Electric Vehicle Charging Infrastructure Deployment Guidelines British Columbia

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ELECTRIC TRANSPORTATION ENGINEERING CORPORATION

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Purpose

The “Electric Vehicle Charging Infrastructure Deployment Guidelines” was developed by BC Hydro with support from Natural Resources Canada with the intent that other jurisdictions across Canada could readily adapt the guidelines to support the deployment of charging infrastructure in their region.

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Electric Vehicle Charging Infrastructure Deployment Guidelines

1. Introduction

The increasing public desire to reduce carbon emissions and transportation dependency on petroleum products is driving public interest and policy to alternative fuel sources and design. Most of the automotive manufacturers are either currently producing or planning to produce Electric Vehicles (EV) or Plug-in Hybrid Electric Vehicles (PHEV) to address this interest. While other modes of alternative energy for vehicles will require dramatic changes and new supporting infrastructure, electricity is generally available throughout British Columbia and can support rapid adoption of EVs and PHEVs.

Establishing Electric Vehicle Charging Infrastructure Guidelines is an essential first step in building a successful infrastructure within the Province of British Columbia (BC). EV and PHEV have unique requirements that internal combustion vehicles do not. In general, the stakeholders are currently not familiar with these requirements. These stakeholder groups include but are not limited to public user, installers, engineers, personnel involved with regulatory approvals, planners, home owners, building owners, strata councils, building developers, building managers, parking lot owners and developers, fleet managers, retail and commercial operations managers, electrical engineers, electricians, and EV owners. Although not intended to be an installation manual or as a replacement for approved codes and standards, these Guidelines provide the necessary information for understanding these requirements and the related governing authority references so that successful planning, design, permitting and construction will lead to successful adoption of EVs and PHEVs in British Columbia.

Section 2 provides an overview of the charging process and governing regulations. The details of the varied charging scenarios are presented in Section 4 following the discussion of current technology and charging equipment designs. Section 5 addresses unique utility interconnection requirements and planning for future features and benefits including “Grid to Vehicle” and “Vehicle to Grid” scenarios. Numerous other topics from Energy Monitoring and Billing to Load Management are included.

In the mid 1990s, a surge of conversion and Original Equipment Manufacturer (OEM) electric vehicles were introduced in selected markets. Although wide adoption did not follow at that time, there were many lessons learned during that process. It is clear that public acceptance and adoption is essential for a successful integration of EVs and PHEVs into public and private transportation. Whereas future developments and directions are not always clear, these guidelines will attempt to project requirements into the 20-year life expectancy. That is addressed in Section 6. Finally, Section 7 will address the anticipated costs associated with establishing this infrastructure for the widely varying scenarios.

The end goal for all involved is the public acceptance and satisfaction with the EV or PHEV. A major component of that is the streamlining of the private Electric Vehicle Charging Equipment (EVCE), also known as Electric Vehicle Supply Equipment (EVSE), permitting and installation process as well as the public and commercial availability of charging locations. Unlike other internal combustion vehicles, the buyer of many EVs and PHEVs may not be able to drive off the dealer’s lot with all the equipment desired for charging. These guidelines are intended to anticipate the questions and requirements to ensure customer satisfaction.

2. Reference Legislation Codes and Standards in BC

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

A. Regulatory Agencies

The *Local Government* Act is the primary legislation for regional districts and improvement districts, setting out the framework for governance and structure, as well as the main powers and responsibilities. Certain municipal provisions remain in effect for matters not covered by the Community Charter. As well, the Act covers important authorities for both municipalities and regional districts, such as statutory requirements for elections, and planning and land use powers. The Act also includes key provincial powers such as authority for the BC Building Code and the office of the Inspector of Municipalities.

The Government of British Columbia's Ministry of Housing and Social Development through Building and Safety Policy Branch, provides policy advice on British Columbia's building regulatory system and is responsible for the BC Building Code (including Plumbing Services) and the BC Fire Code related to safety, health, structural sufficiency and accessibility for persons with disabilities.

The Building and Safety Policy Branch, is responsible for developing and implementing a modern legislative framework for regulating safety in the design, construction and occupancy of buildings. Central to this requirement are the British Columbia Building Code and British Columbia Fire Code. The BC Building Code is based on the model National Building and Plumbing Codes and is adopted by the province with minor modifications specific to British Columbia. The 2006 BC Building Code came into effect on December 15, 2006.

The Building and Safety Policy Branch is also responsible for management of the administrative agreements with eight local governments to administer electrical safety programs within their own jurisdiction. Like the BC Safety Authority, these local governments were delegated this authority under the *Safety Standards Act*, effective April 1, 2004.

Administration of safety services has been delegated in part to the BC Safety Authority (BCSA) which is an independent, self-funded corporation that inspires safety excellence in British Columbia by partnering with business, industry, institutions and the general public to enhance the safety of technical systems, products, equipment and work.

The BCSA licenses residential, industrial and commercial electrical contractors to perform electrical work and maintains records on these licensed contractors. An electrical contractor is required to name a qualified Field Safety Representative.

Applicants who have the necessary qualifications, and pass a written exam, are issued a FSR Certificate of Qualification authorizing them to accept the responsibility for installing, maintaining, operating and repairing electrical products. BCSA is responsible for certifying FSRs. Electricians performing installation of EVSE must be qualified and any permits required by the authority having jurisdiction must be in place.

In BC, the Canadian Electrical Code (CEC) is adopted: with variations, as the BC Electrical Code under the *Safety Standards Act* and administered by the BC Safety Authority. The CEC is a standard published by the Canadian Standards Association (CSA) for addressing the installation and maintenance of electrical equipment. It is prepared and revised by experts and stakeholders representing all interested groups. Eight local governments administer their own electrical safety program and administer this Code. The current CEC standard addressing safety standards for electrical installation is C22.1-09 (Part I). The current CEC standard addressing off-board charging system equipment for recharging Electric Vehicles is C22.2 No. 107.01 Section 17. British Columbia's adoption of this standard is pending.

The Building and Safety Policy Branch is also responsible for management of the administrative agreements with eight local governments to administer electrical safety programs within their own jurisdiction. Like the BC Safety Authority, these local governments were delegated this authority under the *Safety Standards Act*, effective April 1, 2004.

Established as a Crown Corporation under the authority of the *Homeowner Protection Act* the Homeowners Protection Office is responsible for licensing residential builders and building envelope renovators province-wide, administering owner builder authorizations, monitoring the performance of the third-party home warranty insurance system underwritten by the private sector and administering financial assistance programs for owners of water-damaged homes.

The *Engineers and Geoscientists Act* of British Columbia is administered by the Association of Professional Engineers and Geoscientists of British Columbia (APEGBC). The primary duty of the Association is to uphold and protect the public interest respecting the practice of professional engineering and the practice of professional geoscience. In meeting its primary regulatory mandate. APEGBC establishes, maintains and enforces standards for the qualifications and practice of its members and licensees. This includes those practicing in the field of electrical engineering.

The City of Vancouver has initiated the "Green Homes Program" that mandates that all new homes be equipped with a cable raceway that runs from the building's electricity panel directly to the vehicle parking area where an empty outlet box will be supplied. At this writing, the conductors are to be installed at the time of the EVSE installation but consideration is being given to changing the requirement so as to fully complete this circuit.

In January 2006, British Columbia initiated the Modernization Strategy to respond to the need for change in the building regulatory system. This Strategy will roll out in several phases over several years and may impact the permitting and inspection phases by identifying a "Certified Professional" permit approval stream. A CP may be desirable for streamlining the permitting, installation and inspection of EVSE installation projects. The

Building and Safety Policy Branch and BC Safety Authority are actively involved in these discussions.

Canadian Standards Association is very active in the Council for Harmonization of Electrotechnical Standardization of the Nations of the Americas (CANENA), and other organizations involved in facilitating trade in electrical and electronic products. CSA technical committees are reviewing draft CANENA electrical safety standards for their potential to become CSA standards, thereby harmonizing the standards initially within North America. Among the projects for harmonization are the Canadian Electrical Code and the National Electric Code (US) and certain other projects identified below. The harmonization will help to eliminate technical barriers to trade. Because of this harmonization effort, references to codes or standards that exist in the United States but not in the same manner in Canada are discussed for information.

B. Charging Power

For clarity, the terms used to identify the components in the delivery of power to the vehicle are defined first.

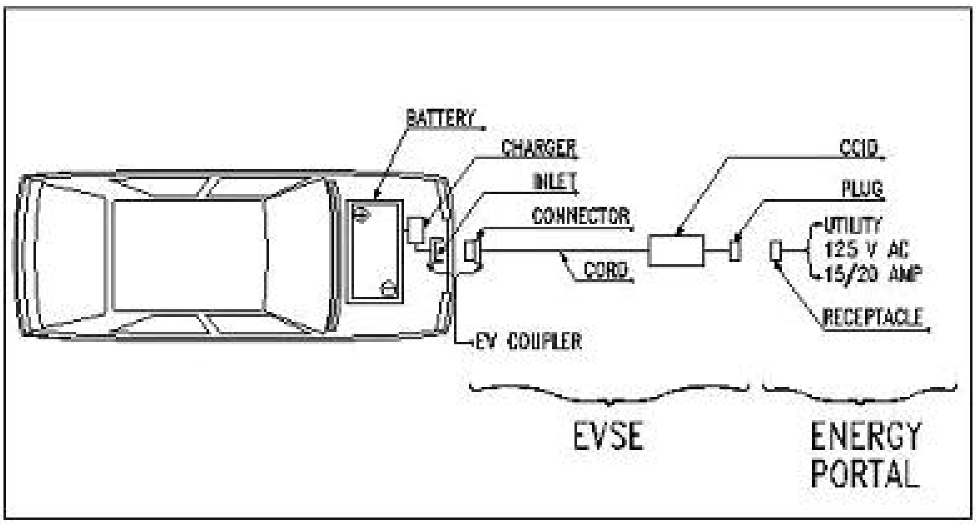

Figure 2-1 Level 1 Charging Diagram

The EV battery is located on-board the vehicle. Power is delivered to the onboard battery through the EV Inlet. The Inlet is considered part of the EV. A connector is a device that, by insertion into an electric vehicle inlet, establishes an electrical connection to the electric vehicle for the purpose of charging and information exchange. The inlet and connector together are referred to as the coupler. The EVSE consists of the cords, connector, attachment plugs, and all other fittings, devices, power outlets, or apparatus installed specifically for the purpose of delivering energy from the premises wiring to the electric vehicle. As will be seen below, the interface between the EVSE and the Utility's premises wiring may be a direct "hard-wire" or plug and receptacle interface.

In the United States 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. Three charging levels were defined by EPRI and codified in the

National Electric Code (NEC) (see Section E below) along with the corresponding functionality requirements and safety systems. EPRI published a document in 1994 that describes the consensus items of the IWC[1]. Although the Canadian Electrical Code (CEC) does not specifically address the charging power in terms of "levels", there is correlation as outlined in the following subsections.

Note that for Level 1 and 2, the conversion from AC to DC occurs in the vehicle on-board charger. AC power is delivered from the utility power into the vehicle for conversion. In Level 3 the conversion from AC to DC power typically occurs off-board so that DC power is delivered to the vehicle. AC Level 3 (delivering high-power AC directly to the vehicle) is defined within the SAE J1772 document, but this approach has never been implemented.

- **Level 1 – 125 volt AC**

The Level 1 method uses a standard 125VAC branch circuit that is the lowest common voltage level found in both residential and commercial buildings. Typical amp ratings for these receptacles are 15 or 20 amps. Level 1 charging is an important aspect of the infrastructure because of the widespread availability of these circuits. Consequently, companies that currently provide vehicle conversions to electric and future EV and PHEV suppliers will likely provide a Level 1 Cord Set (125 VAC, 15/20 amp) with the vehicle. (See the Level 1 Charging figure above.) With a rating of 15 amps, the actual current draw is limited to 12 amps so the Cord Set will draw approximately 1.4 kW of power.

Figure 2-2. Level 1 Cord Set[2]

Level 1 charging typically uses a standard 3 prong electrical outlet (NEMA 5-15R/20R). The Cord Set uses a standard 3-prong plug (NEMA 5-15P/20P) 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 will be the design approved by the Society of Automotive Engineers in their Standard J1772. This connector will properly mate with the vehicle inlet also approved by J1772. The J1772 standard is the subject of a harmonization project with the Canadian Electrical Code Part II Standards.

[1] "Electric Vehicle Charging Systems: Volume 2" Report of the Connector and Connecting Station Committee
[2] Conceptual Design for Chevy Volt, *Electrifying the Nation, PHEV Summit*, Tony Posawatz, January 2009

Figure 2-3 From Left to Right; Typical 125v 15 amp Plug, 20 amp Plug and 20 amp Receptacle

Level 1 charging at 20 amps is specifically recognized in the CEC Section 86 for dedicated EV charging. (Note that the CEC derates branch circuits to 80% for continuous duty so the usable capacities for the above circuits would be 16 amps.) The dedicated circuit requires the use of NEMA 5-20R for the premises receptacle. Many electrical utilities provide a rate structure that considers on-peak and off-peak hours. Home owners may desire to install a timer device in this circuit to control charging to off-peak times.

Because charge times can be prolonged at this level, many EV and PHEV owners will be more interested in Level 2 charging. Some EV providers suggest their Level 1 cordset should be used only during unusual circumstances when the Level 2 EVSE is not available, such as when parked overnight at a non-owner's home.

- **Level 2 – Greater than 125 volt AC or greater than 20 amps**

Level 2 is typically described as the "primary" and "preferred" method for the EVSE both for private and public facilities and specifies a 240 VAC, single phase branch circuit. The J1772 approved connector allows for current as high as 80 amps AC (100 amp rated circuit). However, current levels that high are rare and a more typical rating would be 40 amps AC which allows a maximum current of 32 amps. This provides approximately 7.7 kW.

This level of charge provides the higher voltage that allows a much faster battery charge restoration. The Level 2 method also employs special equipment to provide a higher level of safety required by the CEC and NEC.

The Society of Automotive Engineers (SAE) has been working to standardize the method of coupling for automakers and EVSE suppliers. A standard EV Coupler will be used by EV and PHEV suppliers following the final acceptance of this approved standard. The Coupler and EV Inlet will be the same for both Level 1 and 2 charging. The onboard charger will measure the inlet voltage and determine the available current from the EVSE through the pilot signal and adjust accordingly.

Figure 2-4 J1772 Connector (Preliminary)

Figure 2-5 J1772 Connector and Inlet (Preliminary)

In addition, when connected, the vehicle charger will communicate with the EVSE to identify the circuit rating and adjust the charge to the battery accordingly. Thus an EVSE that is capable of delivering 25 amps will deliver that current even though connected to a 40 amp rated circuit.

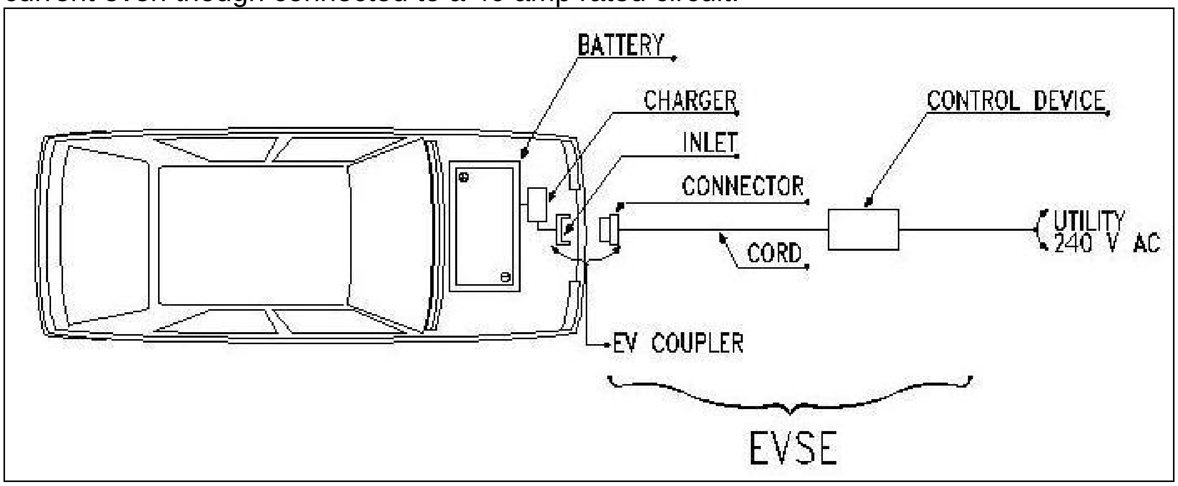

Figure 2-6 Level 2 Charging Diagram

Figure 2-7 Level 2 Charging

J1772 identifies specific requirements for Level 2 charging. As J1772 is a harmonization project, it is expected these requirements will be included in CSA and CEC requirements. These requirements provide:

- The EV Coupler (EVSE connector and vehicle inlet) must be engineered to prevent inadvertent disconnection,
- The EV Coupler must have a grounded pole that is first to make contact and the last to break contact,
- A charge current interrupting device (CCID) must shut off the electricity supply if it senses a potential problem that could result in electrical shock to the user,
- The EV power inlet must be de-energized until it is attached to the EVSE,
- The EV Coupler must contain an interlock device which prevents vehicle startup while connected,
- The vehicle inlet must de-energize prior to removal of the connector,
- The EV Coupler is unique to EV and EVSE charging and cannot be used for other purposes,
- The EVSE must be tested and approved for use by Underwriters Laboratory Canada (ULC) or Underwriters Laboratory (UL), or a similar nationally recognized, independent testing lab.
- The EVSE must be able to initiate area ventilation for specific batteries that may emit potentially explosive gases.

Companies designing Level 2 EVSE will incorporate these requirements. As noted above, many electrical utilities provide a rate structure that considers on-peak and off-peak hours. Many Level 2 EVSE suppliers will provide controls in the EVSE to control charging to programmable times but if not, home owners may desire to install a timer device in this circuit to control charging times.

- **Level 3 Charging**

Level 3 charging or “Fast Charging” is for commercial and public applications and is intended to perform similar to a commercial gasoline service station in that charge return is rapid. Typically, this would provide a 50% recharge in 10 to 15 minutes. Level 3 typically uses an off-board charger to provide the AC to DC conversion. The vehicle’s on-board battery management system controls the off-board charger to deliver DC directly to the battery.

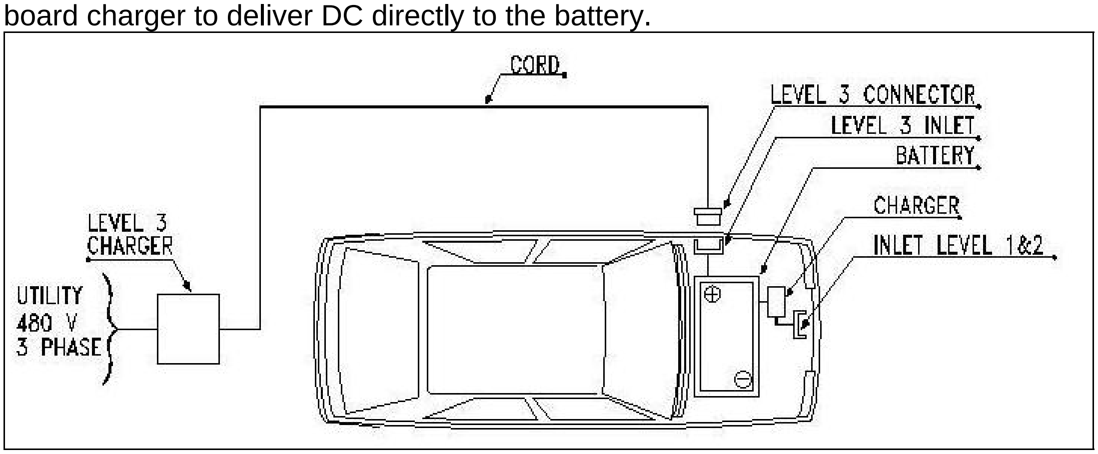

Figure 2-8 Level 3 Charging (DC Charging)

This off-board charger is serviced by a three phase circuit at 208, 480 or 600VAC. The SAE standards committee is working on a Level 3 connector, but has placed the highest priority in getting the Level 1 & 2 connector approved first.

The Level 3 connector standard is expected to be approved in 2010. It is expected it will require the cord set be permanently attached to the EVSE and the EVSE hard wired to the electrical service. Level 3 charging was accomplished for the Chrysler EPIC in the 1990s and it is anticipated that similar, though smaller, equipment will be available for future use.

Note: Although not as common, a vehicle manufacturer may choose not to incorporate an on-board charger for Levels 1 and 2, and utilize an off-board DC charger for all power levels. In this case, the plug-in vehicle would only have a DC charge port. Another potential configuration that may be found, particularly with commercial vehicles, is providing 3-phase power directly to the vehicle. This configuration requires dedicated charging equipment that will be non-compatible with typical public infrastructure.

Figure 2-9 Level 3 Off-Board Charging (90kW)

C. CSA and UL

The **Canadian Standards Association** (CSA) is a not-for-profit association composed of representatives from government, industry, and consumer groups. It sets performance and safety standards for equipment in a manner similar to SAE. It acts as a certifying authority in a capacity similar to Underwriters Laboratory (UL) and ULC. Although the CSA standards for EV and PHEV are not the same as in the United States, there is an effort to "harmonize" them whenever possible. It is anticipated that the requirements for EV and PHEV will be harmonized and these Guidelines makes that assumption.

CSA C22.2 No. 107.1-01 General Use Power Supplies applies to EVSE. Specifically Section 17 Electric Vehicle Chargers contains design requirements for the EVSE. In addition, CSA C22.2 No. 107.2-01 Battery Chargers has requirements for battery chargers in general.

Underwriters Laboratories (UL) provides testing and certification that equipment complies with relevant standards especially in areas involving public safety. Harmonization projects are underway on certain electric vehicle requirements with CSA and CEC standards. It is expected Canadian standards will require equipment used to supply power to EVs and PHEVs should be certified to the following Requirements:

- UL 2202 Electric Vehicle (EV) Charging System Equipment
- UL 2231-1 Personnel Protection Systems for Electric Vehicle (EV) supply Circuits: General Requirements
- UL 2231-2 Personnel Protection Systems for Electric Vehicle (EV) supply Circuits: Particular Requirements for Protection Devices for Use in Charging Systems
- UL 2251 Plugs, Receptacles and couplers for Electric Vehicles

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

D. BC Building Code

The 2006 BC Building Code does not specifically address EVs and PHEVs. While changes are anticipated, The City of Vancouver has already initiated the Green Homes Program. This program proactively "…mandates that all new homes be equipped with a cable raceway that runs from the building's electricity panel directly to the garage, where an empty outlet box will be supplied. This little bit of infrastructure will make the future installation of an electric vehicle charging system a snap."[3]

It is anticipated that car ports will be included in this requirement. In addition, the BC Building Code will consider a percentage of parking in apartment and condominium areas be built with such a raceway.

The BC Building Code addresses a difference between small and large structures. Part 9 Housing and Small Buildings refers to structures less than 600 square meters and less than four stories. Part 9 is quite specific in requirements because it was assumed professionals would not be involved in this structure construction. These requirements were not intended for use by developers of larger more complex buildings. Those structures are identified in Part 3 and all other parts of the code are applicable. The discussions in these Guidelines for multi-family dwellings do not consider which part(s) of the BC Building Code apply since they would be specific to the structure.

E. Canadian and National Electrical Codes

The Canadian Electrical Code, CE code, or CSA C22.1 is a standard 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.

Generally legislation 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.

The *Electrical Safety Regulation,* which falls under the province's *Safety Standards Act*, adopted the safety standards for electrical installations, (CSA Standard C22.1 -06) in

[3] http://vancouver.ca/commsvcs/CBOFFICIAL/greenbuildings/greenhomes/electricvehicle.htm

Part I of the Canadian Electrical Code as the *BC Electrical Code Regulation 2006* with amendments as referenced in the Schedule to the regulation. British Columbia Safety Authority's Electrical Safety Program has been responsible for regulating electrical safety in the province, including all types of electrical equipment and installation since April 1, 2004.

The Safety Standards Act, specifically states that the Act is applicable to all local governments, including Vancouver, which is a charter city. The City of Vancouver may have additional requirements as allowed by their charter in *Section 314 of Part XI – Electrical and Gas Works* and therefore should be consulted for specific installation permitting of EVSE.

The Canadian Electrical Code (CEC) provides the standards to which EVSE equipment is designed and electrical contractors must follow when installing electrical components. CEC 2009 provides:

- ***Approved:*** Couplings and inlets shall be specifically approved for the purpose and marked accordingly (CEC 86-202).
- ***Branch Circuit****:* The EVCE branch circuit must be a dedicated circuit and sized for continuous duty of the EVCE and related ventilation equipment. (CEC 86-300, 302)
- ***Disconnect Means:*** A separate disconnecting means shall be provided for each installation of EVCE rated at 60 amps or more or more than 150 volts – to-ground. This disconnect means must be on the electrical supply side to the EVCE, within sight of and accessible to the EVCE and capable of being locked in the open position. (CEC 86-304).
- ***Receptacle and Wall Plug – Level 1****:* A standard 20 amp residential wall plug and receptacle are acceptable for Level 1 charging (CEC 86-306 1 (a)).
- ***Receptacle and Plug – Level 2:*** Receptacles identified in the CEC will be acceptable (CEC 86-306 1 (b)).
- ***Markings****:* All electric vehicle charging receptacles must be clearly and permanently marked (CEC 86-306 (1)).
- ***Ventilation****:* Where the EV battery requires ventilation, adequate ventilation shall be provided in the indoor charging site; the EVSE shall be electrically interlocked with the ventilation so that the ventilation equipment operates with the EVCE; and if the supply to the ventilation equipment is interrupted, the EVCE shall be made inoperable. (CEC 86-400 (2)).
- ***Warning Sign:*** A permanent sign shall be installed at the connection of the EVCE to the branch circuit warning against operation of the equipment without sufficient ventilation (if required by the manufacturer's installation instructions). (CEC 86-200).
- ***Ground Fault Interrupter:*** The receptacle for Level 1 shall be protected with a ground fault circuit interrupter when the receptacle is installed outdoors and within 2.5 m of finished grade (CEC 86-306 (2)).
- ***Hazardous Locations:*** When EVCE is installed in hazardous locations as defined elsewhere in the Code, those sections apply. (CE 86-102)

The National Electric Code (NEC) in the United States is more restrictive in some cases and is anticipated to provide significant input to the harmonized CSA standards. Appendix A provides comments related to NEC considerations.

F. Occupational Health and Safety

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

Workers Compensation Act (WCA) Division 6 creates and describes the jurisdiction of the Workers' Compensation Board of British Columbia (WorkSafeBC) and its authority to make regulations, inspect workplaces, issue orders and impose penalties. The WCA also explains the rights and responsibilities of employers and workers with respect to health and safety. The COHS Regulation is adopted/amended in British Columbia through legislation and forms the OHS Regulation.

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

G. Signage

In addition to the signs and warnings required by CEC noted above, information signage is recommended for public and commercial access charging stations, including “Parking for Electric Vehicle or PHEV Charging Only”, or if it is an accessible station, signage should be as described in Section I. below. A variety of signs have been used in locations throughout North America. The following signs are typical for use by these guidelines. Standard signage is being addressed for use throughout Canada.

Previous experience has shown that confusion can exist if the signage is blue in color as it can be mistaken for an accessible location. For that reason, green may be chosen for background color. Local control over parking may include penalties for non EV vehicles parking in EV parking stalls. Appropriate signage should be installed when applicable.

Figure 2-10 EV Parking Signs

Wide spread adoption of EV and PHEV will include maps or websites identifying charging locations. It is helpful to post EV parking area signs on adjacent streets and access points directing EV drivers to the charging locations.

H. Lighting and Shelter

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

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

Figure 2-11 Level 2 Public Charging with Shelter and Lighting

In residential garages or car ports, lighting is also important to avoid pedestrians from tripping over extended charge cords while the EV is charging.

I. Disability Requirements

The 2006 British Columbia Building Code provides building accessibility requirements. It does not specifically address accessibility with respect to EVs and PHEVs. In the United States, certain requirements were added to the National Electric Code for EVSE and municipalities provided their guidance for EV parking locations.

It is important that persons with disabilities have access to the EV Coupler and access around the vehicle in order to connect with the vehicle inlet. Whether indoor or outdoor, this means that the EV Coupler should be stored or located at a height of not more than 1.2 m (4 ft) and not less than 600 mm (24 in.) above the parking surface. These requirements are similar to the BC Building Code for elevator controls in that the maximum height is 1370 mm above the floor with 1100 mm being the preferred maximum and 890 mm above the floor for the minimum height.

In addition, accessible parking stalls should be provided. An accessible stall is 3.7m (9-foot) wide by 7.4m (18-foot) deep which includes an access aisle of 1.2 m (5 feet) on the passenger side. A van accessible space is the same size with a 2.2 m (8 foot) 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 the wheelstop.

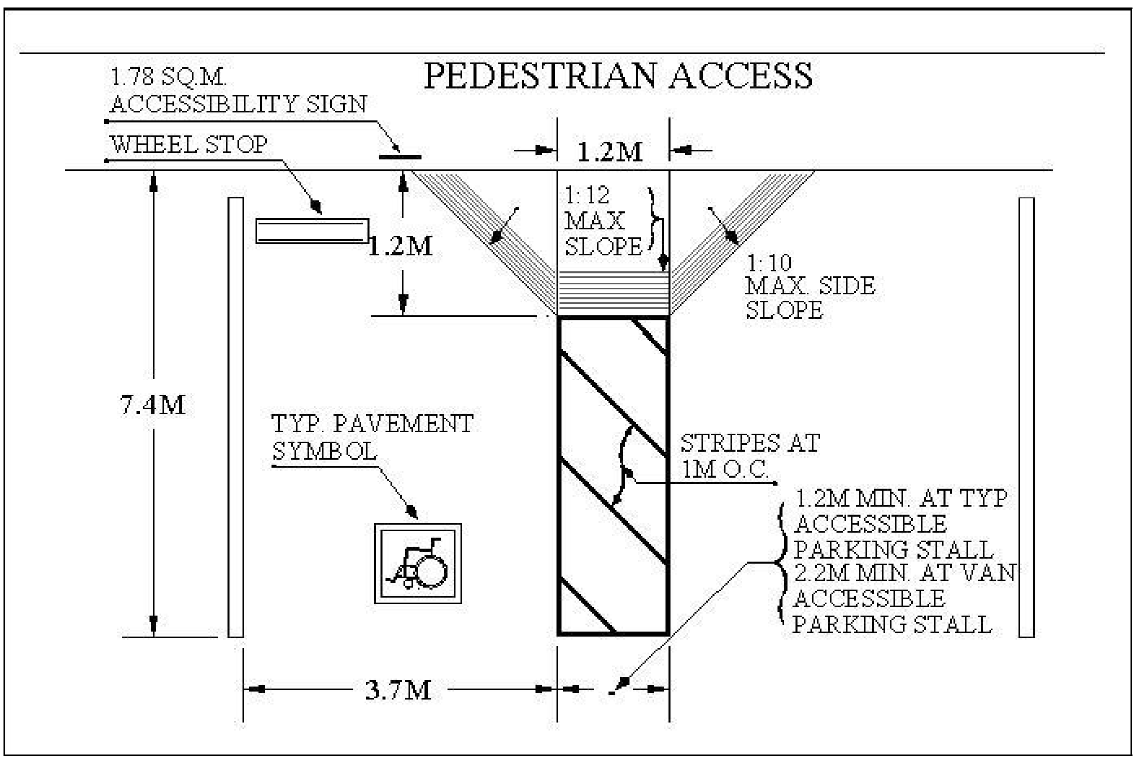

Figure 2-12 Parking Accessibility Requirements

EV parking should be provided in premium locations similar to accessible locations. Because stalls containing EVSE should be for EVs only, the accessible parking stalls should be in addition to those required by the BC Building Code for parking.

The BC Building Code requires where parking is provided that contains more than 50 parking stalls, parking stalls for persons with disabilities shall be provided in the ration of 1 for every 100 or part thereof. Where there are EV charging stations included in the parking area, for every 25 parking stalls with EVSE, one should be accessible. For every 10 accessible stalls, one should be van accessible.

EV Parking Stalls	Accessible Stalls	Van Accessible Stalls
1	1	1
2-25	1	1
26-50	2	1
51 – 75	3	1
76 – 100	4	1

Table 2-1 Accessibility Requirements

EV accessible parking stalls are not exclusive in that EV drivers who do not need accessibility requirements may park in these locations if they are the last space available for charging.

Figure 2-13 Typical Sign for Accessible Parking

J. Block Heater Circuits

A Block Heater is an electric heater that warms the engine of a vehicle 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. A warmer engine is easier to start. The block heater is typically powered by a standard 125 vac, 15 amp circuit with a standard 5-15R receptacle and the block heater cord extends through the vehicle grill to connect to this receptacle.

Figure 2-14 Typical Block Heater with cord

Typical block heaters are rated at approximately 700 watts or 0.7 kW. As noted above, a typical Cord Set for an EV would draw approximately 1.4 kW or twice the power as a block heater.

These electrical outlets may be common in outdoor public parking areas, apartments and condominiums. In some locations, these circuits are cycled with the power on for 20 minutes and off for 20 minutes. As such, these circuits are not in continuous use and local power panels and transformers are sized accordingly.

It is likely that new EV and PHEV owners will attempt to use the electrical outlets for their Cord Sets. Current use of block heater circuits is primarily at night. It will be so also for those using Cord Sets. However, the interrupted power will likely double the re-charge time and leave disappointed EV and PHEV drivers. Building codes may require labeling or metering block heater circuits to indicate the cycling nature of the power.

At this writing, automotive manufacturers developing PHEVs are planning only one power inlet to the vehicle. That is a separate block heater circuit will not be required. The power provided by the cordset or the Level 2 EVSE will be utilized in the vehicle thermal preconditioning cycles as required by the vehicle. The engine of a PHEV is very unlikely to be the primary motive power when the battery is charged and will start when the battery reaches “charge sustaining” operation. The thermal management system in the vehicle comprehends all of the cooling/heating loops in the vehicle.

K. Safety Issues related to Indoor Charging

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

Recognizing that hydrogen is lighter than the air mixture, concentrations would exist near the ceiling. The ventilation system should take this into account to exhaust high and replenish lower.

The CEC identifies three classes of hazardous locations in Section 18. Class I are locations in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive gas atmospheres. Class II locations are those that are hazardous because of the presence of combustible or electrically conductive combustible dusts. Class III locations are those that are hazardous because of the presence of easily ignitable fibers or flyings. This Section provides restrictions or conditions under which EV charging may occur depending on specific class attributes.

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 area. In addition, Section 20-114 states that connectors, plugs, and vehicle inlets shall not be located in hazardous areas defined in this section.

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 lighted and when combined with the tight access around the vehicle and other equipment stored in and around the vehicle parking stall, the possibility of personal injury from tripping exists.

L. Installations Located in Flood Zones

Permits for construction of facilities, including EV charging stations, include reviews to determine whether the site is located in a flood prone area. In the United States, the Code of Federal Regulations, Title 44 Emergency Management and Assistance, Part 60 Criteria for Land Management and Use includes the following requirement:

> "If a proposed building site is in a flood-prone area, all new construction and substantial improvements shall (i) be designed (or modified) and adequately anchored to prevent flotation, collapse, or lateral movement of the structure resulting from hydrodynamic and hydrostatic loads, including the effects of buoyancy, (ii) be constructed with materials resistant to flood damage, (iii) be constructed by methods and practices that minimize flood damages, and (iv) be constructed with electrical heating, ventilation, plumbing, and air conditioning equipment and other service facilities that are designed and/or located so as to prevent water from entering or accumulating within the components during conditions of flooding."[4]

For EVSE components, the two primary ways to minimize flood damage, prevent water from entering or accumulating and be resistant to flood damages involve elevation or component protection. These measures are required by the National Flood Insurance Program (NFIP).

Elevation refers to the location of a component above the Design Flood Elevation (DFE). That is the primary protection for EVSE. All locations approved for EVSE

[4] 44CFR60.3(a)(3)

installation should be above the DFE. It may mean that the EVSE is located outside a garage if inside would be below the DFE. It may mean that certain areas of a condominium parking lot would not contain any EVSE if that elevation is not achievable. It may require EVSE charging stations on the third level of a parking garage instead of the first.

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

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

Dry floodproofing refers to the elimination or minimization of the potential for flood damage by implementing a combination of waterproofing features designed to keep floodwaters completely outside of a structure.[5] If the entire building is protected from flood water, the EVSE is also protected.

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

3. Plug-In Vehicle Technology

This section describes the basic plug-in vehicle technologies that are either available in the market place or coming to market in the near future. The focus of this section is on vehicles licensed for the road 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 fuel energy requirements. Two main vehicle configurations are described along with the three main categories of vehicle applications. Vehicle types and their relative sized battery packs are discussed in relationship to the kind of charging infrastructure recommended.

A. Vehicle Configurations

- **Battery Electric Vehicle (BEV)**

Battery Electric Vehicles (BEVs) are powered 100% by the battery energy storage system available on-board the vehicle. Refueling the BEV is accomplished by connection to the electrical grid through a connector system that is design specifically for this purpose. Most advanced BEVs have the ability to recapture some of the energy storage utilized through regenerative breaking (In simple terms, converting the propulsion motor into a generator when breaking). When regenerative breaking is applied, BEVs can typically recover 5 to 15 percent of the energy used to propel the vehicle to the vehicle speed prior to breaking. Sometimes manufacturers install solar photovoltaic (PV) panels on vehicle roofs. This typically provides a very small amount of energy relative to the requirements of propelling the vehicle, but integrating PV in the roof can typically provide enough power to operate some small accessory loads.

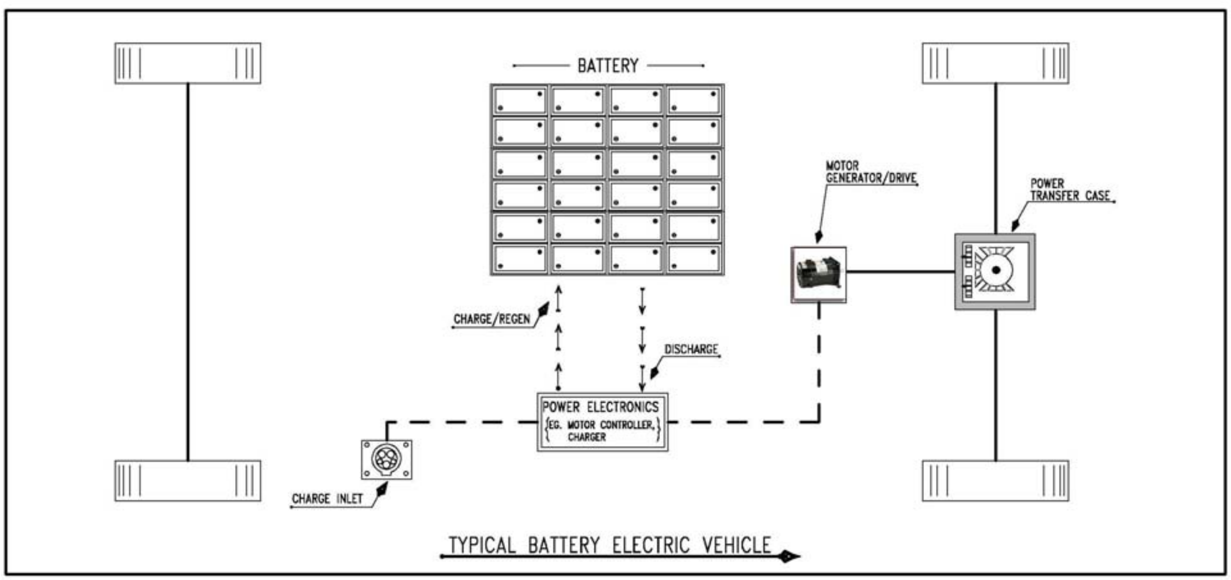

Figure 3.1 Battery Electric Vehicle Block Diagram

A typical BEV can be depicted by the block diagram shown in Figure 3.1. Since the BEV has no other significant energy source, the battery must be selected to meet the BEV range and power requirements. BEV batteries are typically an order of magnitude larger than the batteries in hybrid electric vehicles.

- **Plug-in Hybrid Electric Vehicle (PHEV)**

Plug-in hybrid electric vehicles (PHEVs) are powered by two energy sources. The typical PHEV configuration utilizes a battery and an internal combustion engine (ICE) power by either gasoline or diesel. Within the PHEV family, there are two main design configurations, a Series Hybrid as depicted in Figure 3.2 and a Parallel Hybrid as depicted in Figure 3.3. The Series Hybrid vehicle is propelled solely by the electric

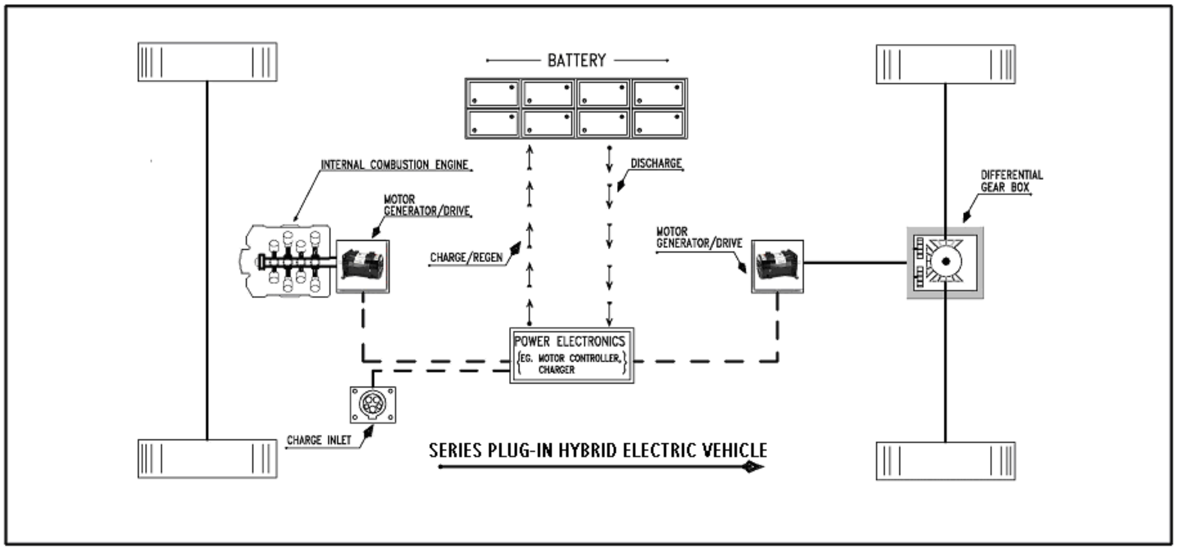

Figure 3.2 Series Plug-In Hybrid Vehicle Block Diagram

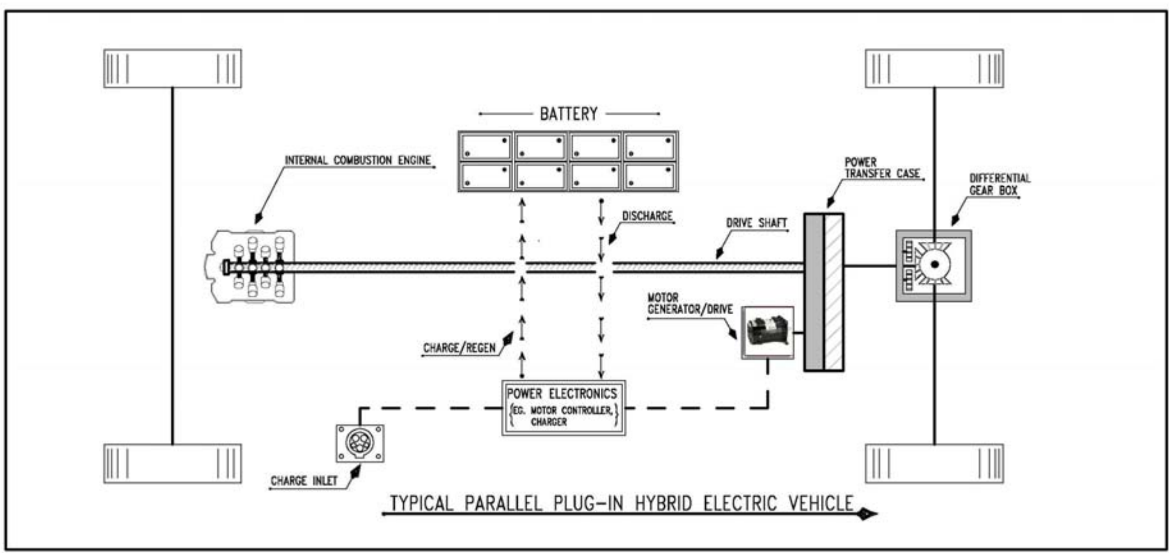

Figure 3.3 Parallel Plug-In Hybrid Vehicle Block Diagram

drive system, whereas the Parallel Hybrid vehicle is propelled by both the ICE and the electric drive system. As with a BEV, a Series Hybrid will typically require a larger and more powerful battery than a Parallel Hybrid vehicle in order to meet the performance requirements of the vehicle solely based on battery power.

B. Plug-In Vehicle Types

Plug-In electric vehicles have been the vehicle of choice in a number of applications including golf carts, industrial lift-trucks, airport ground support equipment and low speed vehicles. The focus of this document is on vehicles licensed for use on public roads. This category can be broken down into the following areas:

1. On-Road Highway Speed Vehicles

   On-Road Highway Speed Vehicle is BEVs or PHEVS capable of driving on all public roads and highways. Performance is similar to ICE vehicles.

2. City Electric Vehicles

   Traditionally, City Vehicles have been BEVs that are capable of driving on most public roads, but generally are not driven on highways. Top speed is typically limited to 88 km/hr (55 mph).

3. Low Speed Vehicles (LSVs)

   Low Speed Vehicles (LSVs) are BEVs that are limited to 40.3 km/hr (25 mph) and can typically operate on public streets posted at 56 km/hr (35mph) or less.

4. Commercial Vehicles

   There are a number of commercial plug-in vehicles including commercial trucks and buses. These vehicles are found as both BEVs and PHEVs. Performance and capabilities of these vehicles are specific to their application.

Over the course of history, plug-in vehicles licensed for use on public roads have had limited success. Although at the turn of the century, electric was the preferred vehicle of choice, with the invention of the engine starter and the proliferation of gasoline stations, electric soon gave way to ICE vehicles. There was a surge of plug-in vehicles in the 70s due to a scare of a gasoline shortage, and again in the mid-90s driven mostly by the Zero Emission Vehicle Mandate from the California Air Resources Board which was ultimately modified to allow the major car companies to implement fuel cell demonstrations.

Today, there are a number of factors driving commercial production of plug-in vehicles for the highway including improved battery technologies, continued regulatory pressures, competition, rising petroleum fuel costs and the general public acknowledgement that there is a limited supply of petroleum and that vehicle tail-pipe emissions are a major source of pollutants. Currently, all major car companies are developing plug-in vehicles and a growing number of start-up car companies with the sole purpose of developing and commercializing plug-in vehicles.

C. Batteries

- **Battery Technology**

The recent advancements in battery technologies will allow plug-in vehicles to compete with ICE vehicles in performance, convenience and cost. Although lead-acid technology serves many plug-in applications like material handling and airport ground support equipment very effectively and is a cost-effective solution, the limitations on lead-acid energy density and cycle life made application to highway plug-in vehicles less practical.

Today, most major car companies utilize Nickel-Metal-Hydride batteries in their hybrid cars and they are looking at various Lithium based technologies for their next generation plug-in vehicles, both BEV and PHEV. Lithium provides 4x the energy of lead-acid and 2x that of Nickel-Metal-Hydride. The materials for Lithium based batteries are generally considered abundant, non-hazardous and lower cost than Nickel based technologies. The current challenge with lithium-based technologies is scaling the battery modules to a traction battery sized cell from the current consumer-type cells while maintaining safety, quality, cycle life and lowering production costs.

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

- **Relative Battery Sizes**

One of the challenges to building a plug-in infrastructure is determining the appropriate size of the charge circuit. This is especially difficult in public situations where the station will serve a plug-in vehicle with as little as a 3 kWhr battery packs to as large as 40 kWhrs or more. Typically, PHEVs will have smaller battery packs because they have more than one fuel source. BEVs rely completely on the storage from their battery pack for both range and acceleration and therefore require a much larger battery pack than a PHEV for the same size vehicle.

Battery size can also be influenced by the vehicle weight since more energy is required to move heavier vehicles. A larger vehicle may carry more people and thus again use more energy. While individuals frequently ask how long a recharge will take, it really depends on the state of charge of the battery which is influenced by the weight of the vehicle, the driving habits of the owner and the relative flatness or hilliness of the terrain to be driven. All these factors weigh into making calculations regarding range of the vehicle and recharge times. In general, Table 3.1 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. The other factors of weight, terrain and driving habits will determine how rapidly the battery is discharged and thus the frequency of recharging necessary.

EV manufacturers often provide instrumentation to alert the driver to the rate of battery depletion while driving so owners of EVs will quickly learn how to modify their driving habits to conserve battery charge.

Table 3-1 Battery Sizes and Relative Charge Times

Type of Vehicle	Typical Usable Battery Capacity (kWhrs)	Level 1 Convenience Charger Time (hours)	Level 1 20 amp Circuit Time (hrs)	Level 2 Charge Time (hours)	Level 3 Charge Time (minutes)
DC Power to Battery		***1.1kW***	***1.5kW***	***6kW***	***60kW***
PHEV-10 (mid-size)	4	3.6	2.7	.67	4
PHEV-20 (mid-size)	8	7.3	5.3	1.3	8
PHEV-40 (mid-size)	16	14.5	10.7	2.7	16
BEV (mid-size)	35	31.8	23.3	5.8	35
City EV (Economy)	20	18	13.3	3.3	20
LSV	8	7.3	5.3	1.3	8
Commercial Hybrid Bus (40ft Transit)	40	n/a	n/a	6.7	40

4. Charging Scenarios

This section covers the details of installation of EVSE in several different locations. Costs for residential garage, car ports, and apartment or condominium complexes, commercial and public parking charge stations are significantly driven by the siting requirements for each environment.

The first consideration for an EV or PHEV owner will be whether to use Level 1 or Level 2 EVSE. Several factors will weigh in on this decision including type of vehicle, size of vehicle, size of battery, expected driving habits with the vehicle, cost, and availability of other public/commercial charging. A PHEV generally has a smaller battery and shorter charge time requirements. Level 1 may be sufficient whereas full Battery EVs may consider Level 1 to be a back-up strategy only. Larger, heavier EVs will consume more power than smaller, lighter ones. An owner who plans on using the EV for local, short trip use only may find Level 1 to be sufficient whereas an owner who plans longer trips or more frequent trips even within the local area may find it inadequate. Owners desiring Level 2 equipment will need to consider the cost of the Level 2 EVSE and its installation whereas the Level 1 circuit may already be present in their garage. EV owners who have the opportunity for Level 2 charging at work or in public areas may find the vehicle battery remains at a higher charge and thus the home charging time is not a concern. EV owners who elect local time of use options with the utility (i.e. off-peak charging) may find that the reduced charge time is insufficient for Level 1 charging. Local educational materials from vehicle manufacturers or conversion suppliers should be prepared to assist the owner in this decision process based upon local demographics.

A. General Requirements

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

Cord Length: The EVSE will provide a maximum of 7.63 meters (25 feet) of flexibility from the wall location to the EV Inlet. This figure was obtained by taking the typical 4.5 meter (15 foot) car length to the 2 m (7 foot) car width plus 1 meter (3 feet) to the EVSE permanent location. The EV Inlet location on the EVs and PHEVs will vary by manufacturer; however, this standard length should be sufficient to reach from a reasonably positioned EVSE to the Inlet.

Tripping hazard: An extended EV cord may present a tripping hazard so the EVSE should be located in an area of minimum pedestrian traffic. An alternative would be to consider installation of an overhead support or trolley system to allow the cord to hang above the vehicle in the location of the EV inlet.

Ventilation Requirements: If there are ventilation requirements, the EVSE will be required to energize a properly sized ventilation system. Such a requirement is expected to be rare since automobile manufacturers are expected to use non-gassing batteries. Some EV owners who convert their own vehicles to electric or purchase conversions vehicles may use gassing batteries. The approved EVSE will communicate with the vehicle and if ventilation is required but no ventilation system exists, the EVSE will not charge the vehicle. In multi-family or parking garage situations that may already have ventilation systems for exhaust of normal vehicle emissions, such a system would be expected to be sufficient. However, calculations should verify this result. It may also be impractical to wire the charger to the ventilation controls or costly to run the system for a single vehicle charging. In these cases, it may be prudent to identify that the chargers are intended for non-gassing batteries only.

Energized Equipment: Unless de-energized by the local disconnect, the EVSE is considered electrically energized equipment. Because it operates above 50 volts, Part 19 Electrical Safety of the Occupational Health and Safety (OHS) Regulation requires guarding of live parts. The requirements for accessible of the connector positions the EVSE so that physical means may be required for protection. Wheel stops are recommended to prevent a vehicle from contacting the EVSE. They also help position the EV for the optimum location for charging.

Figure 4-1 Wheelstop[6]

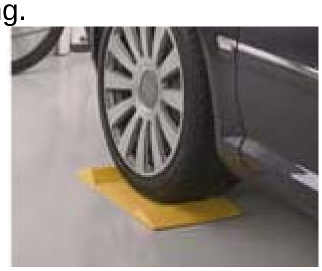

Figure 4-2 Garage Wheel Stop[7]

Shortest Run: In addition to the above requirements, the lowest cost installation generally is the location closest to the electrical supply breaker because it minimizes the conduit run to the charger.

Ergonomics/Ease of Use: Most EV owners will find it most convenient to have the EVSE located near the EV inlet. In some cases, it may be desirable to back into the garage which helps reduce the tripping hazard while at the same time reduces the electrical circuit run to the EVSE.

B. Single Detached Dwellings

- **Siting Requirements**

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

  The installation of the EVSE at the front of the vehicle may be acceptable unless the cord becomes a tripping hazard. Often the EVSE will be placed on an exterior wall to shorten the distance from the electrical box and at the same time positioning the EVSE out of the way.

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

If the EVSE is to be installed after the EV has been purchased, the location of the EV Inlet will play a part in the location of the EVSE. It is best to keep the EVSE as close to the inlet as possible to minimize the cord splayed on the floor. If the branch circuit is installed prior to the EV purchase, the garage junction box should be on the wall closest to the utility service connection consistent with the general requirements above. Typical locations are shown in the figure below.

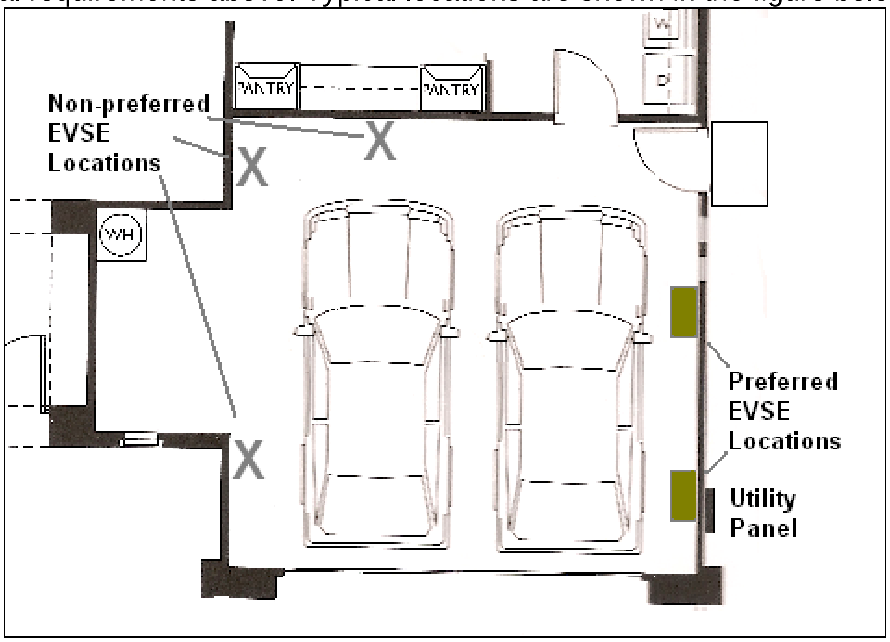

Figure 4-3 Typical Double Garage Location for EVSE

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

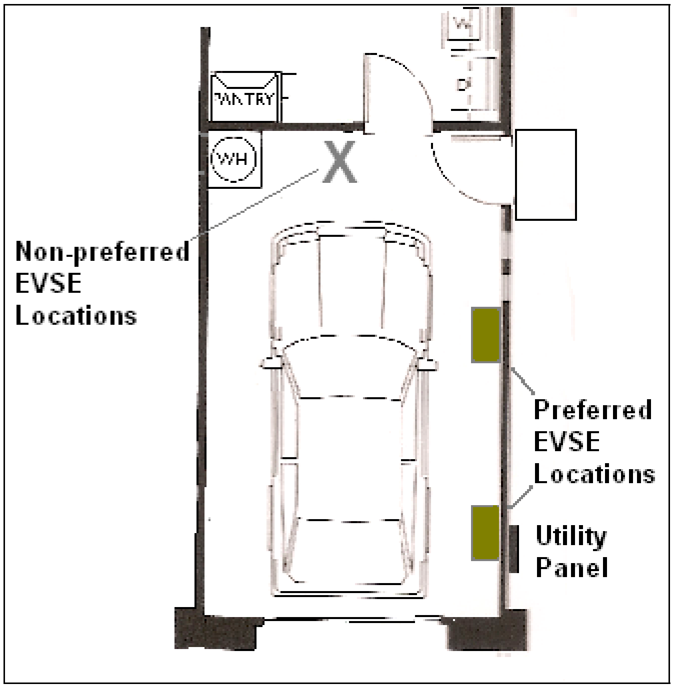

Figure 4-4 Typical Single Garage Location for EVSE

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

The CEC provides additional requirements should the EVSE be located in a hazardous area. The 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 include additional considerations in routing the electrical supply to the garage. Landscaping will be disrupted during the installation process. This may be of great significant to the owner and should be thoroughly planned in advance.

- **Installation Process**

Installation of the EVSE in a residential garage typically consists of installing a dedicated branch circuit from an existing house distribution panel to an EV outlet receptacle (125 VAC, 20 A) in the case of Level 1 charging or an EVSE (operating at 240 VAC, 40 A) for Level 2 charging. If the garage is built with the conduit or raceway already installed from the panel to the garage, the task is greatly simplified.

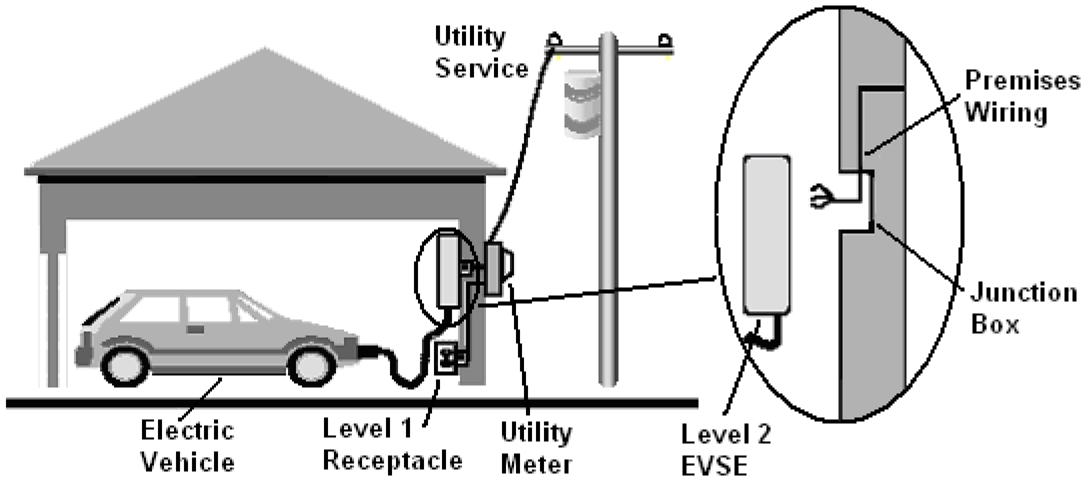

Figure 4-5 Typical Level 1 and Level 2 Installation for a Residential Garage

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

- Consultation with the EV supplier to determine whether Level 1 or Level 2 EVSE is required, electric utility contacts, whether ventilation will be required and what EVSE to purchase
- Consultation with the electric utility to determine rate structure, requirements for a special or second meter
- Consultation with a licensed electrical contractor to plan the installation effort including location of EVSE, routing of raceway from utility service panel to EVSE, Level 1 or Level 2 requirements, ventilation requirements, adequacy of current utility service, and obtain installation quote
- Submission of required permitting documents and plans
- Completion of EVSE installation and utility service components, if required
- Inspection of final installation

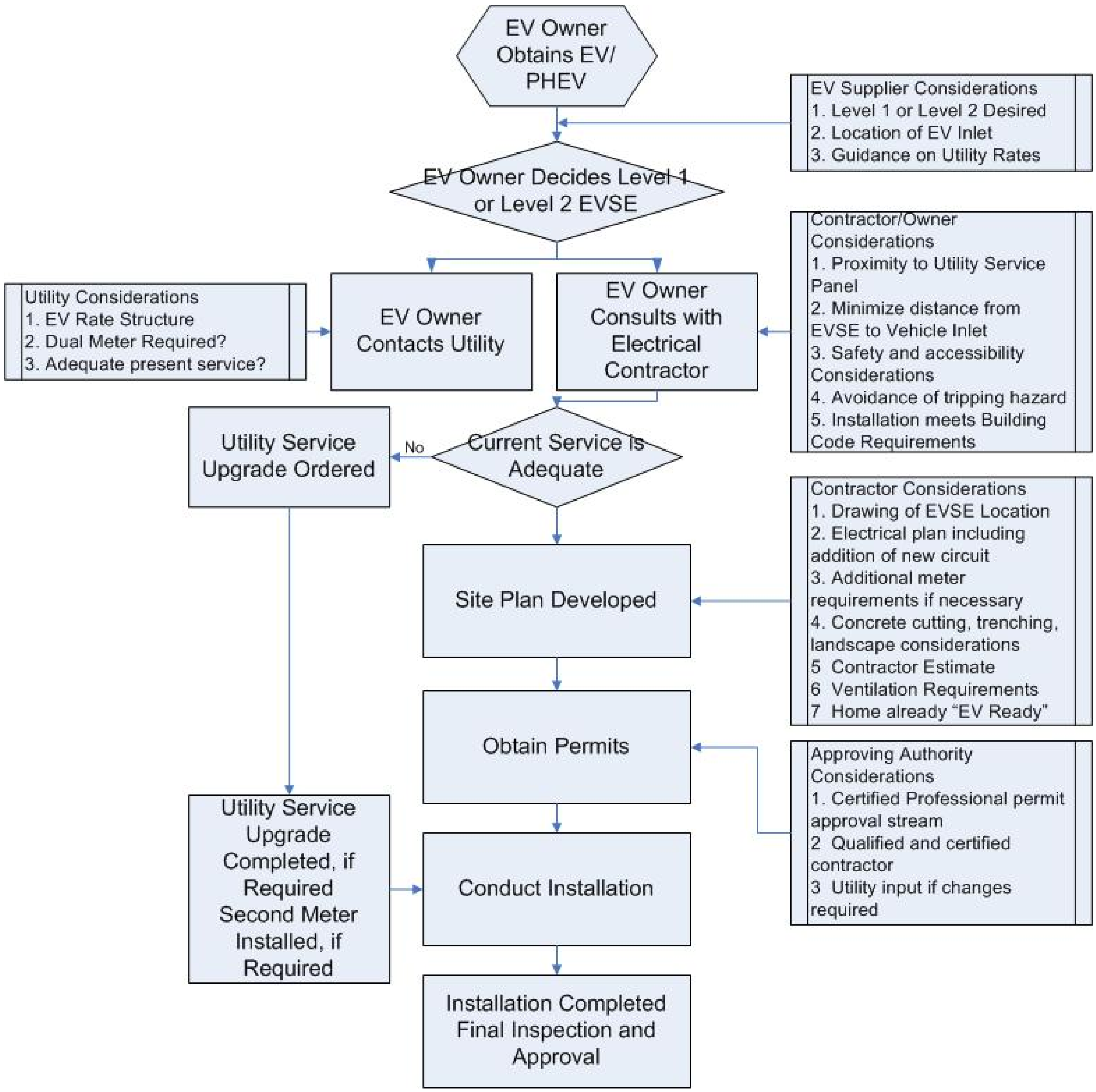

Figure 4-6 Installation Process for a Residential Garage/Car Port

If the garage has a pre-existing raceway, the wishes of the EV owner can determine whether this will be a 125 VAC, 15/20 amp circuit or a 240 VAC, 40 amp circuit. Some homes may not have sufficient utility electrical service to install this circuit. In that case, either a new service must be added as noted or installation of an approved load control device may allow the homeowner to avoid a major panel upgrade and the utility to avoid upgrading the electrical service to the homeowner. Although a new home may already have the raceway installed, a permit for the service is required. Increasingly standards are directing the raceway for an electric vehicle will be included in new home construction. The conductors may or may not be included. If included, consideration should be given to sizing the conductors for the 240 v, 40 amp circuit required for Level 2 charging but installing the 125v, 20 amp Level 1 breaker and receptacle. The home owner would have a functional circuit that could be upgraded easily to Level 2 if desired.

C. Car Port

- **Siting Requirements**

The siting requirements for the car port will include those identified above for the garage. Some owners may elect to place the EVSE in the garage but charge a vehicle outdoors. This is similar to the car port requirements. A car port is considered an outdoor area and the EVSE should be properly designed for exterior use. Consideration must be given to precipitation and temperature extremes. In geographic areas that experience high precipitation, pooling of water in the car port or driveway may be a concern. While the EVSE is safe, owners may have a concern about standing in pooled water while connecting the EVSE. Consultation with the owner will be required when locating the EVSE.

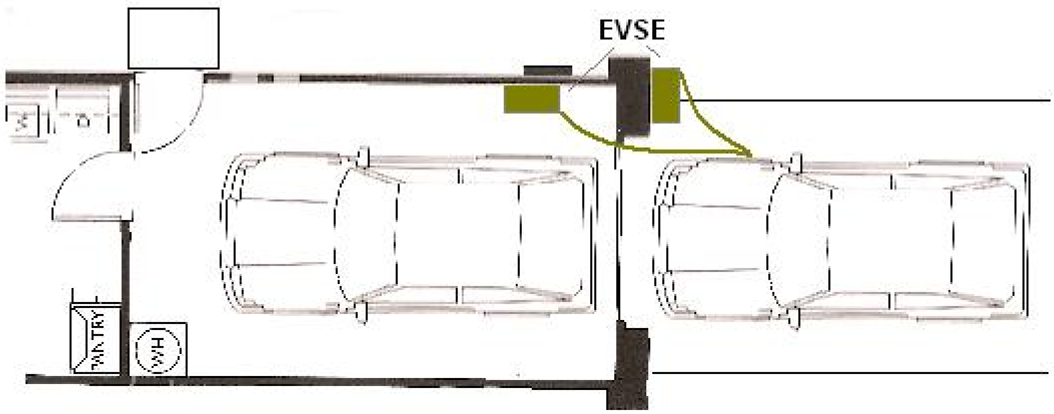

Figure 4-7 Installation Considerations for Outdoor Parking

Freezing temperatures can create an issue for cords freezing to the parking surface and cord support should be considered. Adequate lighting is an addition consideration along with mitigating efforts to prevent vandalism as noted in Section L below. The installation process is similar to the garage process outlined above.

The Canadian Electrical Code requires that the outdoor circuit have ground fault interrupt protection. This may be an issue when using a cordset which contains its own GFI. Past experience has shown some nuisance tripping occurs when two GFI's are located in the same circuit. New cordsets will use a CCID which performs a similar function but helps eliminate the nuisance tripping.

D. Multi-Family Dwellings

- **Siting Requirements**

In multi-family dwellings, there will be additional considerations because the apartment or condominium owner must also be involved in any siting decisions. It is best that the potential EV owner work through the details identified here prior to contracting for an EV or PHEV. A site close to the owner's dwelling will be desired but may not be in the best interests of the apartment owner. Special flooding or drainage conditions may apply. Lighting and vandalism concerns will exist. Payment methods for the electrical usage will need to be identified. There may be insurance and liability questions as well as damages if vandalized. All the concerns should be discussed prior to the EV purchase.

Should the EV owner later relocate, the electrical installation raceway and panel upgrades, if any, will be retained at the multi-family location. Ownership of the EVSE needs to be identified clearly. If the EV owner takes the EVSE, site restoration may be required. Circuit removal or de-energizing methods should be settled. Discussion with the utility is also required since there may be metering questions or issues to be resolved. In condominiums, the Home Owners Association (HOA) may be involved to approve EV or PHEV additions.

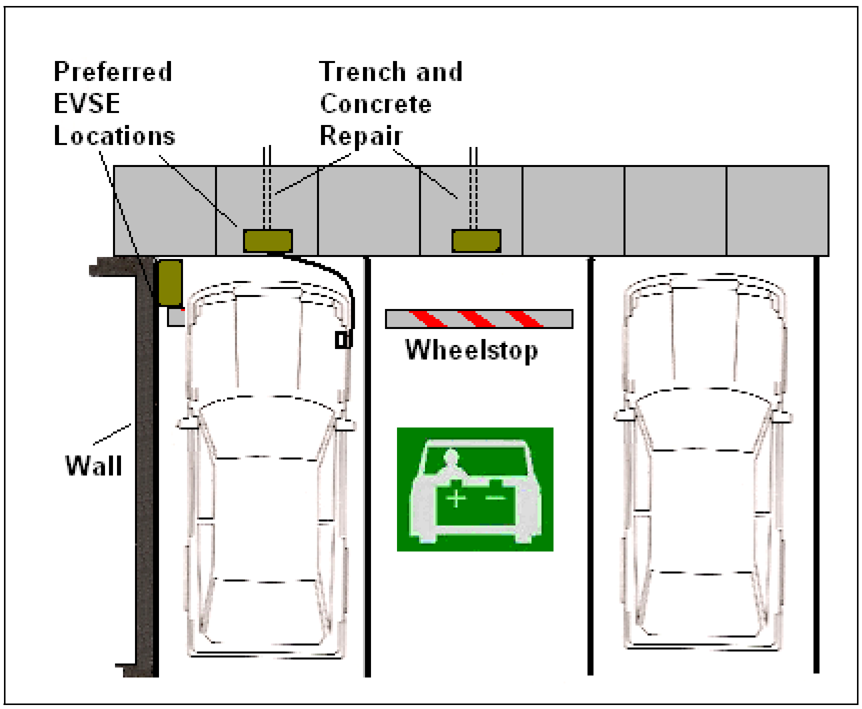

Figure 4-8 Typical EVSE Installation in Multi-Family Lot

In general, the EVSE will need to be outdoor rated unless the location is well protected from the environment. The installation of the EVSE at the front of the vehicle may be the only choice unless an adjacent wall is available. If located at the front of the parking stall, the EVSE should be located on the vehicle side of any walkway to minimize the cord becoming a tripping hazard. The walkway for pedestrians would be on the back side of the EVSE. Because a wheelstop will be installed, consideration should also be given to make sure the EV parking is not in an area of normal pedestrian traffic in order to avoid pedestrians tripping over the wheelstop when no vehicle is present.

Trenching and concrete work and repairs are likely. Consideration must be given to maintaining a safe and secure area around the parking stall to avoid tripping hazards or EVSE interference with other operations.

- **Installation Process**

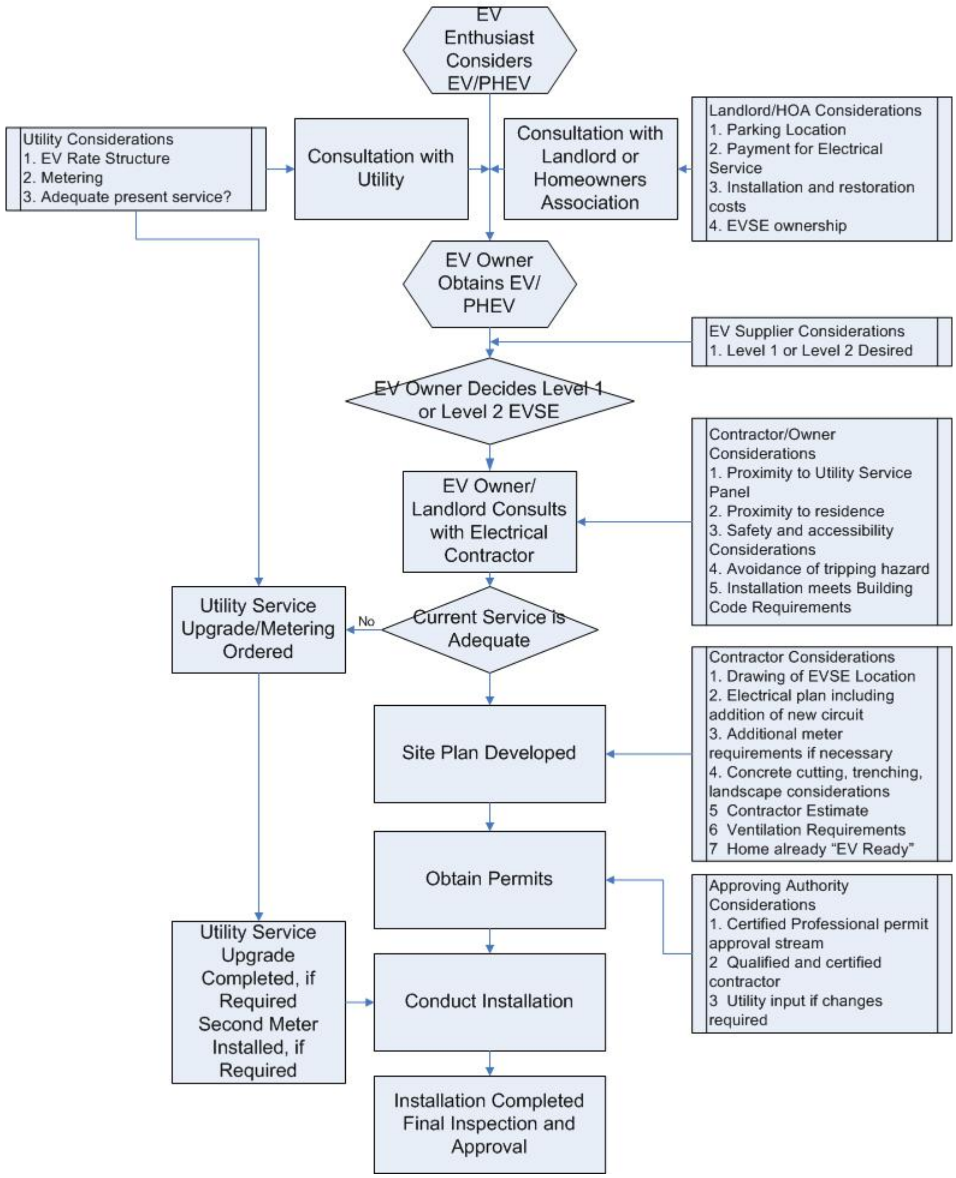

Figure 4-9 Installation Process for Multi-Family

If the parking area has a pre-existing raceway, the wishes of the EV owner and property owner can determine whether this will be a 125 VAC, 15/20 amp circuit or a 240 VAC, 40 amp circuit. This would also require review by the electrical contractor to make sure the service panel is sufficient to support the choice. Although a raceway may have been installed previously, a permit for the service is required.

- **Multiple Parking Stall Installation**

In a new construction or retrofit situation, broad charging infrastructure installation in a multi-residential building will require the services of an electrical consultant to determine the best approach for the situation. For example, the proponent may consider a load control strategy to manage the charging load within the capacity of the electrical service to the building rather than upgrading the service size to accommodate increased building load from electric vehicle charging.

(This topic will be developed in a subsequent version)

E. Commercial Fleets

- **Siting Requirements**

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. Consideration is given to the current requirements as well as anticipated future requirements. Electrical service requirements will be much higher than residential or multi-family installations and can have a significant impact on electrical usage and on the utility. For that reason, electrical utility planners need to be involved early on in the fleet planning process.

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

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

Installation of the EVSE in a commercial facility typically consists of installing new dedicated branch circuits from the central meter distribution panel to a Level 2 EVSE. In a commercial fleet, there are typically many such EVSE units in adjacent parking stalls. Proximity to the electrical service is an important factor in locating this parking area. The length of the circuit run and the quantity will have a significant impact on the cost.

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

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

Fleet manager interest and priorities can also stimulate the development of Level 3 charging. The higher recharge rate means a shorter turn-around for each vehicle and maximizes on-road time. The 480/600 VAC is generally available in commercial facilities.

Figure 4-10 Level 2 Commercial EV Charging Location

- **Installation Process**

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

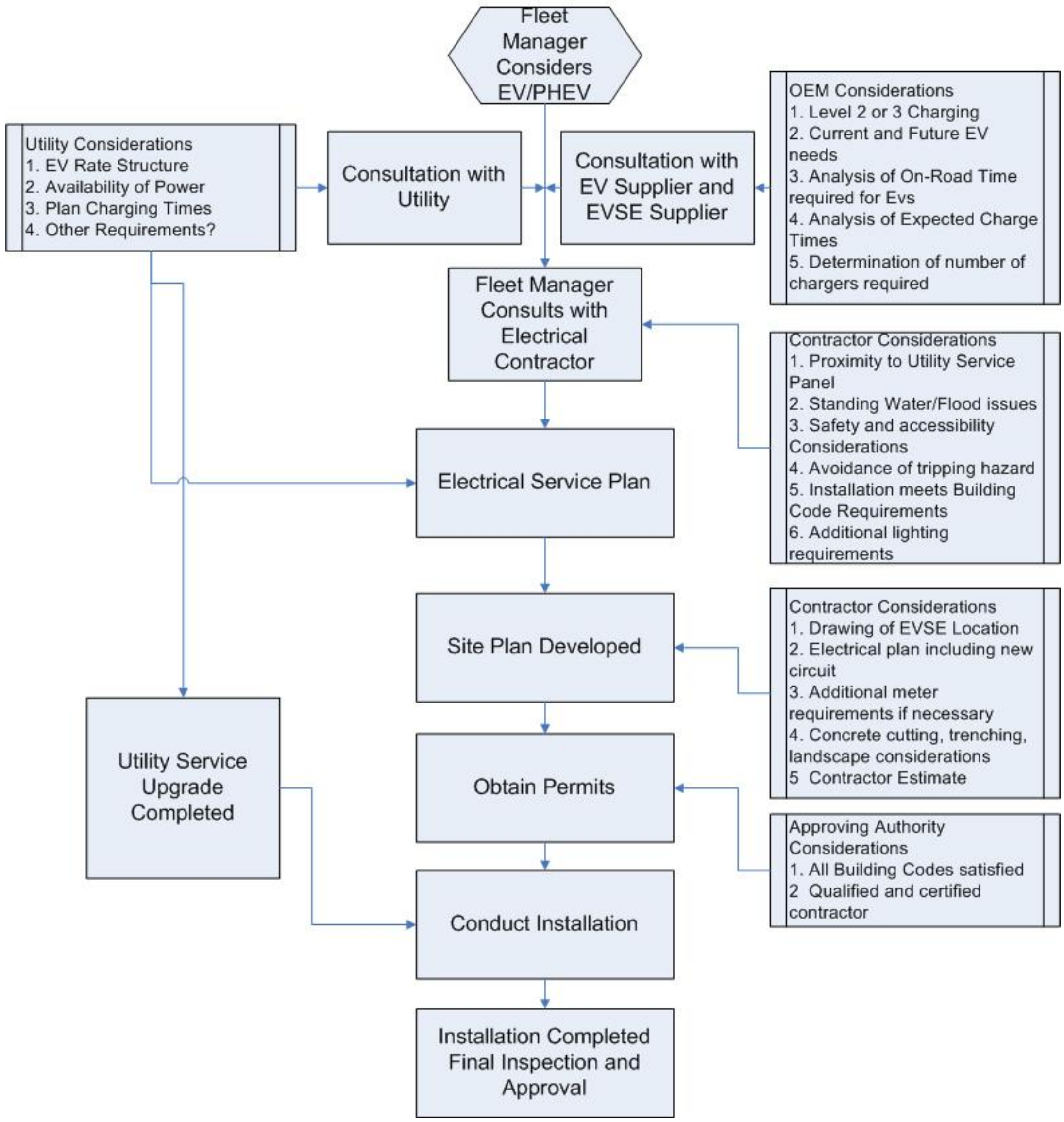

Figure 4-11 Installation Process for Commercial Fleet Operations

F. Commercial Public Access

A significant factor in the public adoption of EV and PHEV will be the ability to extend the range of battery only power. This can be accomplished by the wise installation of public charging locations. Public charging may employ a mix of Level 1 and Level 2 charging stations. There may be select opportunities for Level 3 charging that should also be kept in mind. The availability of 480/600 VAC will be a consideration.

The determination of public charging sites should focus on locations where the EV or PHEV owner will be parked for a significant period of time i.e. 1 – 3 hours. An appreciable recharge can occur during this time period. Locations where owners can be expected to park for this time include restaurants, theaters, shopping malls, governmental facilities, hotels, amusement parks, public parks, sports venues, arts productions, museums, libraries, outlet malls, airports, major retail outlets, among many other choices.

Whether these public stations should be Level 1 or Level 2 will depend on local factors. Recharge times at Level 1 are much longer than at Level 2 and in some locations, the amount of time the vehicle remains at the charging station may be too short for Level 1 charging to have any significant impact on a battery's state of charge. In other locations, the amount of time the vehicle remains at the Level 1 station may be significant and allow for an appreciable recharge. Unless the stay time is at least two hours, Level 2 charging should be selected. For example, a mid-size battery pack identified in Table 3-1 shows two hours of Level 1 charging will restore approximately 15% of a battery capacity whereas two hours of Level 2 will restore approximately 70% of a battery capacity.

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

- **LEED Building Certifications**

A driving force in the design, construction and operation of facilities is the Leadership in Energy and Environmental Design (LEED) Green Building Rating System. It was developed by the U.S. Green Building Council and it provides standards for environmentally sustainable construction and operation of facilities. It requires a study of the CO_2 emissions by company personnel and encourages through monetary incentives or preferred parking the use of alternative fuel vehicles. It provides credits for installing EV charging stations and suggests certain percentages of parking be devoted to alternative fuel vehicles. These locations will apply to employees as well as public using the facility. Companies interested in being certified are excellent sites for public charging stations

- **Siting Requirements**

Siting requirements for commercial public access are similar to other noted but involve many additional considerations. Questions such as ownership, vandalism, payment for use, maintenance, and data collection are addressed in following sections.

Flood prone area restrictions must be considered as well as issues of standing water or high precipitation. As noted above, people will not be comfortable operating the EVSE in standing water. Unlike Fleet use, the area designated for Public use should be in a preferred parking area. Also unlike Fleet use, the area is public and the threat for vandalism will be greater. This will likely be in a high pedestrian traffic area so the considerations for placement of the charger to avoid it, the charge cord or the wheelstop from being tripping hazards is very important.

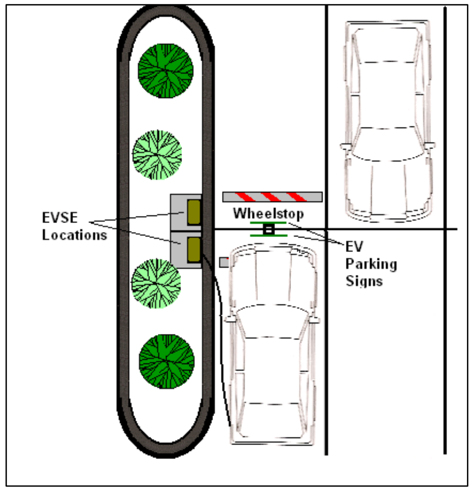

Figure 4-12 Example Public Charging Layout

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

Figure 4-13 Public Charging Examples

The first question to address is location of the stations. Some public charging will be driven by commercial businesses interested in promoting electric vehicle use through personal preference or as part of the LEED certification. They may decide on their own to purchase and install systems or participate in such costs. Other business owners will be receptive to placement of chargers in their parking lots once approached with incentives. Other public, private and governmental agencies will share the enthusiasm for EV parking. Mapping these selected locations will provide input to an overall municipal plan identifying the ideal sites to ensure wide coverage of public charging. EV owners will seek the sites that provide EVSE and publishing such sites on the internet will be desirable. A map of sites will also display any holes in EVSE coverage and provide the targeting of additional sites.

Public sites will also invoke accessibility requirements discussed in Section 2. Once a site is selected for public charging, the quantity of parking stalls to be EVSE equipped is determined and that determines the number of accessible and van accessible stalls.

Lighting and shelter are extremely important in public sites. The EV owner must feel safe when parking at night in addition to being able to read directions and properly locate the EVSE connector and insert into the EV inlet. An indoor stall in a parking structure or a sheltered stall in the outdoor parking lot provides additional convenience for the EV owner.

Installation of the EVSE in a public area typically consists of installing new dedicated branch circuits from the central meter distribution panel to a Level 1 receptacle or Level 2 EVSE. There will likely be many such EVSE units in adjacent parking stalls. Proximity to the electrical service is an important factor in locating this parking area. The length of the circuit run and the quantity will have a significant impact on the cost.

The cost of providing power to the EV parking location must be balanced with the convenience of the parking location to the facilities being visited by the EV owner. It may be more convenient for the EV owner for a large shopping mall to have two or three EV parking areas rather than one large area although the cost for the three will be greater than the cost for the one.

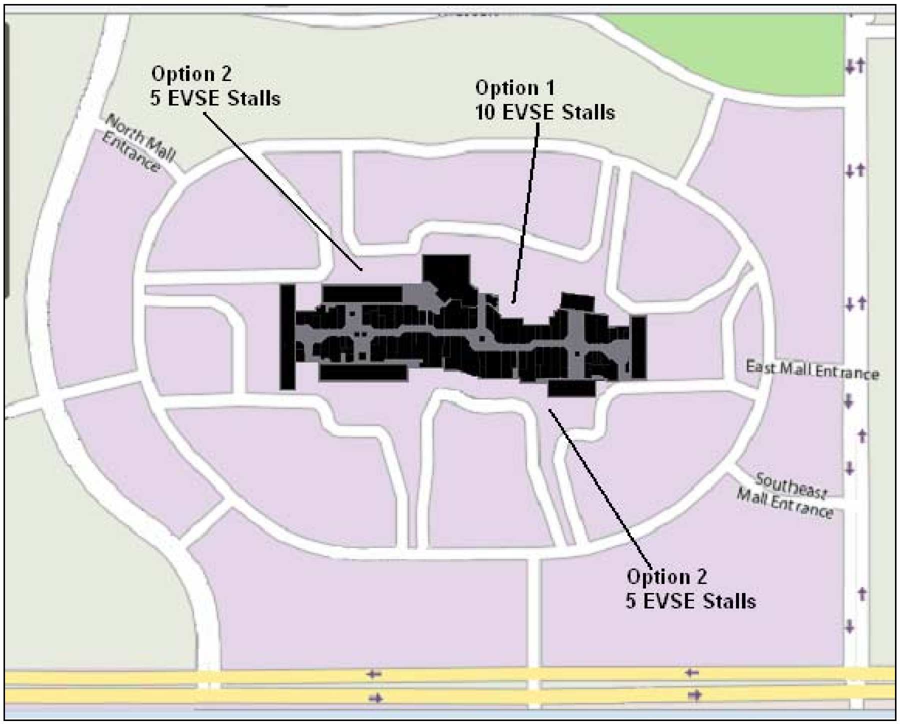

Figure 4-14 Example Shopping Mall EVSE Parking

The local area aesthetics are also important and they may require the installation of landscaping or walls to shield the electrical transformer, panel or other equipment from the public eye.

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

- **Installation Process**

The installation process is similar to the processes shown above except that a lot more detailed planning is required prior to submittal of plans for obtaining permits.

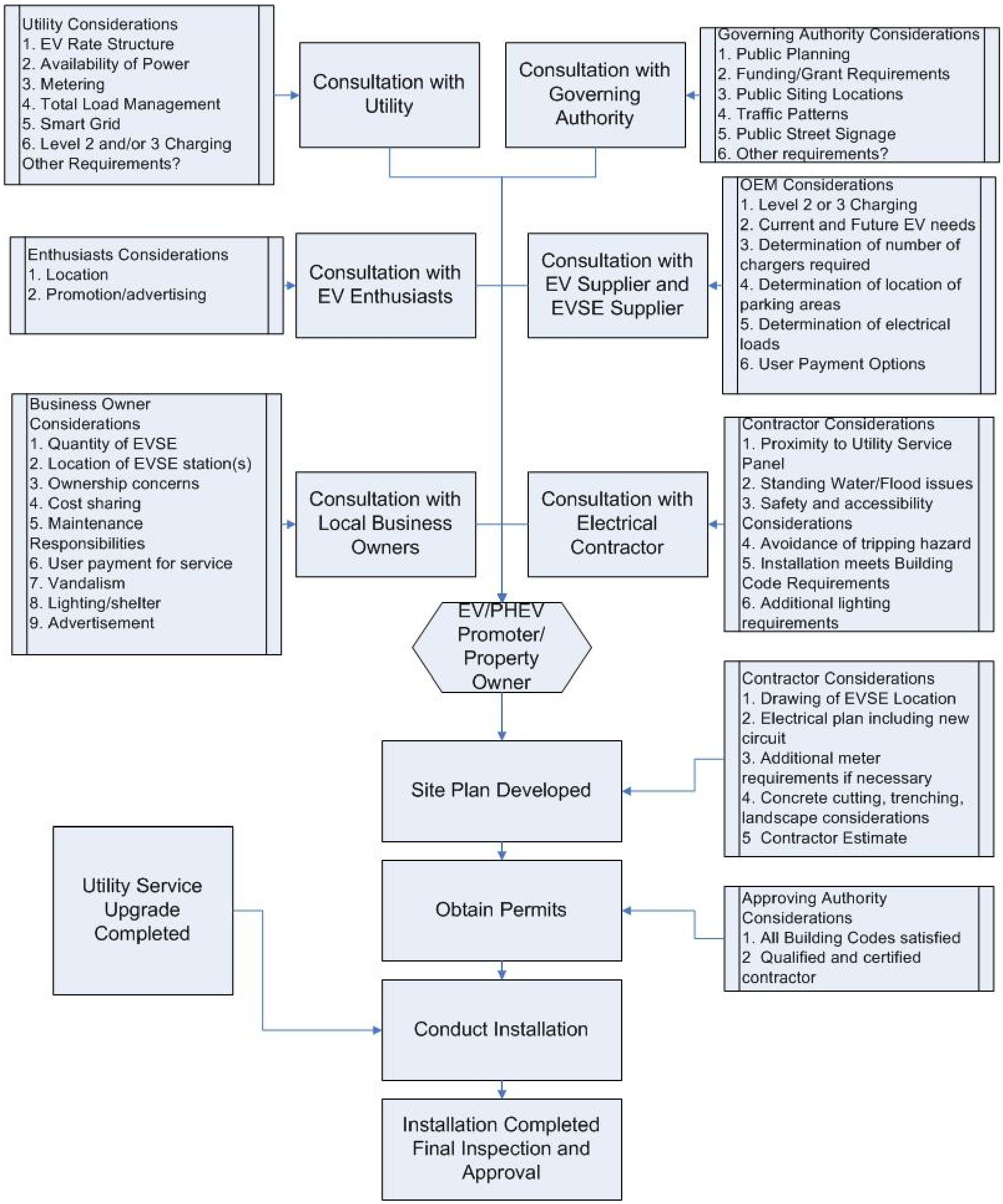

Figure 4-15 Installation Flowchart for Public Charging

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

Figure 4-16 Indoor Public Charging

Figure 4-17 Outdoor Public Charging

G. Point of Sale (POS) Options

Operators/owners of public charging stations may desire to charge a fee for use of the service. During the early adoption stage of EV ownership, most owners will absorb the cost of the electricity used since this actual cost is low per use. However, as the public acceptance and ownership of EVs and PHEVs grow, more will favor having the option for point of sale. In most areas, only electric utilities can actually sell the electricity so fee for convenience will likely be the strategy. The actual electrical costs will remain low and often a credit card transaction fee will well exceed the electricity cost. However, the availability and convenience of charging will be the service the public will desire and purchase. In addition, the payment for actual electrical service will require the installation of metering systems at each EVSE location whereas a service charge will not. A fee for service can assist the EVSE owner in recovering equipment, installation, service and maintenance costs. Several options for point of sale options exist.

- **Card Readers**

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

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

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

Figure 4-18 Smart Card Reader[8]

- **Parking Area meters**

People are very familiar with parking meters used in public parking. A simple coin operated meter is an option for EV parking areas and can be installed at the head of each EVSE parking stall. Another method in common use is for public pay parking lots where a central kiosk is used for credit card purchases. The parking stall number is identified at the kiosk and a parking receipt issued that can be displayed in the vehicle. There is little cost for the meter and a single kiosk reduces the point of service cost for the whole parking lot. This system will require an attendant to periodically monitor the area for violations. Penalties for violators will need to be determined. A coin operated meter also may invite vandalism.

- **RFID Subscription Service**

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

Figure 4-19 RFID fob[9]

[8] ACR-38 Smart Card Reader by Advanced Card Systems
[9] Texas Instruments RFID

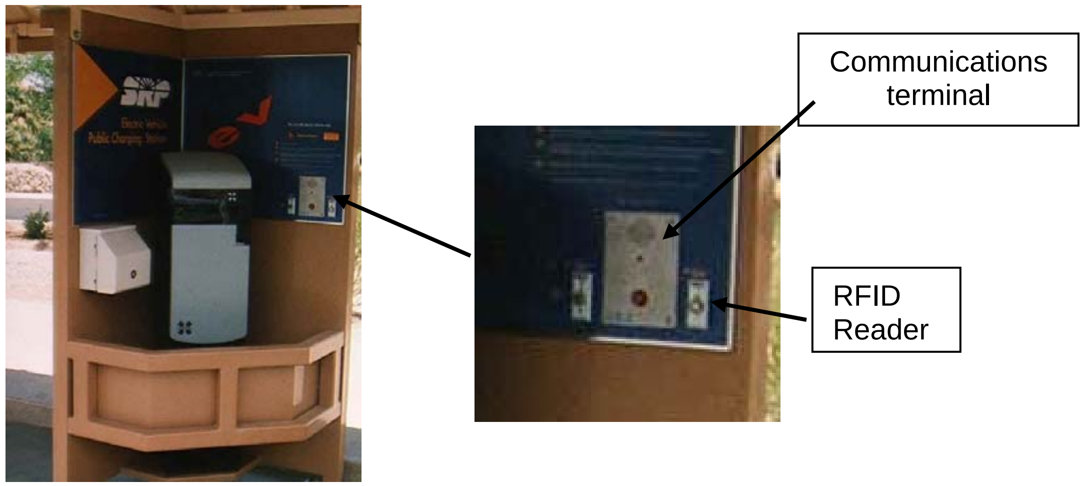

Figure 4-20 RFID reader and communications terminal

H. Data Collection

More than simply recording payment for service, the use of a smartcard or RFID can substantially increase the amount of information available at each public charging station. Section 4F above provides suggestion on public locations where owners may be expected to park for significant periods of time. Data collection systems will track usage at each of the stations and provide feedback on actual owner usage. It may be found that usage at some venues is lighter than expected whereas others may be heavier. This information could be helpful in expanding public charging locations. In addition, the time of day usage may show peak usage at expected or perhaps unexpected times which may impact power utilization studies.

I. Vandalism

Public charging carries the possibility of vandalism and theft. Destruction of property through purposeful defacing of equipment is a possibility, however, such destruction actually proved to be very minor during EV usage in the mid 1990s. However, as public acceptance and the quantity of public charging sites continue to grow, steps should be taken to minimize this possibility.

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

EVSE Owners in condominiums and apartments may desire to protect the equipment with a lockable secure cabinet to prevent unauthorized use and for vandalism protection.

J. Station Ownership

Ownership of the individual charging station may not be entirely clear. A business owner may wish to host public charging but may not have the legal right to the parking lot or for making improvements. Charging stations constructed with public grants or other financing may have split ownership. One entity may own the charger and another may own the infrastructure. The sale of a business may include the EVSE or the sale of the property may include both. EVSE may be rented or leased equipment. Before planning any installation, it is important to identify the entities that have legal rights with respect to the equipment and its installation. Whose approvals are required to obtain the permits and whose approvals are required to remove the equipment later?

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

For 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 ownership along with proper contact information to be shared with the local utility.

K. Maintenance

The EVSE typically will not require routine maintenance. However, all usable parts can wear and periodic inspections should be conducted to ensure that all parts remain in good working order. Periodic cleaning may be required depending upon local conditions. Testing of communications systems and lighting should be conducted periodically. Repair of accidental damage or purposeful vandalism may also be required. Unless otherwise agreed, these responsibilities generally fall to the owner identified in Section J above.

L. Electrical Supply/Metering

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

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

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.

M. Engineering, Permitting & Construction

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

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

Installation drawing requirements may vary by jurisdiction to include simply 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, an engineering company is recommended to prepare the detailed site plans for installation. Several trades may be involved including general contracting, electrical, landscaping, paving, concrete, masonry, and communications systems. As noted above, careful planning is required to coordinate this effort and an engineering company can provide the detailed set of drawings that will be required. In addition, there may be several permitting offices involved with the approval of these plans. Prior to any actual on-site work, the permit must be approved and posted at the site. The permit will identify periodic inspections and approvals of work if necessary. Work shall not be concealed until the inspection is completed and work approved.

5. Utility Integration

A. Background

Electric utilities are under significant pressure 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 minimize new power plant, and electrical distribution and transmission investment by shifting and controlling load while minimizing the impact to the customer. Advanced Metering Infrastructure (AMI) or what is referred to as “Smart-Meters” are being deployed by utilities that see an immediate benefit. One of the immediate benefits is remote meter reading, eliminating the need to manually read thousands or in some cases millions of meters every month for billing purposes. These smart meters also have the ability to control various customer loads which is an important piece in implementing the overall Smart-Grid system. There have been significant advances in computer control of lighting, thermostat, appliances and energy management systems that make the communications with the smart meter possible.

Electric vehicles are one of the better loads to control for the utilities because EVs have an on-board storage system unlike lighting or air-conditioning load which can have an immediate impact on the customer when turned-off. For residential EV charging, the ability to move the charging times into the off-peak time of day could delay distribution system upgrades by several years. For example, local neighborhood transformers may not be sized for every customer on that transformer to be charging at the same time. The ability to schedule the EV charging connected to a neighborhood transformer could significantly extend the life of that transformer or even delay or remove the requirement to replace the transformer with a larger size.

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

- **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, during a time frame where demand on the utility electrical grid is at its lowest point. TOU is currently being implemented by some utilities but there is not a common approach at this time. Discussion with the local utility prior to installation of the charge station is recommended.

- **Demand Response**

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

- **Real-Time Pricing (RTP)**

RTP is a concept that could be implemented in the future for electric vehicles whereby pricing signals are sent to a customer through a number of communication mediums that allows the customer to charge their EV during the most cost effective period. For example, the EVSE (Electric Vehicle Supply Equipment) installed in the EV owners garage could be pre-programmed to make sure the car is fully charged by 6am, 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.

- **Vehicle-to-Grid (V2G)**

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

B. Interconnection Requirements

For vehicle-to-grid (V2G) it will be necessary to contact the local utility to determine if there are any interconnection requirements. These requirements are in place to protect personnel and property while feeding electricity back into the utility grid. Similar requirements are already in place for solar photovoltaic and wind systems that are grid-tied to the utility therefore these requirements are typically readily available.

6. Planning Considerations

The state of EVs and their relation to the utility Smart Grid today have been compared with the first Radio Shack TRS-80 PC, and an internet that was just forming, essentially only used by universities to share data. Therefore, attempting to plan for every potential scenario out 20 years from now is a challenging if not an impossible task. Based on the information we have today we can providing the following planning considerations, realizing of course that technology has a way of coming up with new ideas never imagined.

A. Residential Charging

For a pure Battery Electric Vehicle, the preferred method of residential charging will be Level 2 (240VAC/Single phase) in order to provide the EV owner a reasonable charge time and to also allow the local utility the ability to shift load as necessary while not impacting the customer's desire to obtain a full charge by morning. For Plug-in Hybrid Electric Vehicles, a dedicated Level 1 circuit may adequately meet the PHEV owner's needs. Cost considerations relative to charger performance need to be well understood by the plug-in vehicle owner in order to make the right decision for their particular situation.

Level 1
Power Requirement: Dedicated branch circuit with NEMA 5-15R or 5-20R Receptacle.

Level 2
Power Requirement: Dedicated branch circuit hardwired to a permanently mounted EVSE with the following specifications:

240VAC/Single Phase, 4-wire (2 Hot, GND, Neutral), 40Amp Breaker

Level 2 Notes:

1. The breaker size recommended will meet the requirements of most all BEVs and PHEVs. Some PHEVs with small battery packs (See Table 3.1) may only require a 20 or 30Amp breaker for their recommended EVSE in which case the breaker can be easily changed.
2. The Neutral may not be required by some EVSE but since it is inexpensive to include and may be required at some point in the future if a different vehicle is purchased it is recommended.
3. For new construction, bring the circuit to a dual gang box with a cover plate for future installation of EVSE.

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

B. Commercial Fleet Charge Stations

Power Requirement: Dedicated branch circuits hardwired to permanently mounted EVSE with the following specifications:

208VAC or 240VAC / Single Phase, 4-wire (2 Hot, GND, Neutral), 40Amp Breaker

Commercial fleet charge stations will likely include multiple charge locations and therefore with new construction the additional 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, for existing buildings, the additional load may require an upgrade or new SES and/or utility supply.

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

C. Commercial Public Charge Stations

Commercial public charge stations will vary greatly in design and requirements. It is likely there will be a combination of Level 2 and Level 3 Fast Charge stations throughout British Columbia. Public stations also include a number of other requirements not found in residential and fleet applications such as signage and Point-of-Sale systems, as described in section 4.

Power Requirements:

Level 2: Dedicated branch circuits hardwired to permanently mounted EVSE with the following specifications:

208VAC or 240VAC / Single Phase, 4-wire (2 Hot, GND, Neutral), 40Amp Breaker

Level 3: Dedicated branch circuit hardwired to permanently mounted Charger supplied with the circuit as specified in the installation manual. For chargers rated up to 30kW they may require either 208AVC/3-Phase or 480VAC/3-Phase. For fast chargers greater than 30kW, they will likely require 480VAC/3Phase.

<u>Example Sizes</u>:

1. For 30kW Output Power, typical input power requirements are

208VAC/3-Phase, 4-wire (3-Hot, GND), 125 Amp Breaker, -or-

480VAC/3-Phase, 4-wire (3-Hot, GND), 60 Amp Breaker

2. For 60kW Output Power, typical input power requirement is

480VAC/3-Phase, 4-wire (3-Hot, GND), 125 Amp Breaker

Communication Requirements:

Communication will likely be desired for any public charge stations, but it is not necessarily required. Wireless methods will most likely be utilized, but if a hard-wire internet connection is available it is generally desired over wireless.

7. Cost Estimating

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

A. Residential Cost Worksheet

Referring to Figure 4-5 for a Residential EVSE installation, Table 7-1provides a generic Cost Table Worksheet that can be used as a guideline residential installations. As noted in Section 4, some homes may require a service panel upgrade but the following tables assume they do not.

Table 7-1 Cost Worksheet for Residential EVSE Level 2 Installation

Residential Level 2			
Description	**Quantity**	**Cost, Ea**	**Total**
Labor (hrs)			
Initial Site Visit	2	$ 75.00	$ 150.00
Permit Application / Acquisition	2	$ 75.00	$ 150.00
Installation	8	$ 75.00	$ 600.00
Approval	2	$ 75.00	$ 150.00
Labor Sub-Total			$ 1,050.00
Materials			
EVSE - 40Amp	1	$ 780.00	$ 780.00
40amp Breaker	1	$ 35.00	$ 35.00
#12 THHN Wire	140	$ 0.30	$ 42.00
Conduit - 3/4 EMT	35	$ 3.00	$ 105.00
40Amp Fused Disconnect	1	$ 115.00	$ 115.00
Miscellaneous	1	$ 60.00	$ 60.00
Material Sub-Total			$ 1,137.00
Permit	1	$ 85.00	$ 85.00
		Total	**$ 2,272.00**

B. Commercial Fleet Cost Worksheet (10 Stations)

Referring to Figure 4-10 for Commercial Fleet Charging Station, Table 7-2 provides a generic Cost Worksheet for a Commercial Fleet Charging Station with 10 charging locations.

Table 7-2 Cost Worksheet for Commercial Fleet Level 2 Installation (10 Stations)

Commercial Fleet - 10 Stations			
Description	**Quantity**	**Cost, Ea**	**Total**
Labor (hrs)			
Initial Site Visit	2	$ 75.00	$ 150.00
Engineering	16	$ 90.00	$ 1,440.00
Permit Application / Acquisition	2	$ 75.00	$ 150.00
Installation	24	$ 75.00	$ 1,800.00
Approval	2	$ 75.00	$ 150.00
Labor Sub-Total			$ 3,690.00
Materials			
Distribution Panel (400amp)	1	$ 650.00	$ 650.00
EVSE - 40Amp	10	$ 780.00	$ 7,800.00
EVSE Pedestal	10	$ 450.00	$ 4,500.00
40amp Breaker	10	$ 35.00	$ 350.00
#12 THHN Wire	1000	$ 0.30	$ 300.00
Conduit - 3/4 EMT	250	$ 3.00	$ 750.00
40Amp Fused Disconnect	10	$ 115.00	$ 1,150.00
Signage	10	$ 250.00	$ 2,500.00
Miscellaneous	10	$ 60.00	$ 600.00
Material Sub-Total			$ 18,600.00
Trenching & Repair	200	$ 45.00	$ 9,000.00
Permit	1	$ 85.00	$ 85.00
		Total	**$ 31,375.00**

C. Commercial Public Cost Worksheet

Referring to Figure 4-17 for a Level 2 Public Charging Station Table 7-3 provides a generic Cost Table for a Public Level 2 Charging Station for two charging locations located side-by-side.

Table 7-3 Cost Worksheet for Level 2 Public Installation (Two Charging Spots)

Public Charge Station - Level 2 (Qty 2)			
Description	**Quantity**	**Cost, Ea**	**Total**
Labor (hrs)			
Consultation with Property Owner/Tenant	4	$ 75.00	$ 300.00
Initial Site Visit	2	$ 75.00	$ 150.00
Engineering Drawings	16	$ 90.00	$ 1,440.00
Permit Application / Acquisition	2	$ 75.00	$ 150.00
Installation	24	$ 75.00	$ 1,800.00
Approval	2	$ 75.00	$ 150.00
Labor Sub-Total			$ 3,990.00
Materials			
Distribution Sub-Panel (100Amp)	1	$ 250.00	$ 250.00
EVSE - 40Amp	2	$ 780.00	$ 1,560.00
EVSE Pedestal	2	$ 450.00	$ 900.00
40amp Breaker	2	$ 35.00	$ 70.00
#12 THHN Wire	400	$ 0.30	$ 120.00
Conduit - 3/4 EMT	100	$ 3.00	$ 300.00
40Amp Fused Disconnect	2	$ 115.00	$ 230.00
Ground Signage & Striping (painted)	2	$ 125.00	$ 250.00
Signage (Post Mount)	2	$ 250.00	$ 500.00
Miscellaneous	2	$ 60.00	$ 120.00
Material Sub-Total			$ 4,300.00
Trenching & Repair	100	$ 45.00	$ 4,500.00
Permit	1	$ 85.00	$ 85.00
		Total	**$ 12,875.00**

D. Cost Worksheet for Public Level 3 Charging Station (Single Charge Location)

Referring to Figure 7-1 below showing a conceptual Level 3 Public Charge Station Table 7-4 provides a generic Cost Worksheet for Public Level 3 Charging Station.

Figure 7-1 Conceptual Public Fast Charge Station (2 Charge Locations)

Table 7-4 Cost Worksheet for Public Level 3 Installation (2 Stations)

Public Charge Station - Level 3 (Qty 2-30kW)			
Description	**Quantity**	**Cost, Ea**	**Total**
Labor (hrs)			
Consultation with Property Owner/Tenant	16	$ 75.00	$ 1,200.00
Initial Site Visit	4	$ 75.00	$ 300.00
Engineering Drawings	24	$ 90.00	$ 2,160.00
Permit Application / Acquisition	4	$ 75.00	$ 300.00
Installation	24	$ 75.00	$ 1,800.00
Approval	4	$ 75.00	$ 300.00
Labor Sub-Total			$ 4,860.00
Materials			
Distribution Sub-Panel (480VAC/3Phase)	1	$ 650.00	$ 650.00
Fast Charger (30kW)	2	$ 25,000.00	$ 50,000.00
Point of Sale System	1	$ 2,500.00	$ 2,500.00
60amp 480VAC/3Pole Breaker	2	$ 45.00	$ 90.00
#6 THHN Wire	160	$ 0.30	$ 48.00
Conduit 1"	50	$ 3.50	$ 175.00
60Amp Fused Disconnect	2	$ 150.00	$ 300.00
Ground Signage & Striping (painted)	2	$ 125.00	$ 250.00
Signage (Post Mount)	1	$ 2,500.00	$ 2,500.00
Miscellaneous	1	$ 350.00	$ 350.00
Material Sub-Total			$ 56,213.00
Trenching & Repair	30	$ 50.00	$ 1,500.00
Concrete Work	1	$ 1,500.00	$ 1,500.00
Permit	1	$ 85.00	$ 85.00
		Total	**$ 64,158.00**

Appendix A
Related Topics in the US National Electric Code

In addition to the requirements contained in the Canadian Electrical Code, the NEC provides for the following considerations:

- Section 625.9: The electric vehicle coupler shall comply with
    - A) Polarization. The electric vehicle coupler shall be polarized unless part of a system identified and listed as suitable for the purpose.
    - (B) Non-interchangeability. The electric vehicle coupler shall have a configuration that is non-interchangeable with wiring devices in other electrical systems.
    - I Construction and Installation. The electric vehicle coupler shall be constructed and installed so as to guard against inadvertent contact by persons with parts made live from the electric vehicle supply equipment or the electric vehicle battery.
    - (D) Unintentional Disconnection. The electric vehicle coupler shall be provided with a positive means to prevent unintentional disconnection.
    - (E) Grounding Pole. The electric vehicle coupler shall be provided with a grounding pole, unless part of a system identified and listed as suitable for the purpose in accordance with Article 250.
    - (F) Grounding Pole Requirements. If a grounding pole is provided, the electric vehicle coupler shall be so designed that the grounding pole connection is the first to make and the last to break contact.
- Section 625.13 Electric Vehicle Supply Equipment.
    - Electric vehicle supply equipment rated at 125 volts, single phase, 15 or 20 amperes or part of a system identified and listed as suitable for the purpose and meeting the requirements of 625.18, 625.19, and 625.29 shall be permitted to be cord-and-plug-connected. All other electric vehicle supply equipment shall be permanently connected and fastened in place.
- Section 625.14 Rating:
    - Level 1. 125vac. This method, which allows broad access to charge an EV, permits plugging into a common, grounded 125-volt electrical receptacle (NEMA 5-15R or 5-20R) when cord-and-plug is approved.
    - Level 2. 240 VAC, 40 amp. electric vehicle supply equipment shall be permanently connected and fastened in place.
- Section 625.15 Marking
    - All EVSE shall be marked “FOR USE WITH ELECTRIC VEHICLES” and “VENTILATION NOT REQUIRED” or “VENTILATION REQUIRED”
- Section 625.16 Means of Coupling.
    - The means of coupling to the electric vehicle shall be either conductive or inductive. Attachment plugs, electric vehicle connectors, and electric vehicle inlets shall be listed or labeled for the purpose
- Section 625.17 Cable.
    - The electric vehicle supply equipment cable shall be Type EV, EVJ, EVE, EVJE, EVT, or EVJT flexible cable as specified in Article 400 and Table 400.4.

  - The overall length of the cable shall not exceed 7.5 m (25 ft) unless equipped with a cable management system that is listed as suitable for the purpose.
- Section 625.18 Interlock.
  - Electric vehicle supply equipment shall be provided with an interlock that de-energizes the electric vehicle connector and its cable whenever the electrical connector is uncoupled from the electric vehicle. An interlock shall not be required for portable cord-and-plug-connected electric vehicle supply equipment intended for connection to receptacle outlets rated at 125 volts, single phase, 15 and 20 amperes
- Section 625.19 Automatic De-Energization of Cable.
  - The electric vehicle supply equipment or the cable-connector combination of the equipment shall be provided with an automatic means to de-energize the cable conductors and electric vehicle connector upon exposure to strain
- Section 625.22 Personnel Protection System.
  - The electric vehicle supply equipment shall have a listed system of protection against electric shock of personnel…Where cord-and-plug-connected electric vehicle supply equipment is used, the interrupting device of a listed personnel protection system shall be provided and shall be an integral part of the attachment plug or shall be located in the power supply cable not more than 300 mm (12 in.) from the attachment plug
- Section 625.25 Loss of Primary Source.
  - Means shall be provided such that, upon loss of voltage from the utility or other electrical system(s), energy cannot be back fed through the electric vehicle and the supply equipment to the premises wiring system unless permitted by 625.26.
- Section 625.26 Interactive Systems.
  - Electric vehicle supply equipment and other parts of a system, either on-board or off-board the vehicle, that are identified for and intended to be interconnected to a vehicle and also serve as an optional standby system or an electric power production source or provide for bi-directional power feed shall be listed as suitable for that purpose.
- Section 625.29 Indoor Sites
  - (B) Height. Unless specifically listed for the purpose and location, the coupling means of the electric vehicle supply equipment shall be stored or located at a height of not less than 450 mm (18 in.) and not more than 1.2 m (4 ft) above the floor level.
- Section 625.30 Outdoor Sites.
  - (B) Height. Unless specifically listed for the purpose and location, the coupling means of electric vehicle supply equipment shall be stored or located at a height of not less than 600 mm (24 in.) and not more than 1.2 m (4 ft) above the parking surface.