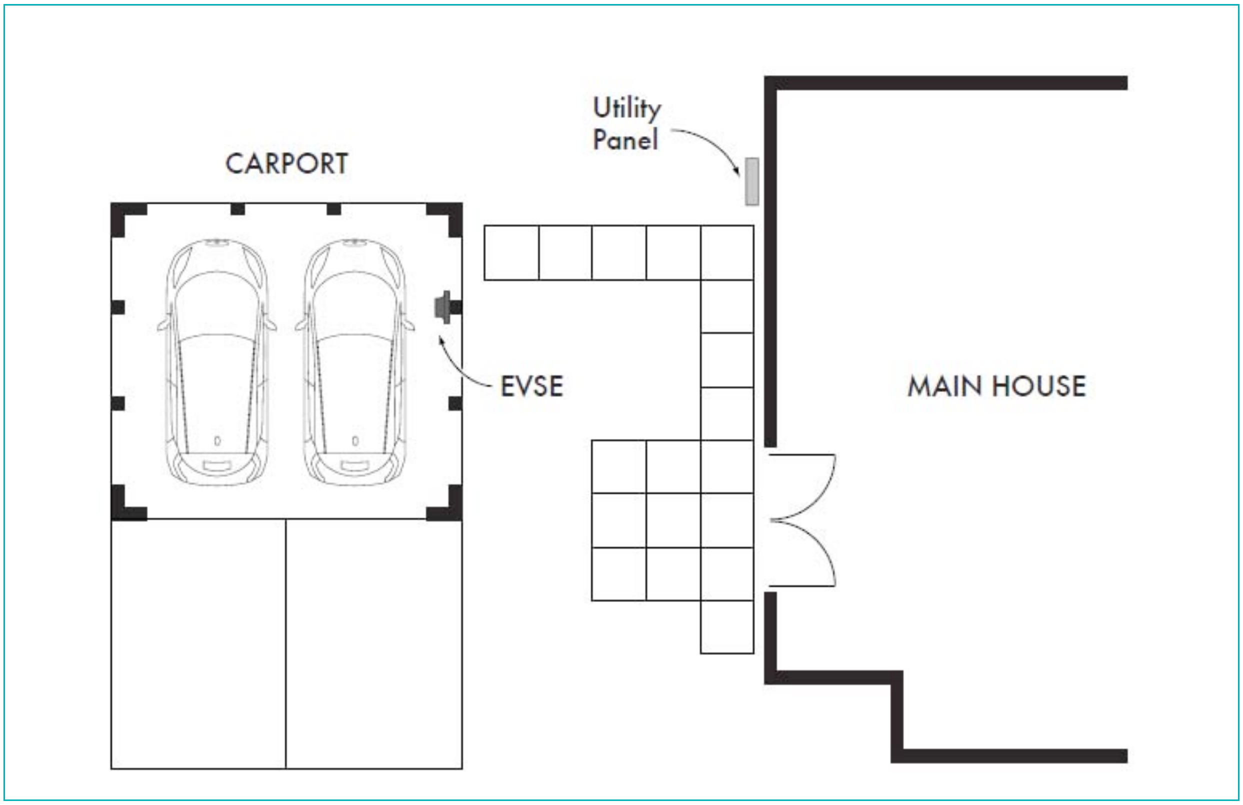

Figure 4-9
Carport

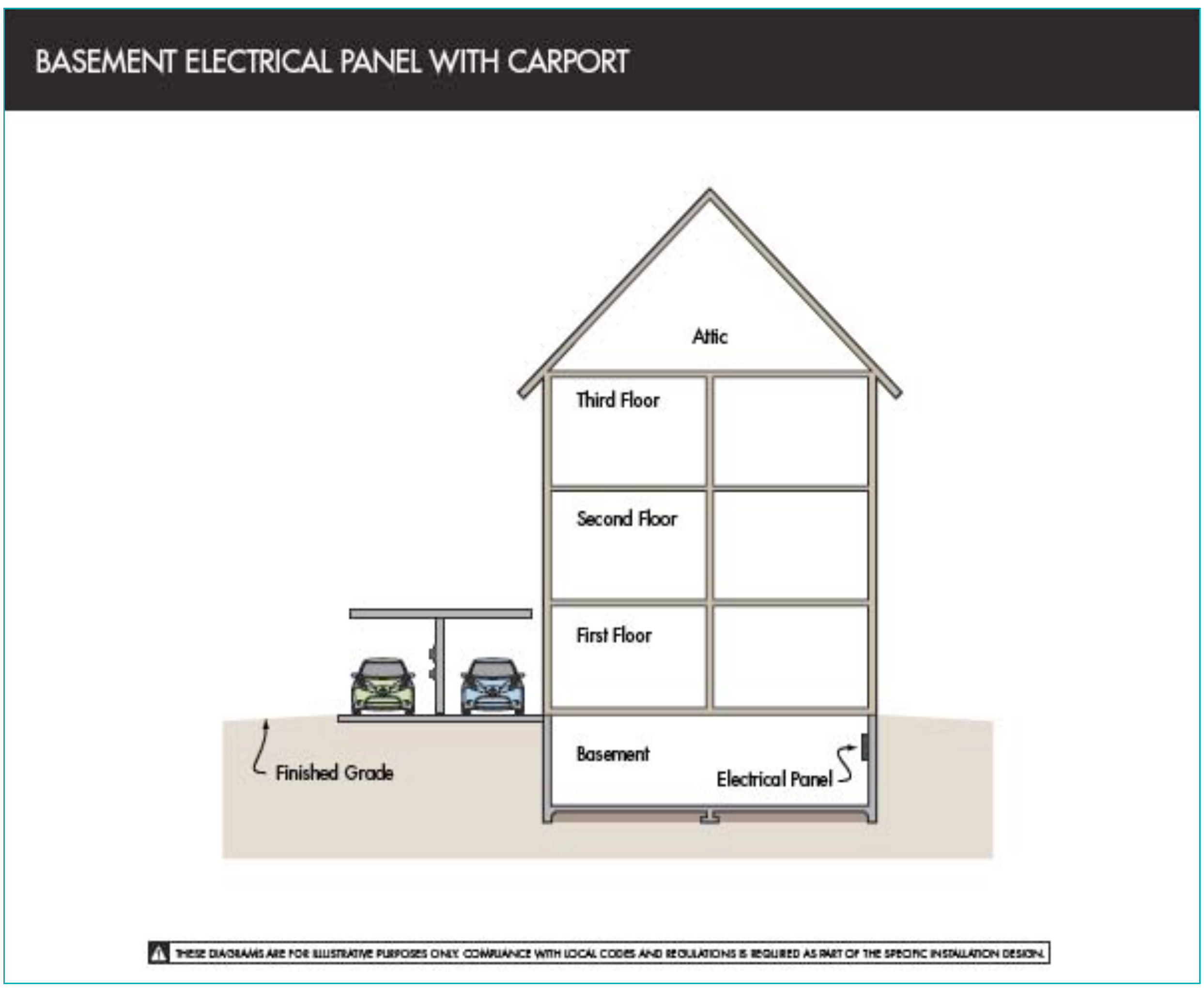

Figure 4-10
Basement Electrical Panel with Carport

4.5 MULTI-UNIT RESIDENTIAL BUILDINGS (MURB)

4.5.1 Siting Requirements

In MURBs, there will be additional considerations to those described above as 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 purchase/own the EVSE
- Determination of who will pay for installation and any needed infrastructure upgrades
- Metering and payment methods for the electrical usage
- Proximity to the EV owner's dwelling
- Potential for water damage
- Potential interference with snow removal operations
- Lighting, insurance, liability, and vandalism concerns
- 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 MURBs, the allocation of physical space for all future electrical equipment and raceway sizing to accommodate the electrical capacity is fundamental early on in the design and planning stage.

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 as shown in Figure 4-11 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 between single family homes and MURBs 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 MURBs 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 which can be costly and would require additional space.

A demand load management system that shares power with existing infrastructure may significantly reduce costs. 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.

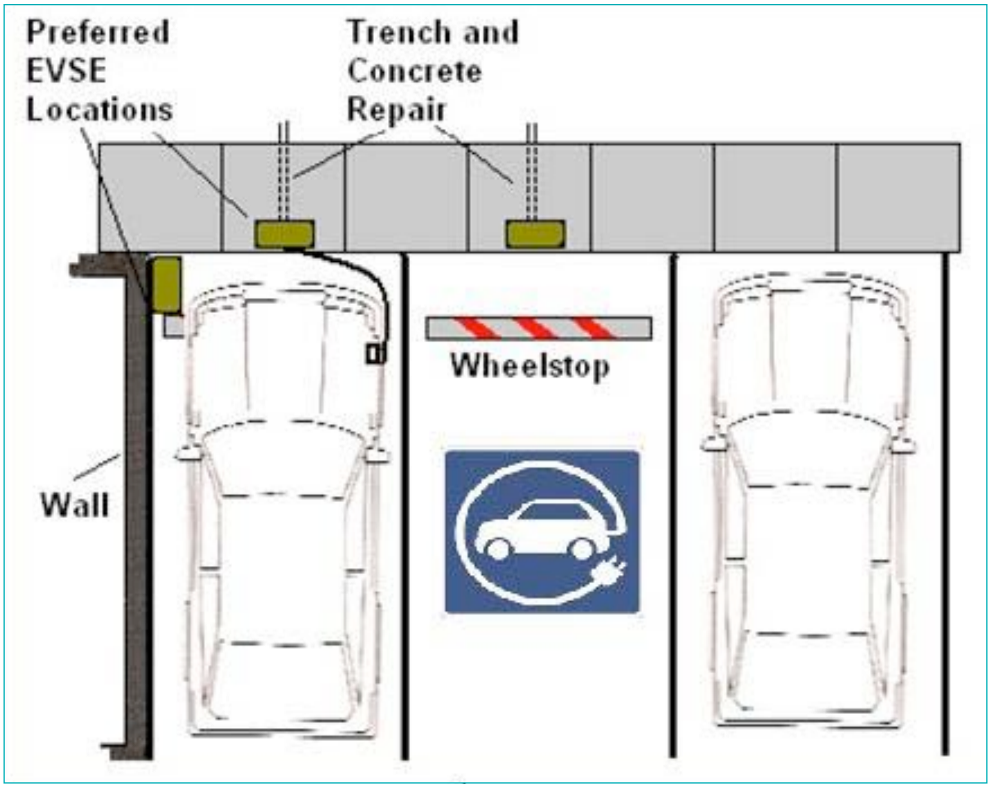

Figure 4-11
Typical EVSE Installation in MURB Lot

One MURB installation scenario consideration may be to install both Level 1 AC charging in mass with Level 2 AC 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 best suited for their specific driving pattern and help to minimize infrastructure costs.

A low rise MURB will differ from a high rise configuration in the electrical plan and layout. In some low rise town home 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 as shown in Figure 4-12.

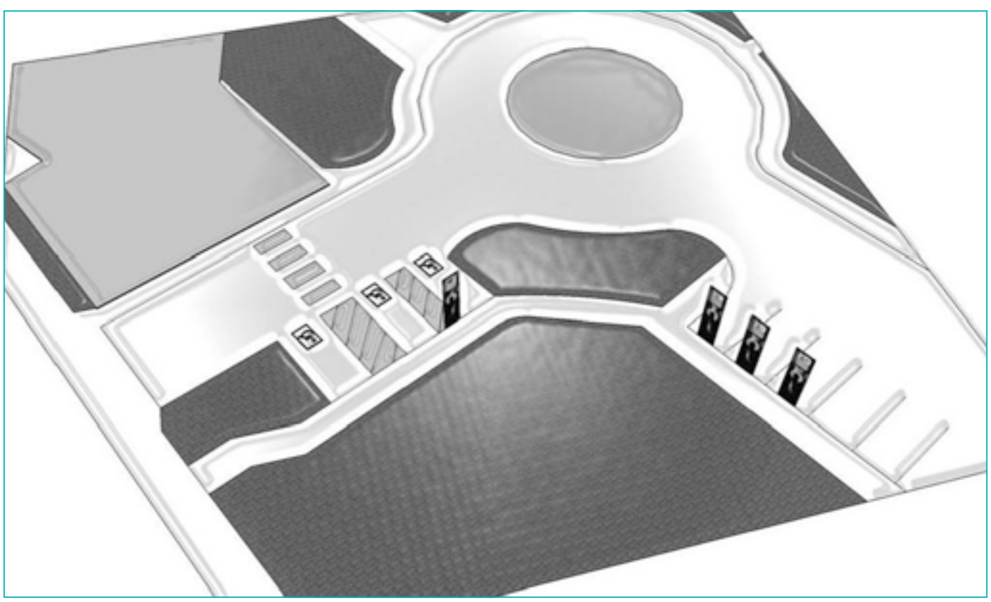

Figure 4-12
High Rise MURB

If power can be shared with existing supplies on a load managed basis, then expensive equipment installation may be avoided. However, this would require control of when EV charging could occur and would be dependent on the peak power periods in each province. This peak power timing may shift from afternoon peaks in the summer for air conditioning to evening and overnight peaks in the 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 120V 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 DCFC with a shared charger amongst nearby parking stalls. Although the charger is more expensive, the cost may be shared amongst users.

INSTALLATION PROCESS

Figure 4-13 below highlights the steps needed for the installation process for MURBs.

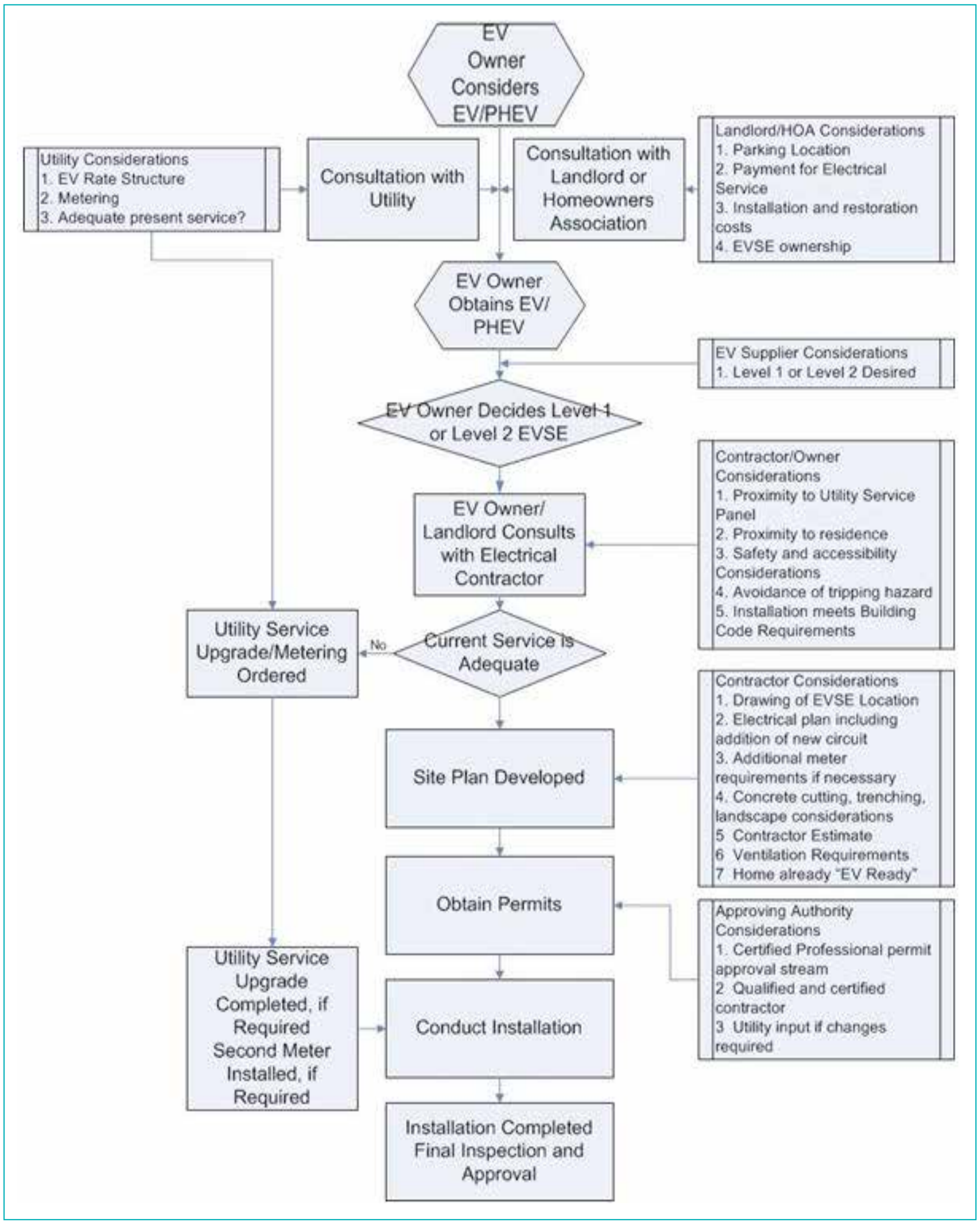

Figure 4-13
Installation Process for MURBs

5.0 COMMERCIAL CHARGING

5.1 COMMERCIAL CHARGING

Commercial applications for EV charge infrastructure may include fleet charging stations and chargers for public use on private or public property such as at a retailer or public park, and can consist of Level 1 AC, Level 2 AC and/or DC Fast Chargers. Site owners will decide on the mix of charging equipment to install depending on the expected users and use of the charge infrastructure.

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 EVs.

It is recommended that the commercial site owner work through the following details when planning an EVSE installation:

- Choose a Charging Strategy: Level 1 AC, Level 2 AC, DCFC or a mixture of the three depending on the expected charging needs.
- 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 the EVSE is required
    - Estimate installation cost for installing the EVSE as per the 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 EV charging rates available

All the above mentioned points are also identified in Figure 5-8 below.

There are many different configurations for the installation of charge infrastructure as outlined in Figure 5-1 through 5-7 below. The site owner/manager will need to assess the best installation scenario for their specific application.

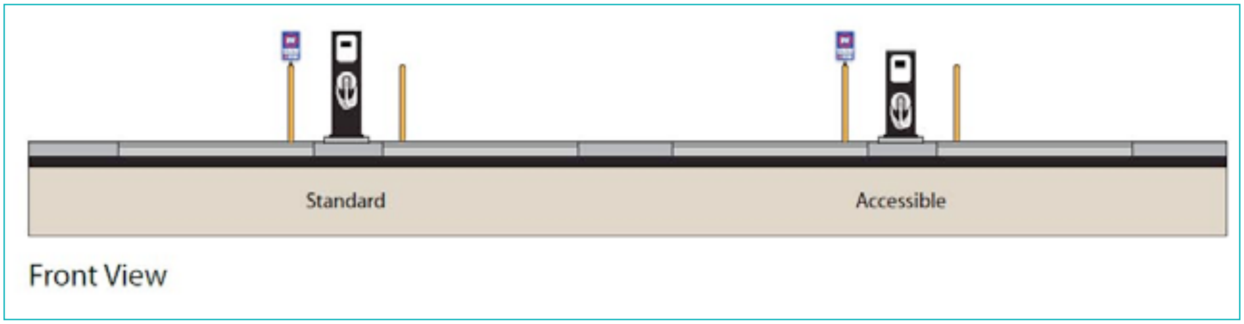

Figure 5-1
Commercial Row Parking Front Placement

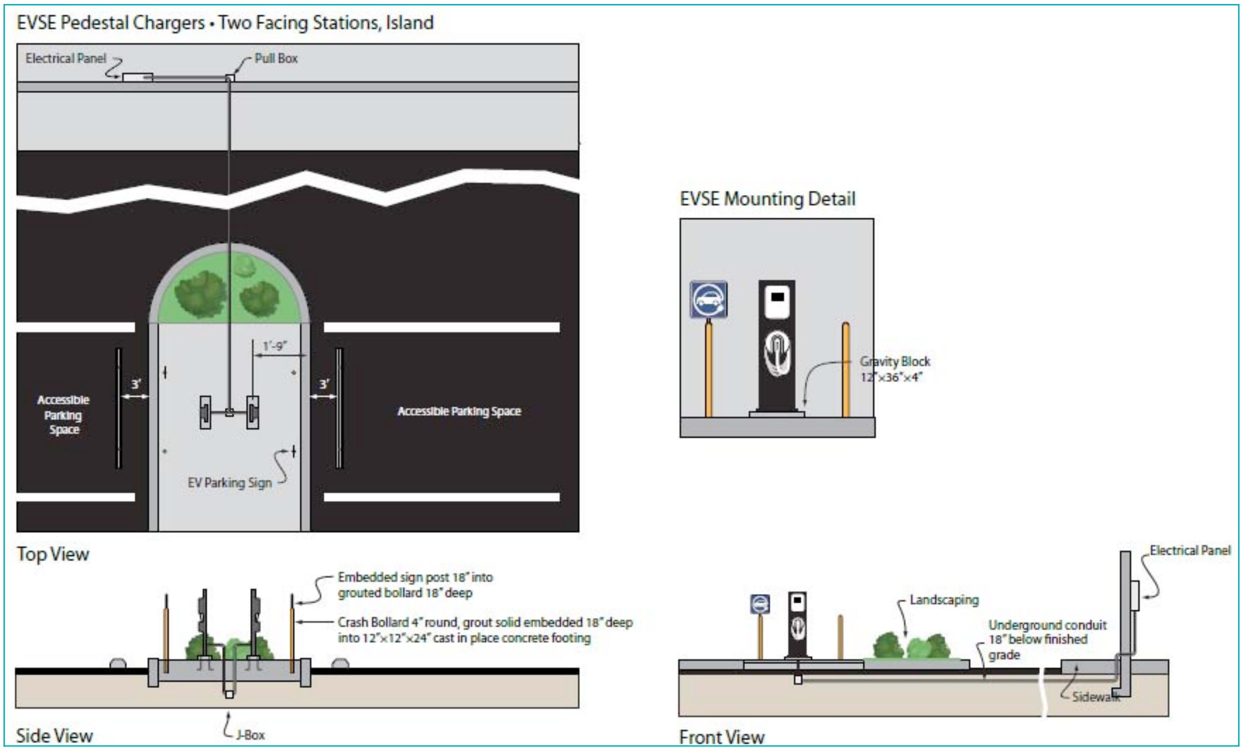

Figure 5-2
Commercial
—Head to Head
Parking

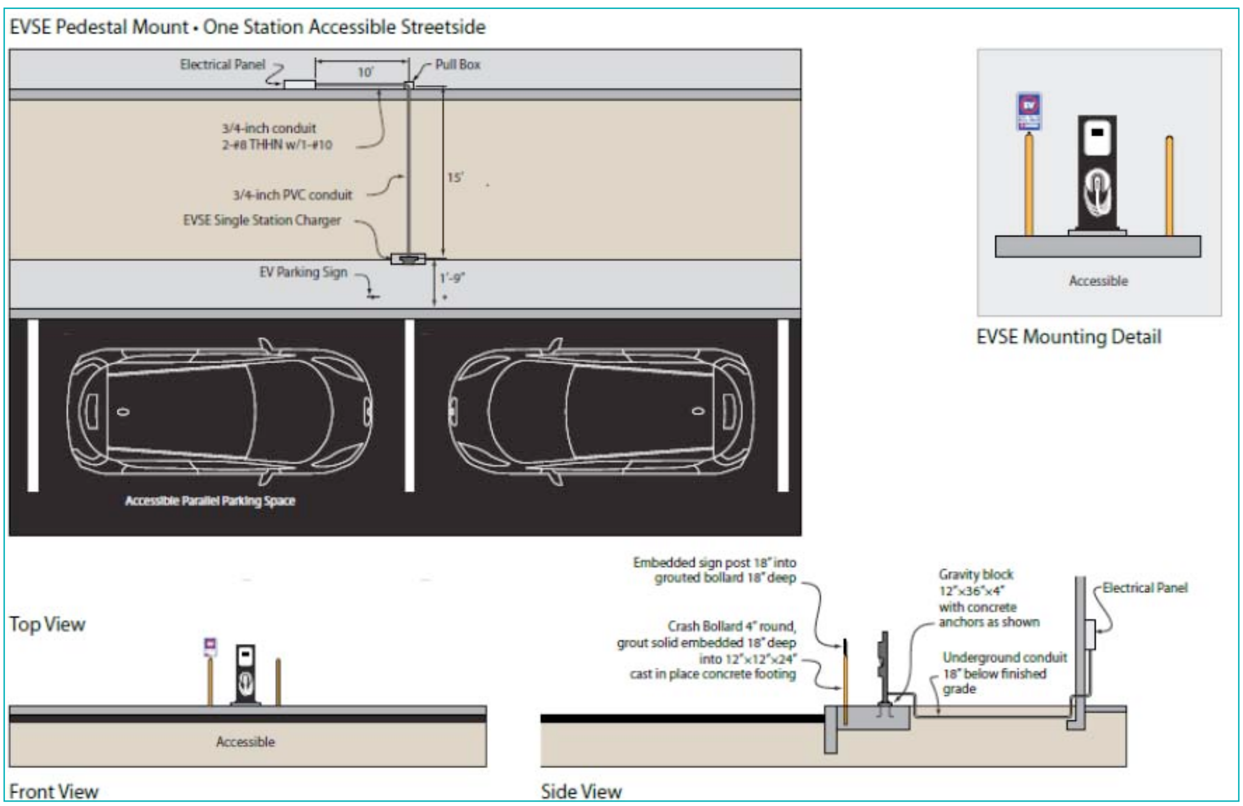

Figure 5-3
Commercial
—Street Side

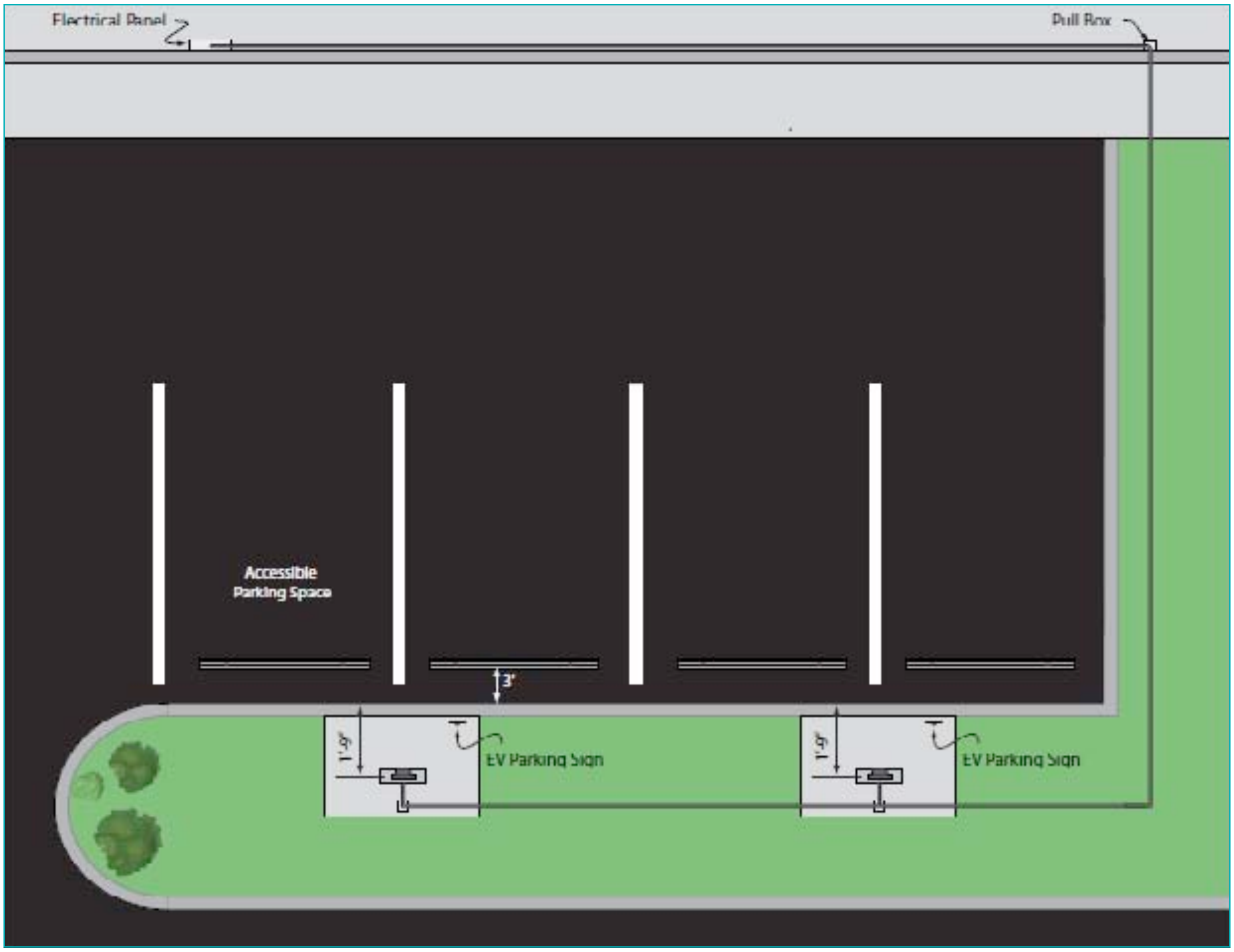

Figure 5-4
Commercial (Pedestal) — Avoid Trenching Diagonal across a Parking Lot

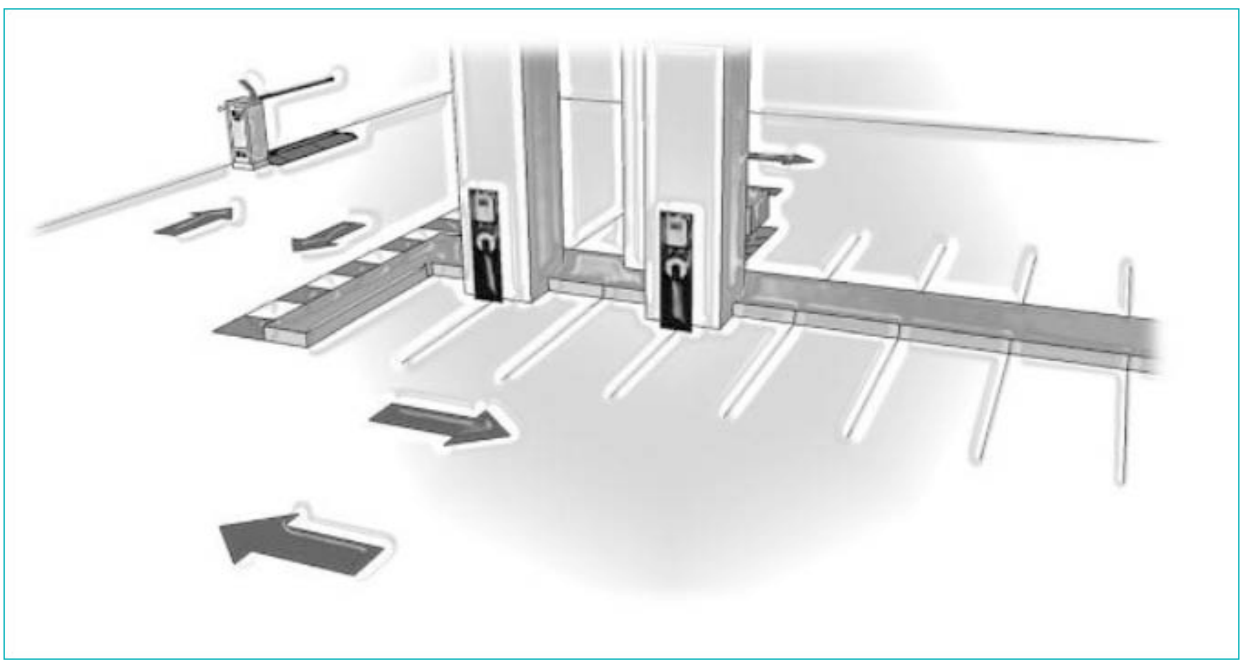

Figure 5-5
Commercial —Row Parking Middle Placement

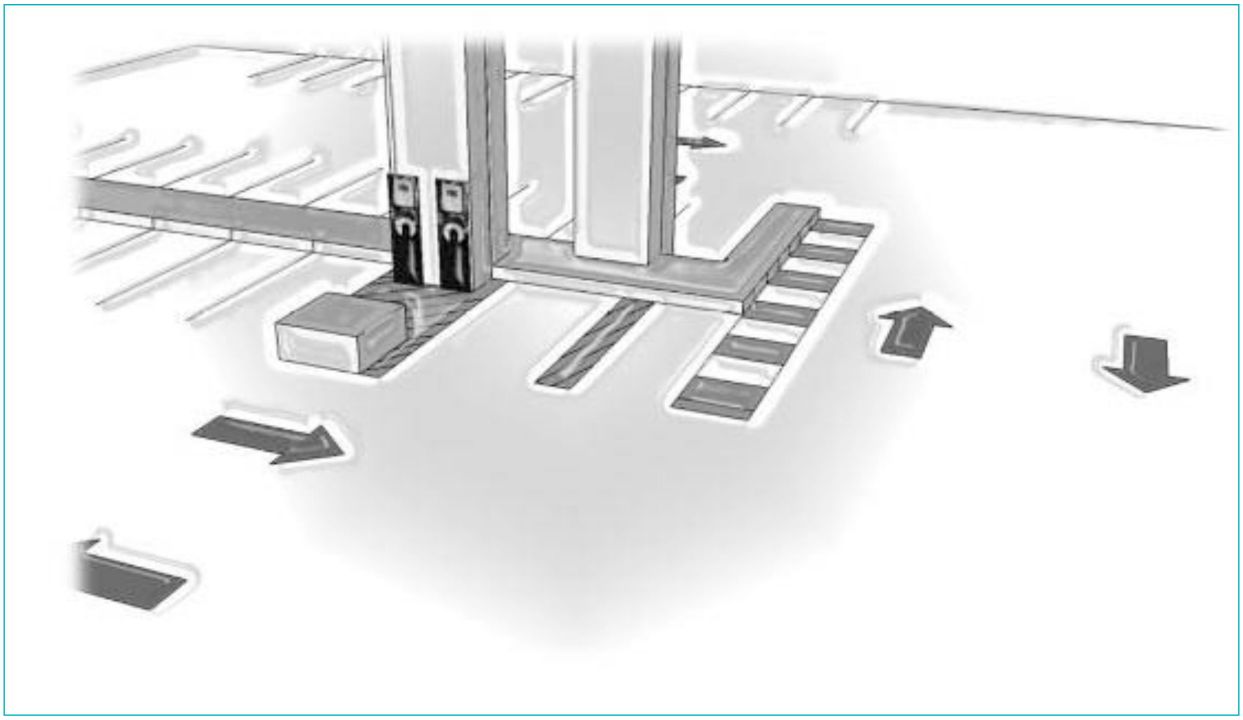

Figure 5-6
Commercia—
Row Parking Middle
Placement

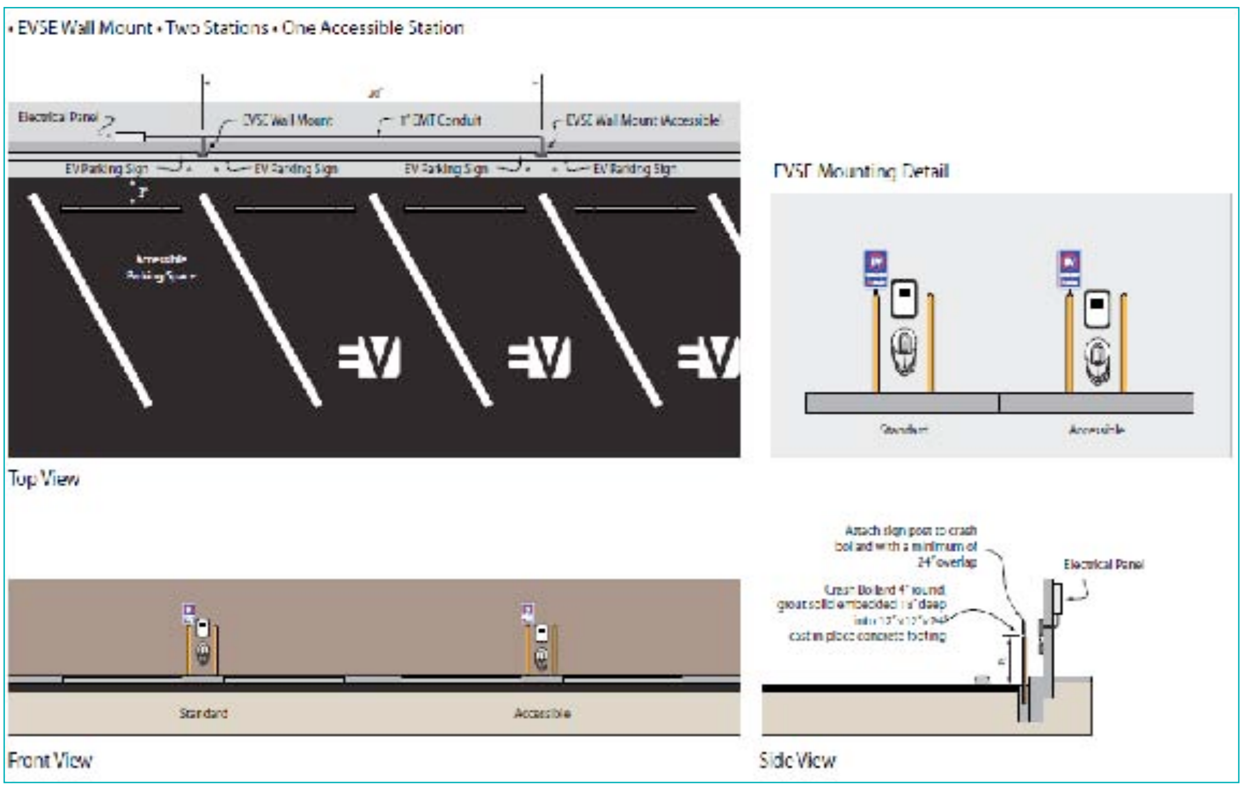

Figure 5-7
Commercial—
Wall Mount

5.1.1 Installation Process

The commercial installation process (Figure 5-8 below) is similar to the processes shown in Figure 4-13. More detailed planning is required prior to the submittal of plans for obtaining permits. The quality of the advance planning will determine the quality of the final installation and ultimately, the EV owner's acceptance and satisfaction.

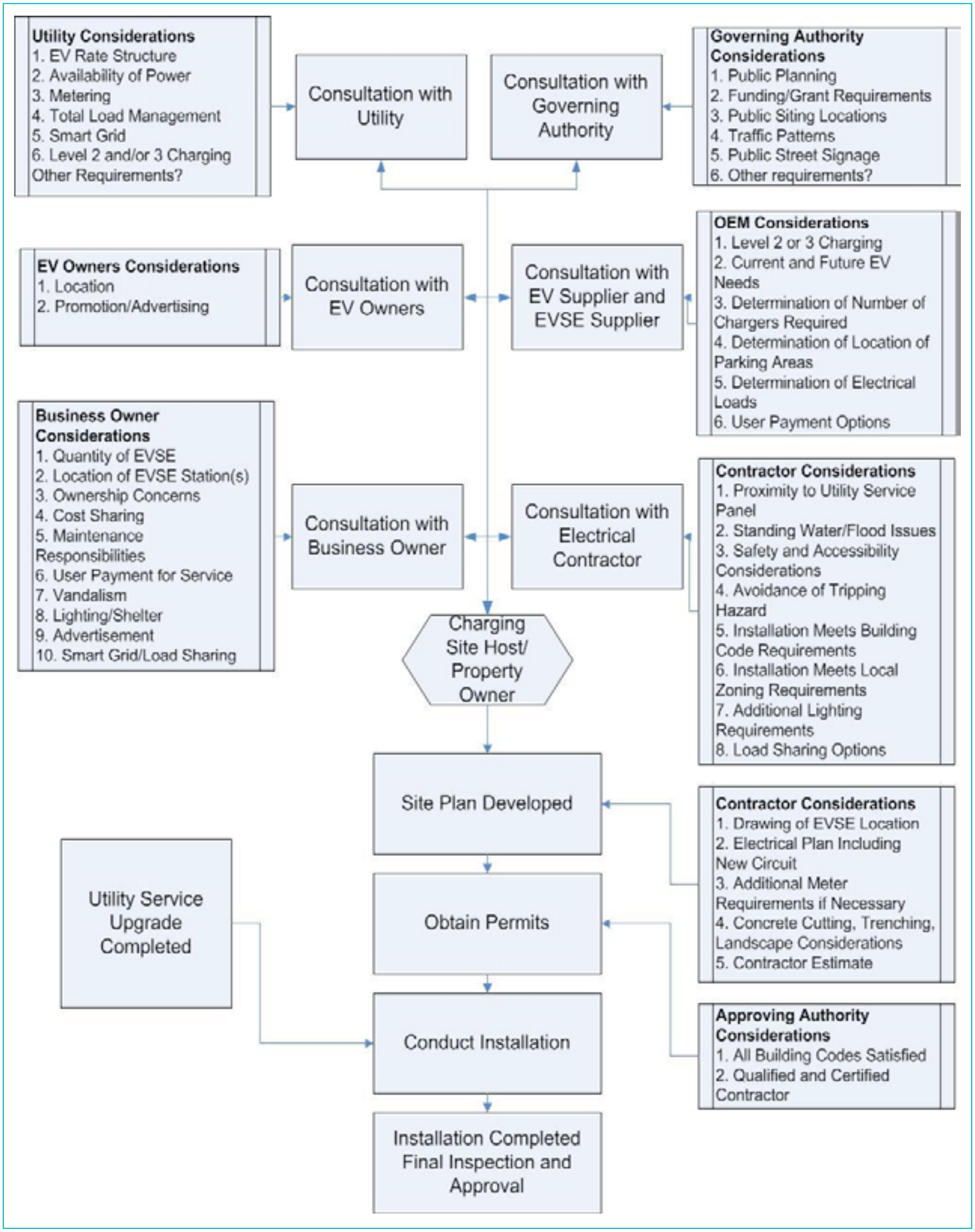

Figure 5-8
Installation Flowchart for Commercial Charging

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 should be given to the current requirements as well as anticipated future requirements. Electrical service requirements will be much higher than residential or MURB 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 AC 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 the parking area as the length and the quantity of the circuit run will have a significant impact on the cost. 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.

5.2.1 Installation Process

The commercial installation process (Figure 5-9 below) is similar to the processes shown in Figure 5-8 above. Detailed planning is involved prior to the owner's final decision and obtainment of permits.

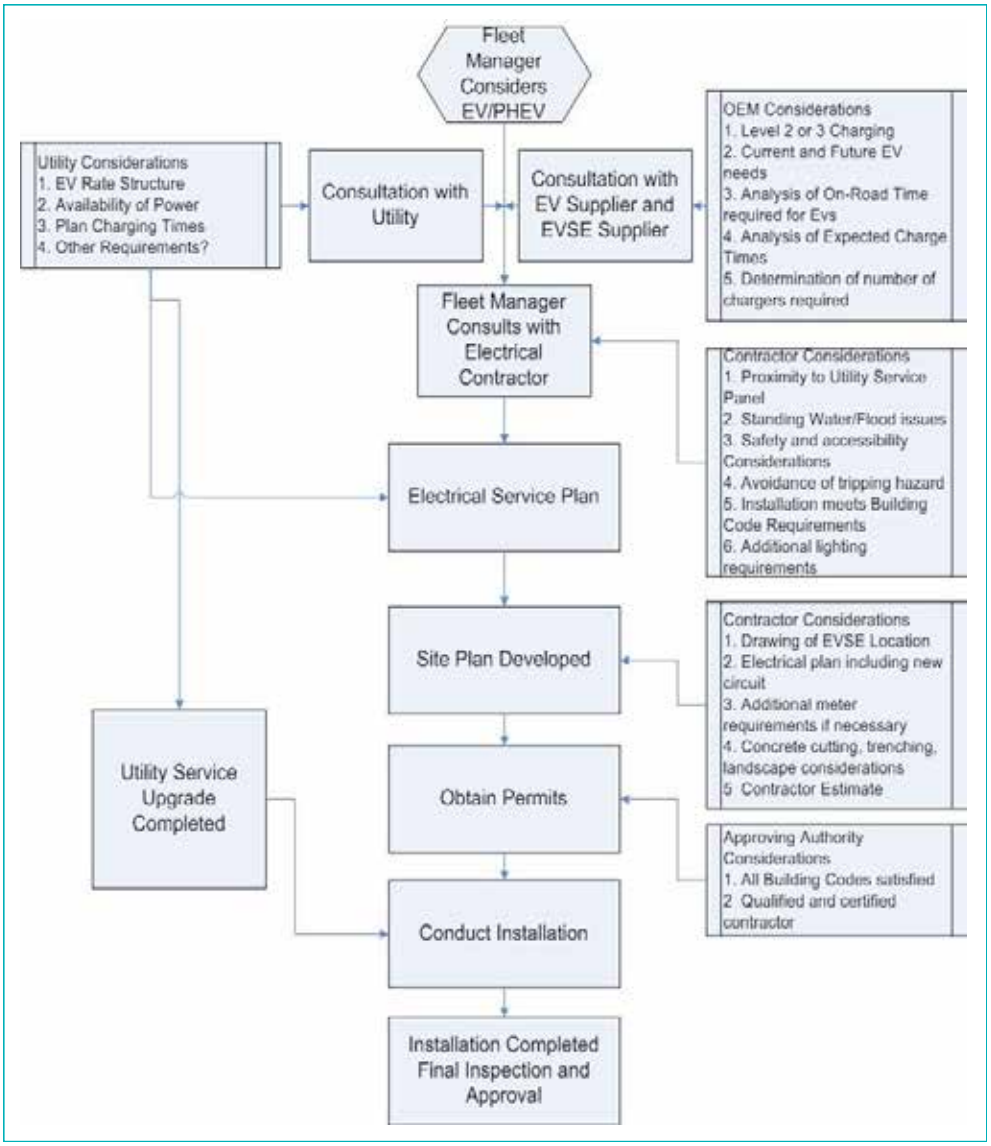

Figure 5-9
Installation Process for Commercial Fleet Operations

5.3 SMART EVSE AND DATA COLLECTION

In general, Level 2 AC and DCFC equipment are manufactured as either basic or "smart" equipment. To elaborate, equipment that meets the sole function of recharging a vehicle is considered basic equipment. EVSE, with the capability of collecting, storing and transmitting usage as well as 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 units with 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 EVSE owner and 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 state of charge. Charging site hosts should weigh the benefits of the "smart" charge equipment against the added costs before making their equipment purchase.

6.0 DC FAST CHARGING

6.1 PLANNING

DC Fast Charging consumes the most electricity of all the EV charging options available. The installation of DCFC equipment is typically the most expensive of the three EV charging options. As DCFC technology is still in the early stages of development and implementation, there is little known regarding its operating costs, frequency of use and rate of market acceptance. Manufacturers of DCFC equipment offer varying performance levels and configurations. Site owners should evaluate the site specifics and user needs against the features and benefits of the available equipment. The installation of DCFC equipment requires an electrical contractor, 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 6-3. The installation process for DCFC equipment includes the following:

- Contact the Local Utility
    - Ensure grid reliability
    - Verify the availability of the local transformer capacity
    - Ask for different energy cost quotes for the light, medium to heavy usage
    - Ask if they offer time of use rates
- Select a DCFC equipment vendor
- Consult with local governmental planning officials
- 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 upgrades
    - Determine if communication to the DCFC equipment is required
    - Estimate installation cost for installing DCFC equipment as per manufacturer guidelines
    - Obtain local permit for installation
    - Schedule the installation
    - Coordinate with local inspector to validate installation

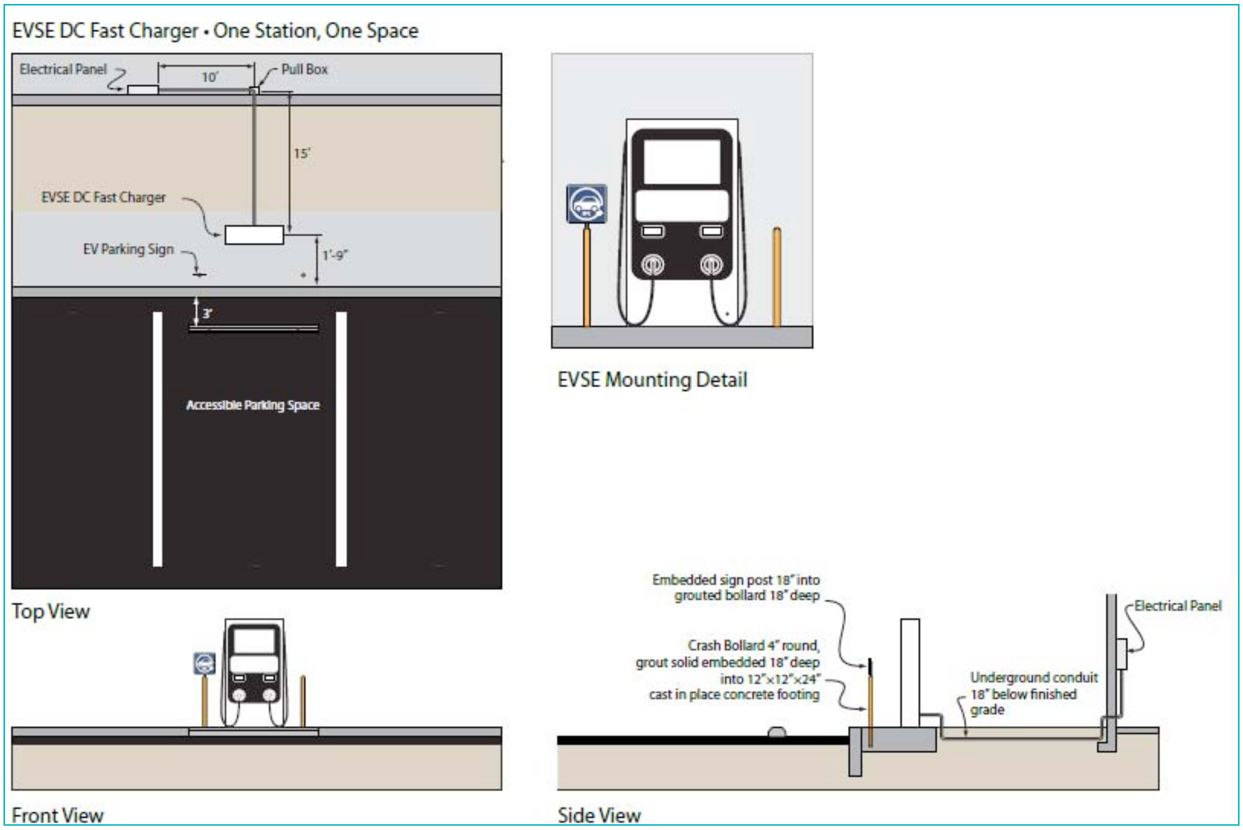

Figure 6-1
DCFC for One Space

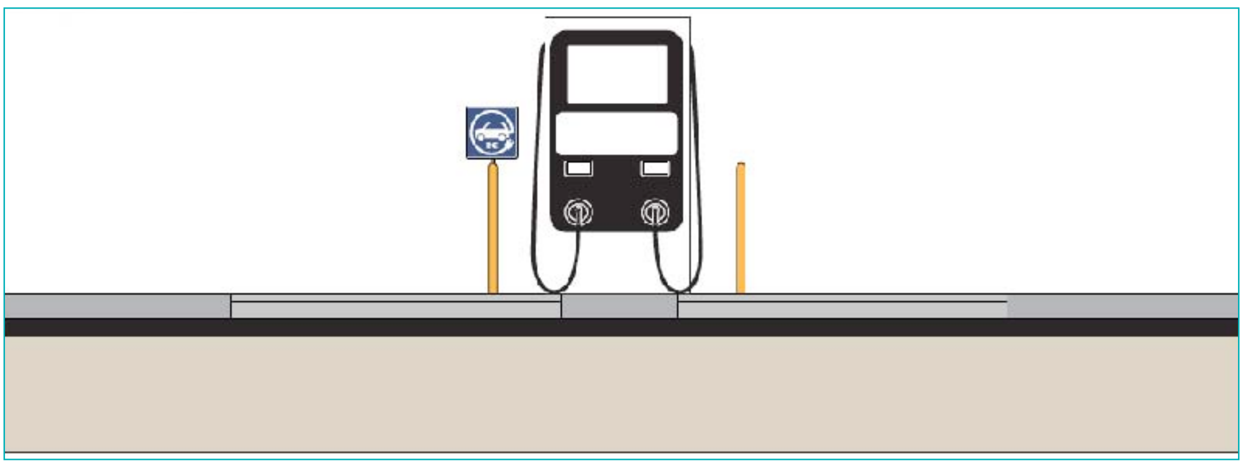

Figure 6-2
DCFC for 2 Spaces
—Front

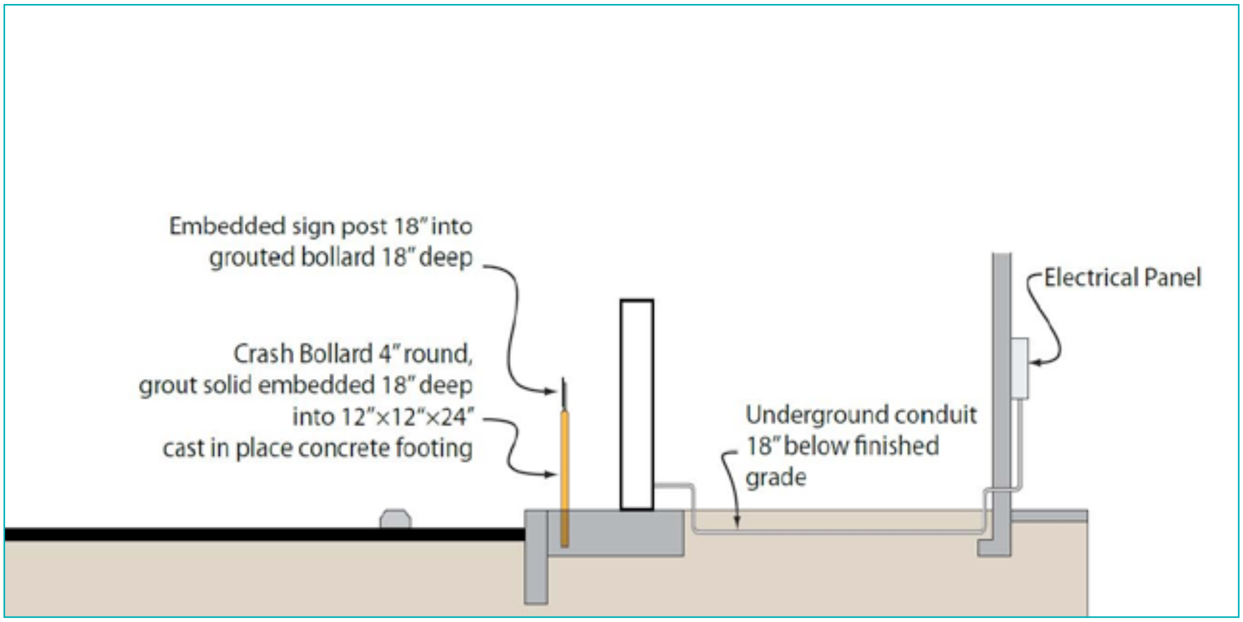

Figure 6-3
DCFC for 2 Spaces —Side

6.2 INSTALLATION PROCESS FOR DCFC

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[12]. In Canada, the "high voltage" rating occurs for voltages above 750 V[13]. Each provinces' Safety Authority's Electrical Safety Program has been responsible for regulating electrical safety in each province, including all types of electrical equipment and installation and should be consulted to determine appropriate contractor qualifications.

[12] *NEC Article 490.2*
[13] *CEC Section 36-000*

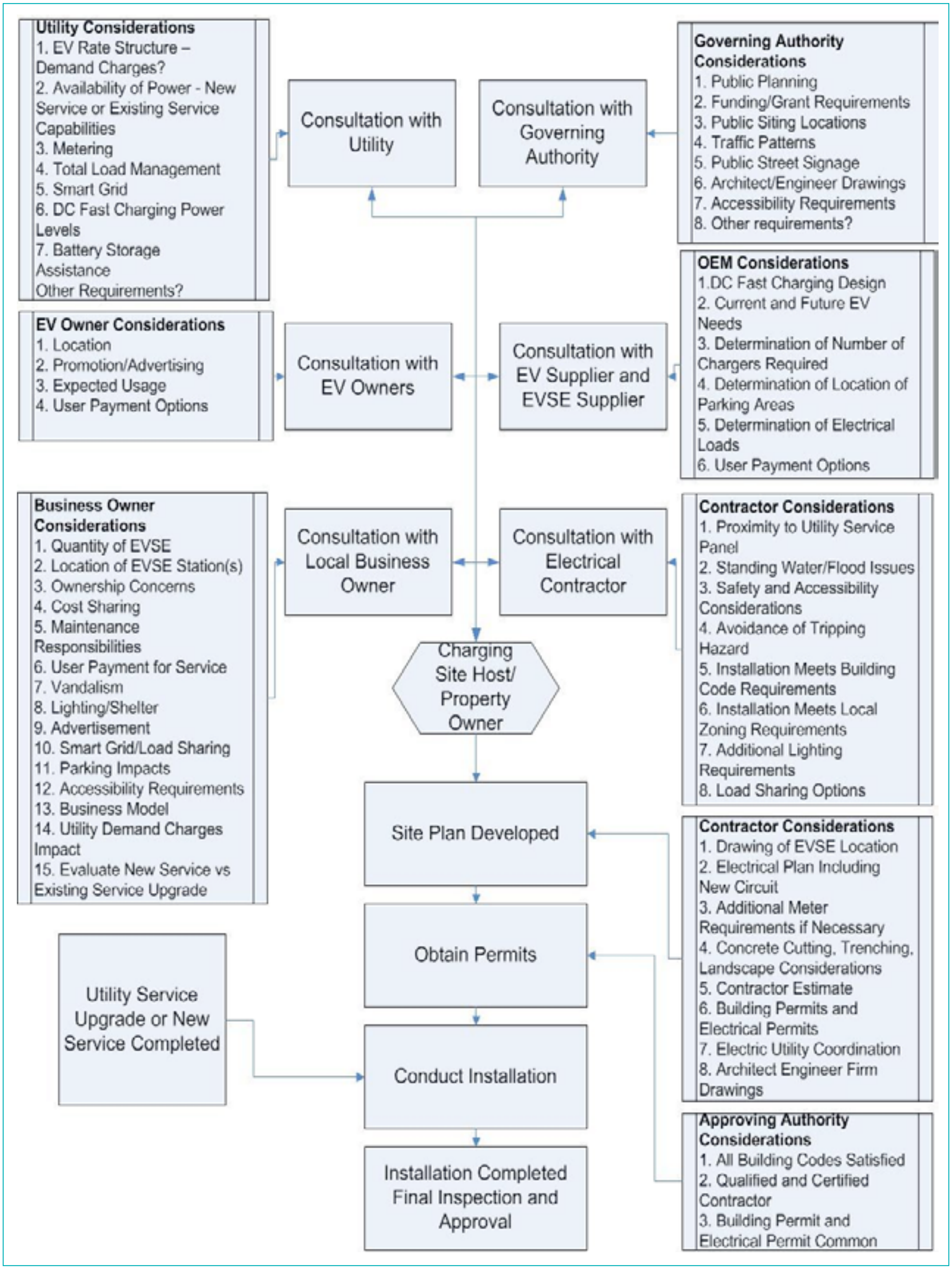

Figure 6-4
Installation Process for DCFC

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 an advantage in being able to recharge vehicles in much shorter times as compared to Level 2 AC charging as noted in Table 2-1 (Page 2-4). 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 although it is too early to evaluate its effectiveness in specific applications, it is thought that DCFC will have three primary roles:

- 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; however, this can still take hours to recharge a fully depleted battery. For the person wishing to expedite their return trip home, the availability of DCFC will be of interest. The short duration of the charge necessary to substantially increase range makes these chargers particularly attractive to the EV driver who is in a hurry to recharge. In this role, DCFC 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.
- 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. DCFC infrastructure is ideal for these transportation corridors. Drivers will want the shortest time to recharge while en route to their destination and DCFC infrastructure will be able to deliver that capability. In general, DCFC infrastructure should be placed approximately 50 km apart for the convenience of BEV drivers.
- MURB Residents: Some MURBs are designed without assigned parking locations for the residents. Installation of Level 2 AC EVSE is not trivial in these locations as discussed previously. One potential solution for those interested in purchasing a BEV, but 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 MURB residents 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 at 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 to be 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% takes approximately 25 minutes.

6.4 UTILITY CONSIDERATIONS

It is very important to coordinate with the local authority or utility when installing a DC Fast Charger 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 DC Fast Charger 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 the light, medium and heavy usage. Ask the utility provider whether the time of day has any effects on the power pricing. If it does, take the operation times into consideration to avoid higher cost power. The equipment's business models should also be considered to anticipate cost recovery from users. Certain sites may require step down transformers. These transformers can be installed either near the building or near 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 rights to the parking lot or rights 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 the property on which it's being installed to determine the necessary approvals required to obtain the permits and future plans for the removal of the equipment at the end of its 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, EVSE installed for MURB 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 connecting 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 EV 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 (refer to Figure 4-7 for Residential Garage/Car Port; Figure 4-13 for MURBs; Figure 5-8 for commercial charging; Figure 5-9 for commercial fleet operation and Figure 6-4 for DCFC) 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 if 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 detailed site plans for each installation. Several trades may be involved including general contracting, electrical, landscaping, paving, concrete, masonry and communication 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 EVSE and the area around their vehicle in order to connect with the vehicle inlet. Whether indoors or outdoors, this means that the EVSE should be stored or located at a height of no more than 1.2 m (4 ft.) and no 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 for people with special needs. 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.

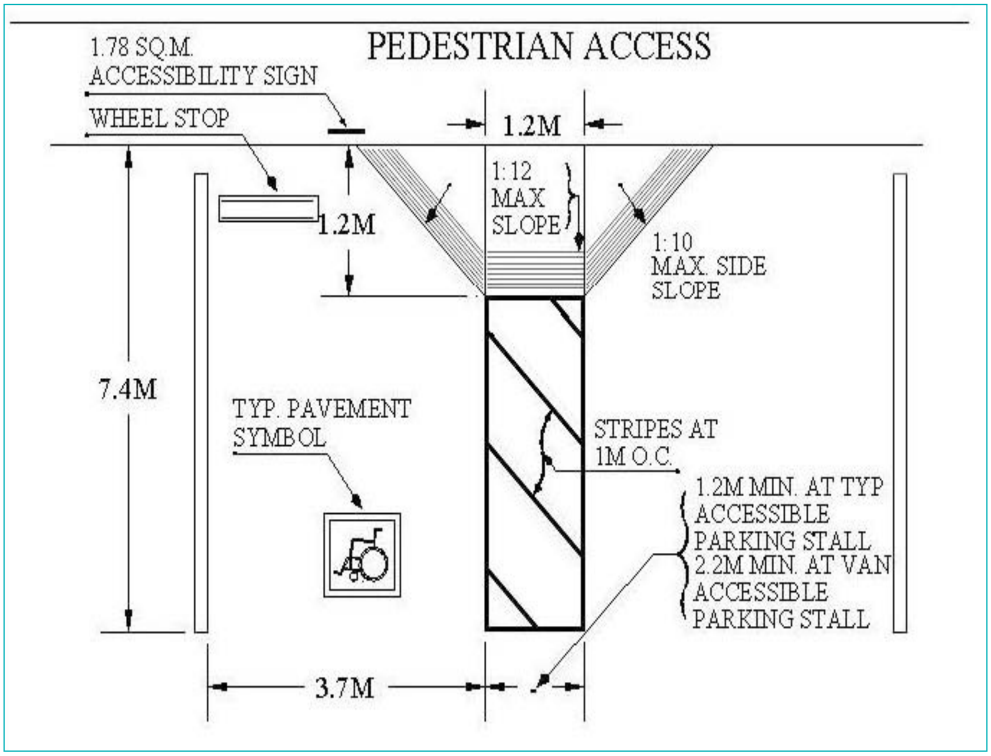

Figure 7-1
Parking Accessibility Requirements

National standards do not exist for dealing with accessibility for EV Parking. Individual jurisdictions in the United States are developing their own requirements based upon interpretations of existing guidelines, but frequently these are confusing and add significantly to the cost of the installation. This subject does require additional study and direction (also refer to Section 11.2 of this report).

7.3 SAFETY PROTOCOLS

7.3.1 Occupational Health and Safety

The Canadian Centre for Occupational Health and Safety 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 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 10 (De-energization & Lockout) and Part 19 (Electrical Safety). These parts will be important in the engineering and design of EVSE installations.

7.3.2 Indoor Charging

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 increases.

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. Nevertheless, the potential of vandalism and the potential measures taken to minimize it should be considered in every installation situation.

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 outdoor 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 ensure that all associated signs, instructions, EVSE controls, tripping hazards and EV inlet locations are visible. Recommendations for lighting levels, including parking structures, can be found in the most current edition of the Illuminating Engineering Society of North America Lighting Handbook.

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

7.4 POINT OF SALE 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 meter and sell electricity in Manitoba. Therefore, the Metered Charging model listed below would not be possible in Manitoba unless it were Manitoba Hydro offering the service. As regulations vary regarding the resale of electricity from one jurisdiction to the next, it is important to review your local regulations before attempting to set 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 that may be incorporated with the EVSE are available. Credit/debit card readers would be simple to use and are already widely accepted by the public.

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 detailed information could be captured in each transaction and used for data recording. The smartcard could be sold as a monthly subscription and imbedded with information on the user. Other payment options include the user prepaying for a preset number of charge opportunities or having their credit card billed for each time of use.

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 is issued, which can be displayed in the vehicle. Using 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.

7.4.3 RFID Subscription Service

Like the smartcard, a Radio Frequency Identification (RFID) fob can be programmed with user information. The RFID reader collects the information from the fob to activate the EVSE. Potential payment options are also similar to those of smart cards including monthly subscriptions, prepaid and linked credit card building.

Note: In the above cases, a communication system from the reader to a terminal for off-site approval and data recording could be required and should be factored into the installation budget.

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 & 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 of implementing AMI technology is the ability to conduct meter readings remotely, thus 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 customer loads, which is an important step in implementing the overall smart-grid system. Making this possible are the significant advances in computer control of lighting, thermostats, appliances and energy management systems that allow them to communicate with the smart meter.

Below is the list of various mechanisms that utilities can use to control EV loads. Note that the availability of these mechanisms varies from region to region.

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" time frame established by the utility. Typically, these off-peak times are in the late evenings through early mornings and/or weekends when the demand on the utility electrical grid is at its lowest point. For residential EV charging, the ability to move the charging times into the peak-off time of day could help delay costly infrastructure upgrades due to higher peak loads.

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 when the utility is experiencing a high demand. The customers are compensated when they participate in these programs to make it worth their while. EVs are one of the better loads for utilities to control as turning off power to a customer's EVSE would not have the same immediate negative effect as compared to turning off their lights or air conditioner. EV owners may participate in such programs in the future as deployment of smart meters becomes 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, an EVSE 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 EVs 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 (i.e., energy can flow both directions) and that the EVSE at the premise also be bi-directional and able to accommodate 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:

208 VAC or 240 VAC / Single Phase, 4-wire (2 Hot, GND, Neutral), 40A 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 & EV 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 an efficient, large scale and rapid build out of "communicating EVSE infrastructure" in support of 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:

- Communication systems and multiple modes of communications including wireless, cellular, local area network and ZigBee that allow for flexible and ubiquitous network connection. The EVSE nodes may be inherently designed as "smart" units whose interactive features are fully enabled when activated with any internet protocol 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 behaviour, 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 a utility-sponsored program.

The process is typically accomplished as follows:

- Customer subscribes to utility service program through a curtailment service provider (CSP) which authorizes 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 the 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 behaviour. In this case, customer education is critical to drive them toward voluntary best-practice charging behaviour such as only charging during off-peak 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 typically lower. 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 or hourly market prices – allows a more automated response to capitalize on lower off-peak rates. In this case, advanced EVSE 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.

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 will 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 refuelling.

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 only apply 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 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 a different approach. The traditional "load shed" techniques do not apply, because of the user 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 behaviour will likely deviate between BEV owners and 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 where available. If the commercial host is enrolled in a TOU 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
- Tiered pricing can be implemented where shorter/faster charge sessions are priced higher than longer/slower charge rates. Customers could accept and activate that upon initiation of charging
- 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 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.

8.4.2.1 Additional Signals Influencing Charging Behaviour

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 behaviour 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 signalled 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 signalling 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 EV charge infrastructure requires planning on a macro scale, such as throughout a province, or a large city, and on a micro scale, such as a major employer, retailer or residence. This section outlines the key cost factors at both macro and micro levels that should be considered when deploying EVSE.

9.1 GEOGRAPHICAL COST FACTORS

EVSE investment made into EV charge infrastructure deployment across large geographic areas requires planning and data analysis. Deployment across a large city, a large employer, a 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 & Vandalism Risk
- Retail Density
- Traffic Corridors
- Disability Requirements
- Proximity to Destinations
- Even Distribution
- Visibility
- Codes & Standards
- Population Density
- Future Growth Areas
- Ownership Models
- Availability to Drivers
- Reserved Parking
- Level 1AC, Level 2 AC or DCFC
- Signage
- Revenue Generation/Cost Recovery
- Grid Impact

9.2 LEVEL 1 AND LEVEL 2 AC COST FACTORS

There are a number of cost factors related to installing/operating EVSE that can cause the cost of one operation to vary greatly from the next. A number of these factors are listed below and should be taken into consideration before making the decision to install EVSE:

- Labour Costs
- Equipment Costs (EVSE, electrical panel, transformers, etc.)
- Material Costs
- Permit Fees
- New Construction vs. Retrofit
- Conduit/Cable Routing
- Distance from EVSE to Car Plug
- Electric Panel Size & Location
- Existing Capacity of Electrical System
- Cost of Electrical Service Upgrades
- Use of Existing Receptacles
- Proximity of Power Access
- Trenching or Boring Costs
- Concrete/Asphalt Repair (Damage from trenching)
- Maintenance Costs
- Electric Rates/TOU
- Charger Access (Shared vs. Single User)
- Shelter Requirements
- Barriers/Bollards/Wheel Stops
- Ventilation Requirements

9.3 DC FAST CHARGE STATION INSTALLATION COST FACTORS

Many of the same cost factors as listed in Section 9.2 exist for the installation of DCFC stations. The voltage and amperage of the DCFC may require a new electrical service and additional coordination with the local utility company. In addition, electric utility demand rates, if any, can increase the cost of operation of a DCFC station.

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 in Table 10-1 below, with 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
Alta Link	http://www.altalink.ca/
Antigonish Electric Utility	http://www.townofantigonish.ca/elec.html
ATCO Electric	http://www.atcoelectric.com/
BC Hydro	http://www.bchydro.com/ev 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/ https://www.bullfrogpower.com/business/factsheets/EV_fact_sheet.pdf http://www.bullfrogpower.com/about/vision.cfm
Burlington Hydro	http://www.burlingtonhydro.com/ 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 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/ http://www.hydroottawa.com/residential/saveonenergy/community/chevy-volt/
Hydro-Quebec	https://www.hydroottawa.com/ 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/ 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/
Newfoundland Power Inc.	https://secure.newfoundlandpower.com/
Northland Utilities (NWT) Limited	http://www.northlandutilities.com/
Northland 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 http://shareready.nspower.ca/
Nunavut Power	http://www.nunavutpower.com/home/
Oakville Hydro	http://www.oakvillehydro.com/ 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 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 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/ 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 vary in their degree of readiness for EV and EV infrastructure deployment. Listed below are links to each Provincial Government website. These websites (Table 10-2) 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 under the province name. In cases where EV information is currently unavailable, please use the links provided to contact your Province directly for information on how to proceed with EVSE installation. 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 http://www.energy.alberta.ca/Electricity/pdfs/SmartGrid.pdf
British Columbia	http://www2.gov.bc.ca/ http://www2.gov.bc.ca/ http://www.empr.gov.bc.ca/RET/TransportationPolicyPrograms/plug-in/Pages/default.aspx http://www.livesmartbc.ca/incentives/transportation/index.html
Vancouver Site	http://www.veva.bc.ca/home/index.php
Manitoba	http://www.gov.mb.ca/ http://www.gov.mb.ca/iem/energy/initiatives/hybridvehicles.html http://www.gov.mb.ca/iem/energy/transportation/images/elec_vehicle_road_map.pdf
New Brunswick Climate Change Policy	http://www2.gnb.ca/content/gnb/en.html http://www.gnb.ca/0009/0369/0015/0002-e.asp
Newfoundland 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	No website
Ottawa	http://www.cflco.nf.ca/
Durham Site	http://www.coopsjb.com/
Prince Edward Island	http://www.emera.com/en/home/default.aspx
Quebec	http://www.enersource.com/Pages/index.aspx http://www.enersource.com/about-enersource/MediaRoom/Enersource Drives into the Future.pdf
Saskatchewan	http://www.enmax.com/home.html
Yukon	http://www.enwin.com/

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 in Table 10-3. Please refer to the links provided for general EV information, location of public infrastructure networks and EV progress throughout Canada. As developments in EV technologies and adoption rates increase, many new resources for prospective EV owners will become available.

Table 10-3 Canadian National Links

EV Society	http://www.evsociety.ca/index.php 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 EV Technology Roadmap	http://canmetenergy.nrcan.gc.ca/transportation/hybrid-electric/329
Canadian Energy Efficiency Alliance (CEEA)	http://www.energyefficiency.org/index.html
Transport Canada: EV 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 are 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 (Table 10-5) 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 expected to be released in the near future.

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 links listed below in Table 10-6 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 EVs 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 (Table 10-7) 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/
EV 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 were frequently vacant giving the visible impression that EVs are not being adopted. Such locations were also prone to frustrating ICE drivers who did not appreciate the preferential treatment given to EV users. 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 a preferred parking space.

When installing EVSE, it is more cost effective 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 mount vs. pedestal EVSEs can also help to reduce installation costs.

11.2 ACCESSIBILITY REQUIREMENTS

Section 7.2 addresses Accessibility Requirements. When preparing for EVSE installations in the United States for The EV Project, it was realized that there were no national accessibility guidelines for the installation of EVSE. Consequently, some EVSE suppliers and local jurisdictions approving permits ignored the subject. Others wishing to be fully compliant with strict interpretations of accessibility requirements created conditions where the installation of EVSE would be impossible or so cost prohibitive that no host would agree to install the equipment. As a result, several organizations initiated studies to consider what accessibility 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

Encouragement of the adoption of EVs can be supported by the public availability of the EVSE. Public availability of the EVSE means that the EVSE 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 discovered 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.

Signage standardization is important as it has been found that without regulation, drivers of ICE vehicles will not recognize the EV symbol as restrictive and will park in the designated locations. This is particularly true when the parking locations are 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 it is not recommended that the sign read “EV Parking Only”, since providing a place for EVs to park is not the incentive. Providing a place to “charge” is the incentive. With that in mind, an EV that is not charging should not be taking up a designated changing space.

When designing laws and regulations to ensure designated EV charging stalls are available to EV drivers, it is important to exercise moderation when deciding on penalties for those who choose to break them. In some situations penalties were so severe that they acted as disincentive for eligible EV drivers, which were counterproductive to the adoption of EVs by the general public.

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 a routing of the electrical supply to the garage. Landscaping may be disrupted during the installation process, which may be of great significance to the owner and should be thoroughly planned in advance.

11.4 INSTALLATION QUOTES

It has been found that requesting two quotes by the electrician/contractor before installing EV 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 the inspections required.

11.5 FUTURE EXPANSION ALLOWANCES

When installing EVSE infrastructure in new or existing sites, the planning team should consider oversizing or running additional conduit to allow additional charging stations. This will help to expedite and lower the cost of future infrastructure expansion.

11.6 ZONAL COMPLIANCE

Every province and their regions have different zoning requirements 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 a household circuit for an electric 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 discourage potential EV adaptors.

11.8 EVSE INFRASTRUCTURE PLANNING

Various approaches to EVSE infrastructure planning are being developed. Some are using a geographic information systems (GIS) approach to finding the ideal locations based upon traffic flows, land use planning, employment locations, EV owner 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 MOTIVATORS

Depending on the situation, the primary motivation for installing EVSE can vary greatly from one scenario to the next. Below are some common EVSE site selection motivators:

- Create a public symbol to promote EV use
  - If the motivation is to provide a highly visible location that can be used as a public symbol for promotional purposes; care must be taken to insure that it is will also be a highly utilized and accessible unit.
- Generate Revenue
  - If generating revenue is the primary motivator, choosing a location with high user turnover would be desired. A good example would be a medical office with a steady flow of patients throughout the day. A poor example would be a long term parking lot at an airport.
- Customer Incentives
  - Some businesses may look to provide onsite EVSE to entice their EV driving customers to frequent their business. A good example would be a restaurant parking lot.

- Employee Incentives
    - Employers may wish to incent their employees to adopt EVs by providing free charging at their place of business. Before doing this, it is recommended that the employer review their personnel policies to ensure that they are not unfairly providing benefits to certain employees over others.
- Promote Charging Access
    - Public stations may be installed to promote charging access for those users who don't have easy access to EVSE at their residence. An example of a good location would be a high density neighbourhood where residents live primarily in MURBs who rely on street parking or whose buildings do not have on site EVSE.

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 behaviour. 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 the EVSE is available for charging; and charging demand – as in, 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.

Interpretation of Figure 11-1 would show that at 4 a.m., at no time during the quarter, there were less than approximately 25% of the residential EVSE in operation and no 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.

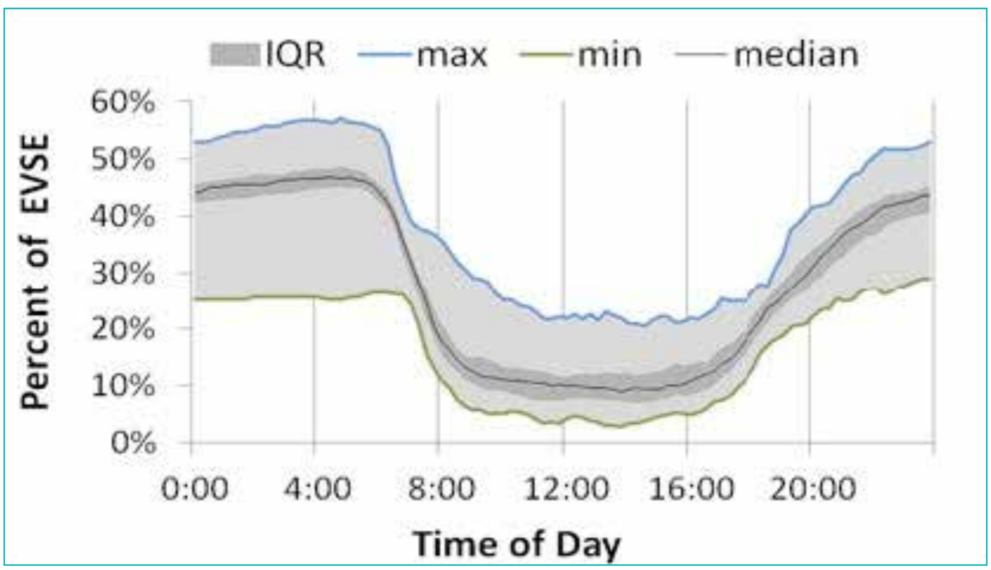

Figure 11-1
Weekday Residential EVSE Availability in Nashville, TN

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

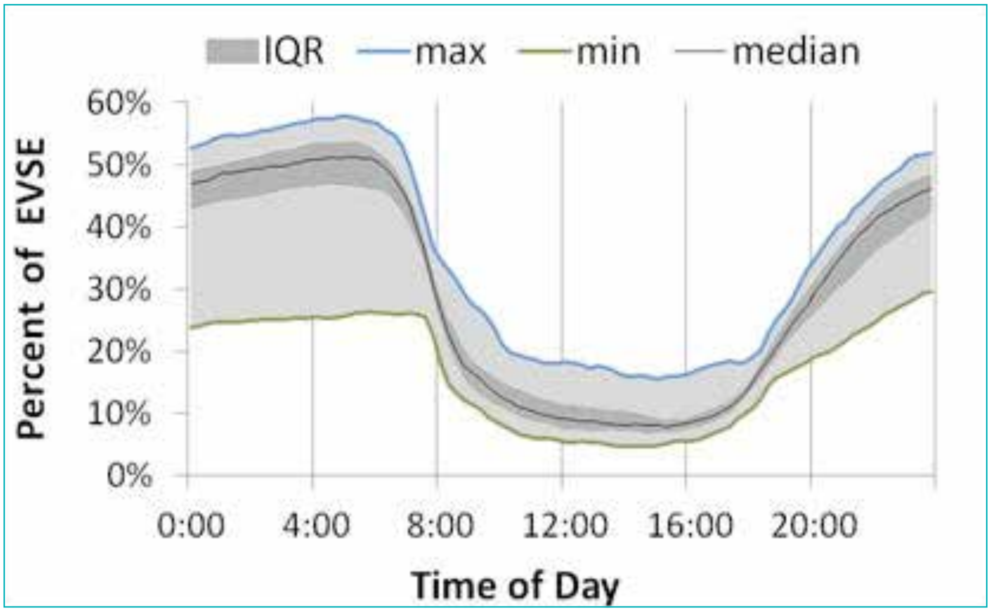

Figure 11-2
Weekday Residential EVSE Availability in San Francisco

The graph shown in Figure 11-2 of San Francisco shows a consistent EV driver behaviour 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.

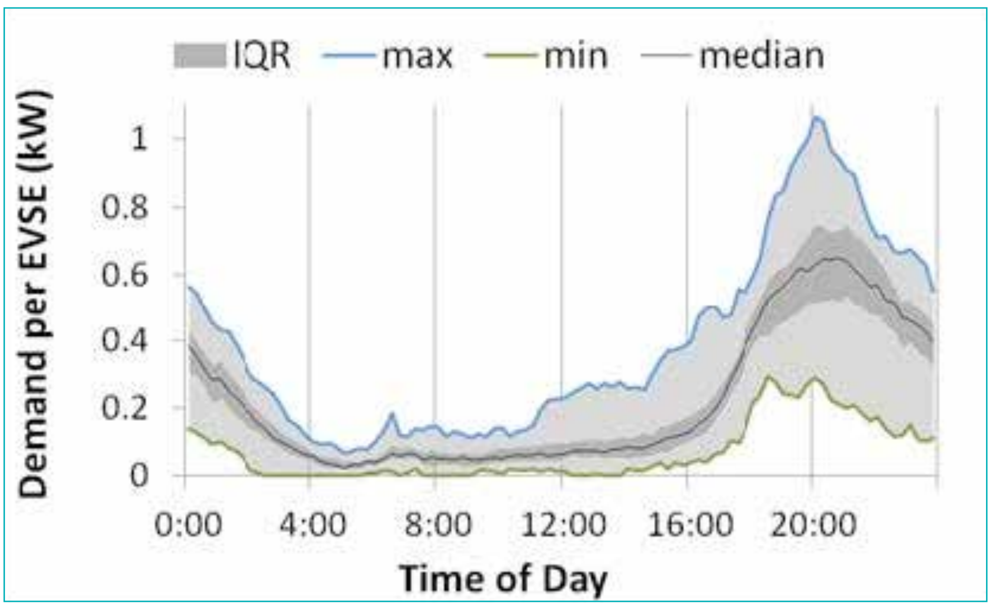

Figure 11-3
Weekday Residential EVSE Charging Demand Nashville

The charging demand curve follows the availability curve in Figure 11-3 very closely, 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.

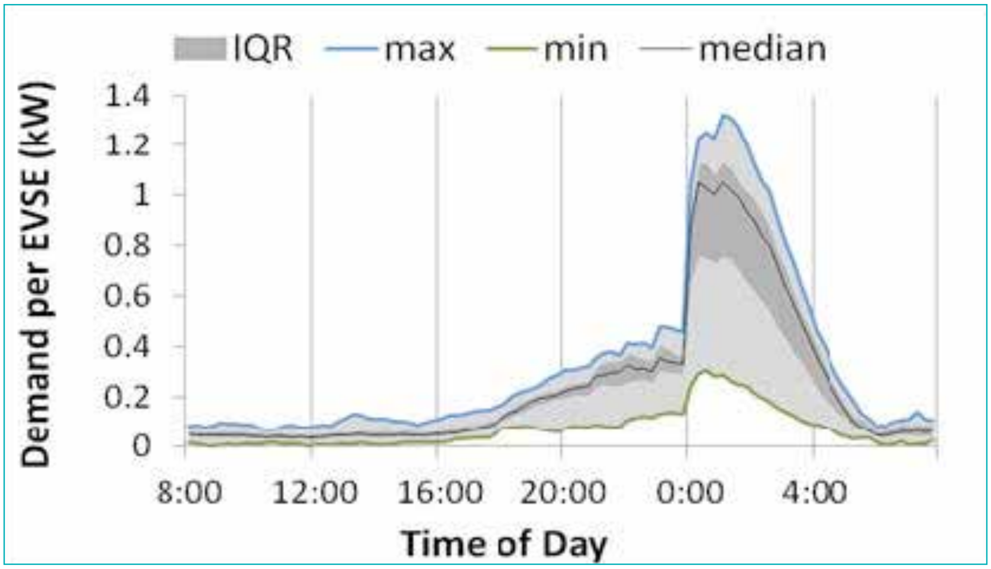

Figure 11-4
Weekday Residential EVSE Charging Demand San Francisco

Figure 11-4, which shows the charging demand curve for San Francisco, has a dramatic increase at midnight, and thus the scale was adjusted to depict this effect more clearly. While the EVs were plugged in at the same time of the day as those in Nashville, the actual charge events did not start until midnight. The significant difference between Nashville and San Francisco is that the electric utility in San Francisco has a 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 behaviour.

This also points out additional issues for consideration by the utilities that 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 and is anticipated to produce significant data on EV owner behaviour. Results of the study will be posted at www.THEEVPROJECT.com at no cost to the user.

11.11 DC FAST CHARGER 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 of electricity users. That is, a separate charge may be assessed to a facility for the peak demand that it may draw above a 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 DC Fast Charger (e.g., 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 disincentive 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 DC Fast Charger operators to exempt them from demand charges. 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 DC FAST CHARGER INSTALLATION

While the process for installing a DC Fast Charger 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 equipment 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 a DC Fast Charger 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 200A at 208 VAC to 71A at 600 VAC. More typically, the unit is installed with a maximum current of 89A 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 AC and DCFC. However, the site permitting requirements have generally required more architect and engineer support with more detailed site drawings and calculations. In the case of the Blink DC Fast Charger, the advertising screen required another plan review with the local authority having jurisdiction over outdoor advertising.

Locating the DC Fast Charger in the parking lot is similar to that for Level 2 AC. However, there is a slight distinction when considering accessibility requirements. With Level 2 AC 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 for coming to the facility is to visit the facility, not to charge. Thus all the accessibility requirements listed as follows are important:

- Being able to exit the vehicle and approach the EVSE
- Use the accessibly designed EVSE
- Complete the charger connection with the vehicle
- Provide an accessible route to the facility.

For DCFC, the primary purpose for coming to the facility 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, which is the accessible route to the facility, may not be required. Depending upon where the DC Fast Charger is located, a route to the facility that meets all the slope and obstacle requirements associated with an acceptable accessible route can add significant cost to the project.

The EV Project has found that installation costs for the DCFC typically range from $15,000 to $25,000 not including the charger. 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 reduce costs.

11.13 LEVEL 2 AC WITH DCFC

A DC Fast Charger can serve several purposes, including a backup to the local community Level 2 AC network 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 Level 2 AC network with the presence of the Level 2 AC EVSE. Thus, placing Level 2 AC EVSE near the DCFC equipment on site is becoming common. The costs for Level 2 AC installation are reduced when installed at the same time as the DCFC equipment.

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 units but they can be significantly higher than the Level 2 AC EVSE. Consequently, new business models are in development for the ownership, operation and maintenance of DCFC equipment. 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 equipment.

As another potential revenue stream for the charging site host or managing third party, advertising is a common design feature for some DCFC locations. 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 add an additional source of revenue.

11.15 INSTALLATION AT A GASOLINE REFUELLING STATION

Installation of EVSE at gasoline refuelling stations has certain advantages in that the public is comfortable in accessing these locations for vehicle refuelling and they are readily available. Considerable effort has been expended in market research on the part of the owners to site these facilities in ideal traffic locations, and these facilities frequently have convenience stores attached where the driver may browse and purchase items while the EV is charging, which may be of more interest to EV drivers,. Many fuel station providers consider providing electric refuelling as an extension of their business. Because of the nature of the site, DCFC may be the most appropriate type of EVSE to be considered at these refuelling locations since driver stay times are typically short.

Installation at gasoline refuelling stations does have additional complications. Specific areas of these refuelling stations are classified as hazardous locations per the National Electric Code14 in the United States and the CEC15 in Canada. These are identified as Class 1 - Flammable gases, vapours or mists exist that may concentrate to produce flammable or explosive danger; Class 1 Division 1 locations are where this may occur as part of normal operations, and Class 1 Division 2 locations are where these gases are handled or processed. The installation requirements require that the DCFC station be located outside the Class 1 Division 1/2 locations. ECOtality also found that the DCFC station was required to be located greater than 25 feet from the tank field where the fuel tanks are filled. Figure 11-6 shows a typical gasoline refuelling station with the hazardous areas identified. It also shows two potential locations for the DCFC station.

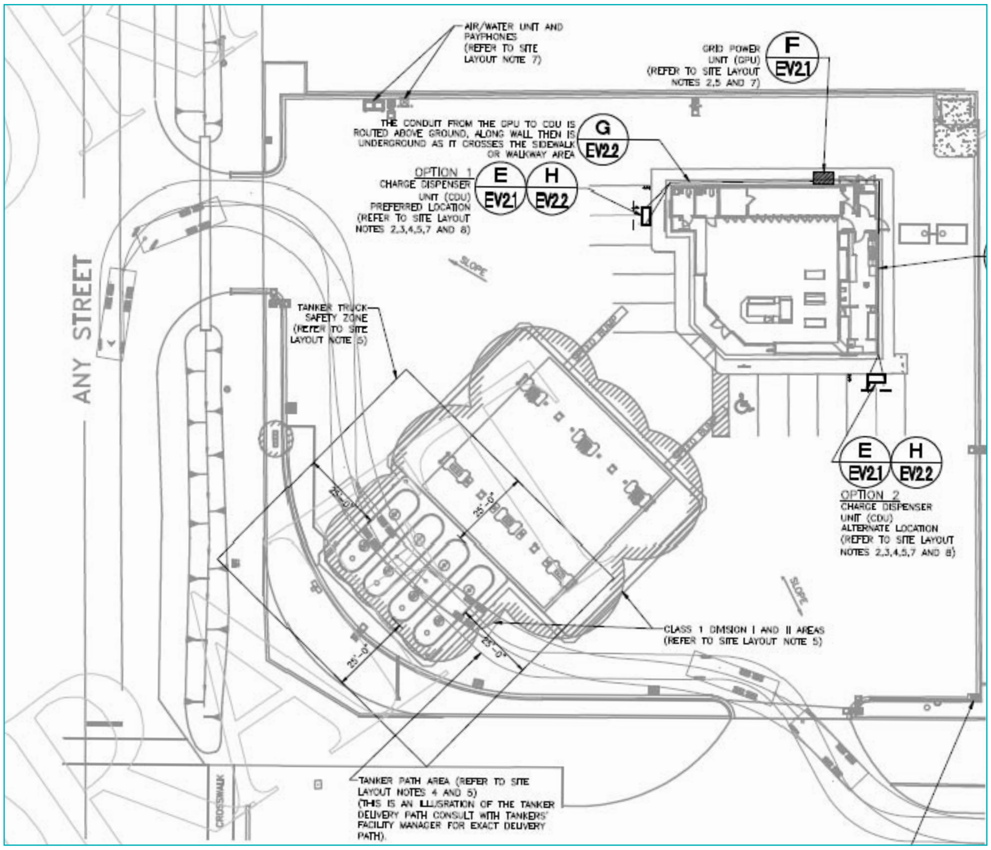

Figure 11-6
Typical Gasoline Station with Hazardous Areas Identified

Gasoline refuelling stations also consider the "tanker pathway," which is the path the tanker will use when entering, refilling tanks and exiting the refuelling station. Frequently this path will cross parking locations near the convenience facility. An additional requirement found desirable was that the DCFC station should not be within or interfere with the tanker pathway. The DCFC site should also avoid the areas established for air/water/vacuum amenities so that it does not cause access issues or interference. As previously discussed, local jurisdictions should be consulted for any additional or specific site design requirements.