Level 2 Public Sector Charging Stations

Best Practices Guideline

EV INFRASTRUCTURE TEAM
POWERTECH LABS INC.

July 09, 2020
Version 1.0

BC Hydro
Power smart

CS–68

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Executive Summary

BC Hydro is committed to support installation of public Level 2 EV by publishing best practice guidelines, helping identify system upgrade requirements, providing guidance on eligible EV charger models, verifying project compliance, reimbursing partners based on NRCan's contribution and encouraging Indigenous participation by assisting with affordability.

This guideline provides best practices for selection of public Level 2 chargers considering regulatory standards and impacts on hosts and Electric Vehicle (EV) drivers.

Public Level 2 charging stations have two main components: hardware and software. The hardware is the physical charger and cable which will be addressed in Section 1. The second component is the software including network management system handling operation of networked chargers and Electric Vehicle Energy Management System (EVEMS) optimizing multiple charging at one location. Network types and EVEMS will be address in Section 1.6 and Section 2. Station placement and site design criteria will be in addressed in Section 3. Section 4 elaborates on procurement options and installation guideline. Finally, Section 5 provides two examples of public Level 2 charging stations in British Columbia and rationale for selected parameters.

The followings are key areas and recommendations for hardware and software selection of Level 2 charging station:

- Circuit Configuration: Depending on available electrical capacity, "dedicated circuit" is recommended for installation of one Level 2 charger, "static load management" is recommended for installation of two Level 2 chargers and "dynamic load management" is recommended for installation of more than two Level 2 chargers.
- Charger Type: Networked Level 2 charger with SAE J1772 socket is recommended. Please see BC Hydro eligible charger list [1].
- Charger Speed: Delivering 30–32 A to the vehicle is generally considered full speed. The J1772 standard allows for, and some newer, longer range, vehicles (including current Teslas which can use J1772 via an adapter that comes with the car) can accept up to 48 A. When using load management its best to supply at least 8 A to each vehicle and preferably 16 A or more.
- O&M: Consider parts availability, access to local maintenance personnel, and warranty coverage.
- Weatherproof: Consider enclosure rating of charger based on indoor/outdoor use as per Appendix A.2.
- Network: It is recommended to include a public EV charging system network connection as per Appendix A.1 in order to provide payment options, real–time status (available/in–use/out–of–order), location/routing guidance on providers mobile application, and etc.

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Definitions

ESA: Electrical Supply Agreement

EVC: Electric Vehicle Charging

EVEMS: Electric Vehicle Energy Management System

kW: Kilowatt

NFC: Near Field Communication

NRCan: Natural Resources Canada

OBC: On–board (vehicle) Charger

OEM: Original Equipment Manufacturer

OCPP: Open Charge Point Communication Protocol

O&M: Operation and Maintenance

PHEV: Plug–in Hybrid Electric Vehicle

RFID: Radio Frequency Identification

ZEV: Zero Emissions Vehicle

1. Level 2 Equipment and Vendor Selection

1.1. CHARGER CHARACTERISTICS

Table 1 [3 & 4] outlines approximate supply voltage, current, application, charge time, charger cost and installation cost for typical J1772 AC Level 2 charger. Charging speed can be reduced by the EV's on-board charger based on the EV model. As a result, selecting a higher power charger does not necessarily make a difference in charging speed. Charging capacity of various EV models are listed in Appendix B.

TABLE 1. AC LEVEL 2 CHARGER CHARACTERISTICS

Charging Level	Approximate Vehicle range added per charging time and power	Time to fully charge(1)	Typical Supply Power	Typical Application	Approximate Charger Cost (2)	Approximate Installation Cost per charger (2)	Connector Type
AC Level 2	16 km/hour @ 3.4kW	3-10 Hrs	208/240vac (16-80a)	Public & workplace	$1,200-$8,000	$1,200-$15,000	J1772
	32 km/hour @ 6.6kW						
	96 km/hour @ 19.2 kW						

(1) Time to fully charge depends on the battery size (kWh), on-board charger capacity (kW) and charger station output (kW), but this range is what drivers generally expect since these suit overnight charging
(2) Cost estimates are in CAD based on prices in 2020

Tesla vehicles use a proprietary connector but come with an adapter so they can use J1772 type AC Level 2 chargers. Tesla also offers a proprietary AC Level 2 charger that comes with the proprietary connector that other EV manufacturer's vehicles cannot use (without a very specialized adapter) commonly referred to as a Tesla Wall Connector or Tesla Destination charger.[5] The Tesla Wall connector is in its third version and can provide up to the 48 A that current long-range Tesla vehicles can accept. Tesla Wall Connectors do not comply with most incentive programs but are relatively inexpensive given their feature set and capabilities. Other incentive programs like those noted by ZEVIP [2], PlugInBC [6], or ZAPBC [7], generally prefer the more universal J1772 connector. These programs don't generally provide greater incentives above 32 A although that is likely to change as EVs incorporate faster on-board chargers to compete with Tesla.

1.2. CHARGING PORT

The chargers are typically either single or double port. Double port chargers are a good fit for larger installations and those with limited installation space. Cost per stall for double port chargers is typically lower than single port chargers due to sharing of infrastructure. Double port chargers may charge both cars at full speed, one car at full-speed, or two cars at half-speed (depending on the hosts objectives, cost sensitivity and required coverage) [8].

1.3. ANTI-VANDALISM

Publicly available charging stations are subject to vandalism and theft and this should be considered when selecting a charger for your site. Some Level 2 chargers are constructed of more durable materials (e.g. heavy gauge metal rather than plastic) or are easier to repair/maintain (e.g. finishes that graffiti removal will not damage).

1.4. INDOOR/OUTDOOR

EV charger enclosures are classified based on indoor/outdoor use. Please see weatherproof ratings and applications in Appendix A.2 [8].

1.5. ELECTRICAL CAPACITY

An electrical engineer and/or electrician can determine the available electrical capacity at your location based on historical demand and overall capacity at various points in the electrical system. Available electrical capacity defines the power that can be delivered per charger based on where and how the chargers are connected as well as the current and foreseeable number of charging points.

Below are some configuration options [9 & 10] that affect how much capacity impact each EV charger station has. The advantages and disadvantages of each option is explained in Appendix A.3.

1. Dedicated circuit
2. Circuit sharing
    a. Static load management
    b. Time-shared load management
    c. Dynamic load management (see also EVEMS in Section 2)

The electrical capacity of your location may not be sufficient to supply all the EV charging stations that you plan to install. A separate electrical service can be provided, or the existing infrastructure can be upgraded, but that is often relatively costly. The circuit sharing option can reduce or eliminate the need to upgrade your electrical system capacity.

Dedicated circuits provide the most predictable charge time but are generally the most expensive option and most likely require a costly electrical capacity upgrade.

Among the circuit sharing configurations, static load management (e.g. two half-speed chargers connected together) is the simplest configuration. The time-shared is simple while providing fair charge sharing to EV drivers. The dynamic load management typically provides the most power to each EV charger but is also typically the most complicated configuration. This configuration can charge at various speeds that may change during the active portion of the session. Dynamic load management can be used to achieve various objectives such as pushing charging toward fleet vehicles instead of staff vehicles, staff versus public, or to control the electrical load for several reasons (see EVEMS in Section 2).

The applicable safety standards and BC Hydro requirements for metering installation are listed in Appendix C.

1.6. CHARGER NETWORK TYPE

Majority of government funded programs for Level 2 chargers require installation of networked chargers to be eligible for funding [2].

1.6.1. NON-NETWORKED OR BASIC

The non-networked chargers do not come with prepackaged network. If network is required a non-network charger can be integrated with a third-party network for an additional cost. Chargers that cannot communicate to each other or a shared communication and/or control platform through some form of basic network are not suited to public or large-scale deployments [8].

1.6.2. NETWORKED

Networked chargers come with built-in Wi-Fi, cellular, or other basic network capabilities [8]. The EV Charging (EVC) networks (e.g. BC Hydro EVC network) connect to several chargers and provide charger monitoring, and remote control usually including via mobile application. EVC Networks can be oriented to the individual (single family dwelling) or public (e.g. BC Hydro EV). Not all networked chargers are capable of dynamic load management. Dynamic load management capability is identified in BC Hydro's eligible charger list.

Public EVC networks can be provided in several ways:

1.6.2.1. PRIVATELY OWNED / SELF-MANAGED

The host manages the stations via open/proprietary communication protocols (e.g. Open Charge Communication Protocol (OCPP) software, or a stand-alone direct wired control system). Typically, the system has been developed or purchased outright with little or no ongoing subscription costs, however there may be periodic costs (e.g. technology upgrades). This provides maximum control and responsibility for the owner. This solution requires:

- A network connection between charger and controller (Wi-Fi/cellular/wired/other)
- An open protocol or proprietary server/controller
- Charger that are compatible with the shared protocol/controller
- Management/administrative software, an application, or similar (to configure system)
- Technical and administrative staff/support

1.6.2.2. WHITE-LABEL -MIX

The EVC network software can be developed by an Original Equipment Manufacturer (OEM) and rebranded to a host company to make it appear theirs. Alternatively, it can retain the branding of the OEM but the host provides day-to-day administration (e.g. administering the users on a local version of the EVC network for a community). The host partially manages the stations via the platform built by the third-party. The host may still require support for operation & maintenance and updates from the OEM. Typically, these use custom EVC networks built on open protocols (e.g. OCPP) and a selection of open protocol compatible chargers. The division of responsibilities varies and can usually be negotiated, thus the cost is usually a mix of capital cost and operation costs (e.g. software updates and phone support). This method provides a medium degree of control and responsibility for the owner.

1.6.3. VERTICALLY INTEGRATED

Vertically integrated EVC network software suppliers generally offer a turn-key solution where they handle most of the duties, but with ongoing subscription costs for related services (e.g. extended warranties and service plans). A third-party system operator provides the chargers, software, administration. The operators remotely monitor and manage the station via their own communication platform. If desired, they can also manage the station installation. This simplifies the operation, billing, payment, and often the maintenance, for the host, but is usually the most expensive option. Typically, these systems are tied to specific charger hardware and proprietary networks, which limits the selection of hardware and features.

Advantages of Public EVC networks for hosts: Having a public EVC network enables revenue generation by handling billing and payment to use the charger(s). The billing can be set by the host based on time-based, session or other characteristics (eg. public vs. owner). In addition, EVC networked chargers enable real-time status of available, in-use, charge-complete, or out-of-order chargers for the host and drivers. Payment based on time, status, and notifications can help to increase station revenue and reduce squatting. Charger reservation fees can also provide revenue. With payment processing and load management, the host can change charging fee, speed, and limit to influence user behavior and avoid overloading the electrical infrastructure. Public EVC networked chargers are usually mapped on EVC network mobile and web applications, including integration with navigation systems in vehicles or mobile device applications, providing free advertising. If the selected Public EVC network has a roaming feature, hosts will gain exposure to users of other EVC networks.

Advantages of Public EVC networks for users: Depending on the particular provider and configuration, public EVC networked chargers can enhance customers' charging experience by providing simple payment options, real-time station status (available, in-use and out-of-order), charging data, charge completion notification, session summaries, the ability to reserve a station or stop a charge.

Disadvantages of Public EVC networks: Networked chargers with load management capability may charge at unpredictable rates if they need to reduce charging speed to avoid overloading the electrical system, so the amount of charge received in a given session may be less than expected. Similarly, depending on the pricing structure the anticipated cost of a session may differ from what was expected. Fortunately, the ability to notify users of adjustment in charging speed, or pricing, and potentially offer the ability to opt out for a fee, can mitigate this issue.

1.7. OPERATION AND MAINTENANCE (O&M)

The industry standard for EV charger life expectancy is 10 years [11]. Several factors affect the life expectancy and maintenance cost of Level 2 chargers such as use, environment, vandalism and technological progress. When selecting a vendor, it is important to consider availability of parts and local maintenance personnel, reputation, warranty, network fees and feature upgradeability.

Often networked chargers are equipped with predictive maintenance feature and manufacturers provide monitoring and repair (maintenance agreement) service for a fee, or under warranty. It is recommended that owners select chargers with minimum 3 years of warranty. Hosts should also consider how much O&M they wish to be managed in-house or by third-party service providers, including things like snow removal, parking enforcement and periodic inspection (physical or virtual).

1.8. CUSTOMER EXPERIENCE

Call Center: Based on your business model, you may need to provide call center support to respond to users if they have any issues during charging session. Some manufacturers of networked chargers provide call center service as a part of their service offering.

Billing & Payment: One option for hosts who wish to have billing and payment management is a subscription-based public EVC network where users subscribe to the EVC network (e.g. BC Hydro EV network). The users initiate a charge either by RFID card or mobile application and make payment through the app. A second option is a more universal payment method such as credit card, or NFC payment (e.g. Apple Pay). Typically, a universal payment method is added to a subscription-based public EVC network so that the other features of the EVC network can be leveraged. Payment can be based on time, session, etc. and can vary with charge speed, time of day, or payment method.

The advantage of billing by time is that it is very similar to paying for parking while charging for free. That was a common strategy adopted to avoid being considered a utility selling electricity, prior to the provincial ruling permitting EV charging service providers who are not public utilities to charge for electricity (Ministerial Order No. 2019-M104 [12]). Charging by time also discourages drivers leaving their EV attached after completion of charging.

Billing by consumption (kWh) relates well to the marginal cost paid by the host (and per above is now acceptable for most hosts). However, the reality is that the electricity cost is only a small fraction of the overall cost incurred by a host to install and operate a charger. In general, it is challenging to set a rate that is easy to justify based on consumption alone. Also, charging by kWh consumption does not encourage drivers to disconnect after charging which results in other users cannot use the charger.

Charging by session is rarely used as it generally does not suit either the host or driver in terms of fairness. In addition it does not discourage drivers leaving their cars connected after charging session completed.

Generally, charging for parking (which generally significantly exceeds the cost of electricity) and permitting charging for free, with a time limit on charging (two to four hours), is the most common solution, with the second most common being billing by time (a certain amount per minute, multi-minute or partial-hour segment, or hourly). Complicated combinations of per session, time, speed, idle time, etc. are possible but rare.

2. Electric Vehicle Energy Management System (EVEMS)

EVEMS controls a group of individual EV chargers by connecting, disconnecting, increasing or decreasing charging speed via network control to manage the rate or amount of energy consumed. EVEMS are typically combined with dynamic load management at the individual charger level to provide precise control, but some crude control is possible without it (e.g. disabling the chargers at night). EVEMS are deployed for various reasons such as to minimize utility demand costs (peak-rate power), avoid time-of-use metering costs (when utility rates vary based on time of day, week, season, etc.), avoid overloading individual branch circuits, electrical panels, or the overall building (or other shared electrical service).

EVEMS are typically combined with EVC networks so users can be informed of what is changing and potentially interact with the system. This combination is best suited to larger system deployments where the additional cost and complexity can be spread across more chargers and justified based on the increased benefit. For example, if a hundred chargers are to be added to a large building, the potential increase in peak electrical load is significant. An EVEMS can facilitate that number of chargers to be added. It also provides adequate charging and minimizes or even eliminates any increased load by shifting the charging time to off peak hours. However, some increase in load and some upgrades to the electrical system cannot always be avoided.

3. Station Placement and Site Design

In terms of station placement, several factors should be considered such as being easy to find, being nearby amenities while the car is charging and being perceived as a safe place to leave your car.

Common places to find chargers in the past included urban shopping malls (since it encourages shoppers to spend time shopping and to choose that mall over others), grocery stores, restaurant districts, entertainment venues, civic facilities, and public pay parking lots in downtown areas. The early EV adopters were considered affluent and educated which was a target market for several of those businesses. In the case of civic facilities, there was less of a commercial interest and more a public service interest given that EVs are perceived as a simple way to decrease carbon emissions. Now that many of those locations are addressed there remains two logical areas to encourage the next generation of EV adopters – locations near where those drivers live or near where they work as both are well suited to AC-L2 charging. New multi-family buildings generally now require EV charging infrastructure but that does not address existing multi-family buildings or the rental market. Similarly, many workplaces cannot or will not support charging. [35]

In existing multi-family or rental market neighborhoods, curbside charging (for example around public parks, in front of apartment buildings, or in commercial districts) is a good option. Currently, this option is minimally used. For public bodies, the issue of fairness is a potential challenge (people may dispute the location of chargers depending on their needs). Consideration whether cars parked for extended periods (overnight) would bother neighbors should be factored into location evaluation. [35]

In terms of station layout, there are considerations such as the assumed location of the charge port. Unlike most gasoline cars, EV manufacturers have not standardized on charge port location with some being in the front and others being on the side at either the front or back. The variation in port location can be dealt with even for a parallel parking curbside site by specifying a long charge cord. However, a longer charge cord requires cable management (retractor, or at a minimum a hook) [13].

Other layout considerations include handicap accessibility (adequate space for a wheelchair-bound driver to safely exit the vehicle and access the charger and charge port), cable management (should not be a tripping hazard, even at night in the rain), perceived security (if adequate area lighting is not provided), wayfinding (GPS gets you close but drivers often need help finding the station quickly while driving for the last 50 – 100 m or so), signage (EV parking restrictions), stall identification (making them clearly different to prevent non-EVs blocking the charger aka ICE'ing), potentially covered areas (for all-season charging), and conspicuity (one way to make it apparent that there is public charging is to make it obvious to people who are not really looking for them thus reaching more of the potential audience). Signage can be expanded to include educational and informational content (e.g. why the host is promoting EV adoption, how to use the charger and find others).

4. Procurement and Installation Guideline

In simple installation cases such as a pair of full-speed third-party vertically integrated networked chargers on their own pedestal fed from an existing building or its own electrical service, most hosts typically retain an electrical contractor to purchase the chargers. The chargers are often procured under a previously arranged discount like those available through BC Hydro or the provincial government procurement program. Contact BC Hydro regarding their current agreement. The provincial government program [14] is separate but allows for supply-only or supply and install.

In complicated installations such as more than six full-speed third-party vertically-integrated networked chargers at one site, or deploying EVEMS to do a large number of chargers fed from an existing but limited service, it becomes more appropriate to consider using a more specialized electrical contractor or consulting engineering firm. BC Hydro, Fraser Basin Council, Technical Safety BC, and others can provide relatively unbiased referrals (see below for details) depending on the complexity of the situation.

BC Hydro encourages users to provide a separate utility meter for electric vehicle charging where the EV charging is a significant portion of commonly metered load and cannot be calculated accurately (such as with the built-in meters of vertically-integrated networked chargers). An advantage of a separate meter is the ability to pay different electricity rates when they become available, and to capture emissions and carbon reduction credits. However, the ZAPBC program [7] (which provides a heavily discounted charger for homeowner use) requires applicants to agree to surrender ownership of all emissions and carbon reduction credits.

There are several local resources and programs available to assist those looking to install public or private chargers such as ZEVIP [2], PlugInBC [15 & 16] ,BC Hydro [17], Community Energy Association BC [5], Electric Mobility Canada [18], Fortis BC [19], Natural Resources Canada [20], BC Government (it is basically the same as PlugInBC) [21], UBC [22], and various others. Unfortunately, some of these guides are becoming obsolete as the technology of the marketplace is evolving rapidly, however they all still have plenty of valuable guidance.

BC Hydro also has an electrician referral program [23]; PlugInBC has an EV Advisor Service [15]; the Provincial purchase program makes allowance for installation, and EJTC has an EV Infrastructure electrician training program [24].

There are various lists of available chargers in addition to the ones listed in this guide such as PlugInBC [25] but there is significant overlap between the lists since there are only so many manufacturers represented in BC.

There are also guides specifically for Strata as they are particularly challenging: BOMA [26], MetroVan [27], and CHOABC [28].

5. Level 2 Public Facility Examples

Two examples of public Level 2 charger station will be addressed in this section. The objective is to familiarize the reader with selected parameters, rationales, and recommendations for a public charging station.

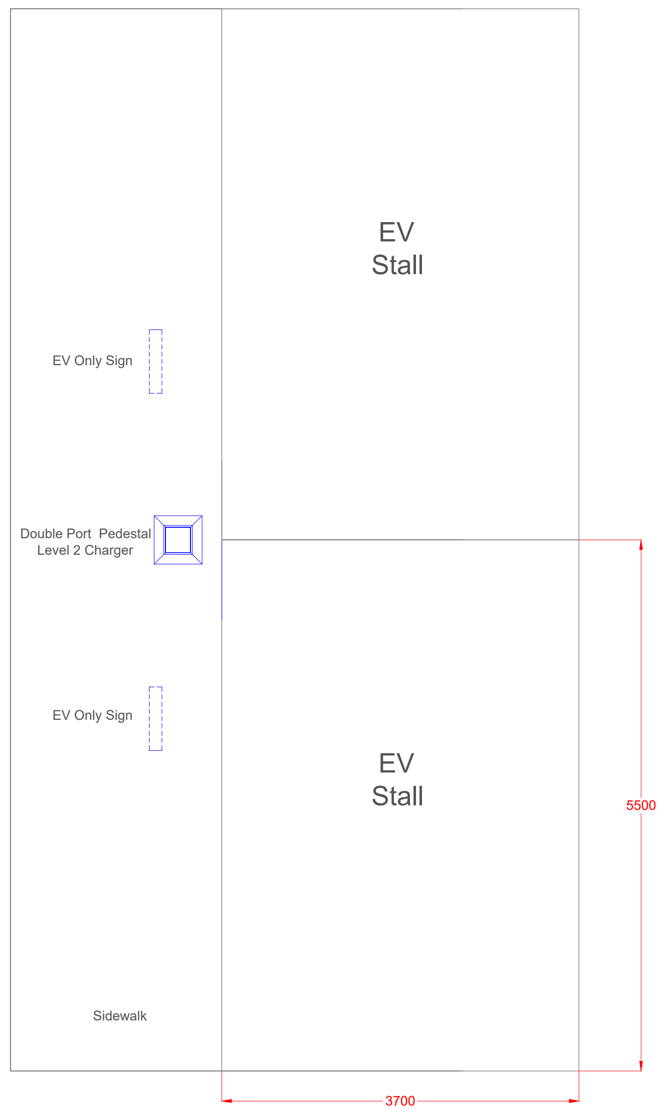
The first example is public street curbside Level 2 charging. The following scenario is for deployment of EV charging stations at 20 outdoor street curbsides. BC Hydro recommends allowing for the stalls to be accessible. Table 2 listed the selected parameters and reason for each selection for curbside example.

TABLE 2. PUBLIC STREET CURBSIDE LEVEL 2 CHARGING STATION EXAMPLE

parameters	Curbside Example	Explanation
Number of Level 2 Chargers	1 double-port per site, 10 sites	Some government funding programs (e.g. ZEVIP) require a minimum 20 charging stations but counts each port [2]. The project is still eligible if chargers are distributed across many sites, so this example has 10 sites with a double-port charger per site.
Charger Network Type	Networked EVC	Networking is also a government funding program requirement [2], and using a Public subscription based EVC network has many benefits in this application.
Indoor/Outdoor	Outdoor	Most locations will be outdoor and subject to vandalism.
Circuit Configuration	Dedicated circuit or EVEMS	If the host wants to manage load of charger they can use EVEMS, if they prefer two full-speed ports they can provide dedicated circuits.
Electrical Capacity Upgrade	Can be mitigated with EVEMS	EVEMS can be used to minimize the need to upgrade the electrical system even if the chargers are fed from an existing building or other service.
Charging Port	Double	Chosen to minimize cost per stall and serve the most customers.
O&M and Customer Support	Third-party vertically integrated	Chosen due to high number of distributed chargers and to provide reliable 24/7 monitoring and support with minimal burden on the host.
Bill	Yes	Time-based fee recommended to discourage squatting. Cost should be the same or higher as meter parking rates to avoid stalls being used by non-EV or charge-completed EVs.
Credit card acceptance	Discretionary but probably unnecessary	Currently most public chargers that charge a fee are on a subscription based public EVC network. Generally only tourists or people using someone else's car would want to use a credit card. American tourists can generally use the same network subscription they do at home since roaming is common. People who loan out their car usually think to provide the subscription RFID card with the EV keys.
Stall Accessibility	Accessible recommended.	As the industry phases out fossil fueled vehicles the need for accessible EV charging will increase. BC Building Access Handbook [29] requires minimum width of 3.7m for wheelchair users which includes 1.2m wide space for entering and leaving the vehicle.

Figure 1 is an example of site layout for outdoor curbside charging station with double port pedestal Level 2 charger.

FIGURE 1. EXAMPLE OF CURBSIDE CHARGING STATION LAYOUT [30]



There are many Level 2 charger brands/models that are suitable for street curbside parking application. Among eligible EV charger models listed by BC Hydro, FLO, EV Box, Charge Point and Sema have special models for street curbside application.

Figure 2 is an example of a public curbside oriented charger, a FLO SmartTWO–BSR charger.

FIGURE 2. CURBSIDE CHARGING STATION WITH FLO SMARTTWO–BSR CHARGER

One of the challenges for public parking is providing proper space to install utility meter and circuit breaker panel. This particular system is designed to include the meter and panel and be part of up to a three–post six single–port charger group. The two other post would not have the integrated panel and meter and instead be fed from this main post. The sign at the top helps EV drivers find the chargers (way–finding) and accommodates the cord retractors that keep the long cables tidy. This particular installation was part of a test conducted by Powertech to verify compatibility with BC Hydro four–jaw iTron meters. The detail of that compatibility verification is available in Appendix D.

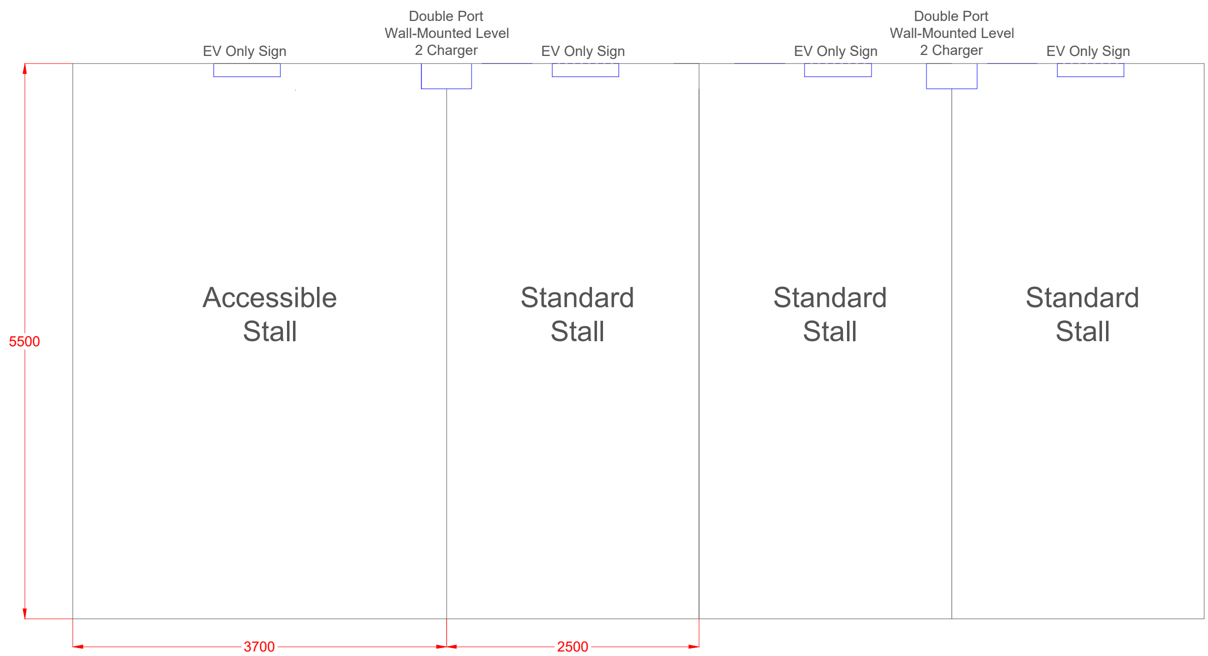
The second example is a large shopping mall. The parameters and rational for shopping mall example are listed in Table 3.

TABLE 3. SHOPPING MALL LEVEL 2 CHARGING STATION EXAMPLE

Parameters	Shopping Mall Example	Explanation
Number of Level 2 Chargers	10 double-port	10 stations with double ports provides 20 connectors.
Charger Network Type	Networked EVC	Networked chargers are required to be eligible for funding by majority of government funding programs. Using a networked EVC provides free advertising of the stations location and provides information to the mall about utilization.
Indoor/Outdoor	Outdoor	While an indoor or covered charger location is recommended to maximize use, the area may still be unheated and wet and subject to vandalism.
Circuit Configuration	Circuit sharing static or EVEMS	Typically shopping malls provide free charging so full speed charging is not necessary to attract drivers and malls typically want to attract as many drivers as possible. A 2 hour stay at 30A will provide about 60kM of range, or the average daily commute.
Electrical Capacity Upgrade	Probably required	Typically, some form of upgrade (parking area panel, mall section) will be required for such a relatively large installation.
Charging Port	Double	Cost per stall will be cheaper using double-port charging stations so more customers can be served for the same cost.
O&M and Customer Support	Depends	Customer support can be outsourced to the Public EVC. With a concentration of chargers like this, and existing mall maintenance and operation staff, many O&M tasks may be handled internally.
Bill	No, or time of day based	Typically, EV charging in shopping malls are free to attract customers, however downtown malls often locate the chargers in pay parking lots that charge much more than typical EV charging rates. Malls with free parking may want to consider charging a fee for EV charging when the mall is not open.
Authentication	Yes	Subscription based public EVC chargers typically have authentication and this enables fee-based charging off-hours.
Stall Accessibility	Some	It is recommended to provide some stalls that are accessible in a similar proportion to the regular parking stalls as the industry phases out fossil-fuel vehicles.

Figure 3 is an example of site layout for indoor nose in parking lot charging station with double port wall–mounted charger. Both accessible and standard stalls were considered for this site.

FIGURE 3. EXAMPLE OF NOSE IN CHARGING STATION LAYOUT [30]



Another challenge for public parking is providing power to the chargers. One option is to feed the chargers from site host electrical panel. If the electrical panel does not have additional capacity for chargers, then an alternative option is feeding the chargers from their own separate electrical service (electrical distribution, meter, etc.).

Figure 4 is an example of a nosed in parking lot and different types of Level 2 charger installation is shown in the following photo.

FIGURE 4. NOSED IN CHARGING STATION AND VARIOUS LEVEL 2 CHARGER INSTALLATION.

Conclusion

Various options for hardware and software selection of Level 2 chargers were explained. Different ownership model of EVEMS was elaborated. Two examples of public Level 2 chargers were outlined including recommendations on how to select hardware/software parameters based on site specific requirements and limitations.

Following are recommendations for selection of parameters listed in Section 1 and 2.

HARDWARE

- Available electrical capacity of site host to be verified by an electrician and preferred circuit configuration to be identified. Depends on available electrical capacity, it is recommended to select Dedicated Circuit for installation of one Level 2 charger, Static Load Management for installation of two Level 2 chargers and Dynamic Load Management is recommended for installation of more than two Level 2 chargers.
- A networked charger with SAE J1772 socket is required for eligibility under majority of government funding programs. The number of charging stations to be determined based on budget, charging need and ensuring the minimum number of charging stations requirement is met to be eligible under government funding program.
- It is recommended to select chargers with an outdoor rating for durability and vandal resistance.

SOFTWARE

It is recommended to select an EVC Network per Appendix A.1.

O&M

- Availability of spare parts and access to local maintenance personnel, reputation, etc. should be considered when selecting a Level 2 charger brand.
- Minimum 3 years warranty coverage is recommended to minimize O&M cost.

CUSTOMER EXPERIENCE

Current and future need for billing, authentication and call center should be considered when selecting the charger to ensure capability.

Appendix A—Hardware and Software Options

A.1. EV CHARGER NETWORK PROVIDER AND COMMUNICATION PROTOCOL

EV charging stations communicate with charging management system via a communication protocol. Some manufacturers have adopted Open Charge Point Protocol (OCPP) which is an internationally established open protocol. Some manufacturers have created their own proprietary communication protocol which means once customer purchased their chargers and network, they can not switch to another network provider.

Some manufacturers claim that their communication protocol is very similar to OCPP such as Open Network Protocol (ONP), but this could be misleading. This should be verified by asking the manufacturer if their chargers work with a third-party network provider. The main advantage of chargers supporting OCPP is the long-term flexibility for the host to switch network without replacing hardware. The advantage of manufacturers with non-OCPP chargers is they are one stop shop for both hardware and software. In addition, they claim that their proprietary communication protocol reduces O&M costs. Table 4 includes a list [31] of network providers in British Columbia and their communication protocol.

TABLE 4. NETWORK PROVIDERS AND COMMUNICATION PROTOCOL.

Network Provider	Communication Protocol
Addenergie (Flo)	ONP
Blink	Proprietary
ChargeLab	OCPP
ChargePoint	OCPP
Electrify Canada	OCPP
GE	Proprietary
Greenlots	OCPP
SemaConnect/ Sema Charge	Proprietary
Sun Country Highway	Proprietary
Switch	OCPP
Siemens	OCPP

A.2. EV WEATHERPROOF RATING AND APPLICATION

TABLE 5. WEATHERPROOF RATING AND APPLICATION [32]

Rating	Application	Description
NEMA 1	Indoor	Protects users against contact with hazardous components and protects the components from the ingress of solid objects, such as fingers and falling dir
NEMA 2	Indoor	Same as NEMA 1 but adds protection against the ingress of dipping and light splashing water.
NEMA 3	Indoor/Outdoor	Same as NEMA 2 but adds stronger protection against the ingress of water and dust. It protects against windblown dust, rain, sleet, and snow and will be undamaged by ice forming on the enclosure.
NEMA 3R	Indoor/Outdoor	Same as NEMA 3 but without the protection against windblown dust. The standard doesn't say this, but typically the difference is that there is no gasketing on NEMA 3R enclosures.
NEMA 3S	Indoor/Outdoor	Same as NEMA 3 but adds the provision that external mechanism remain operable when ice laden.
NEMA 3X, NEMA 3RX, NEMA 3SX	Indoor/Outdoor	the X signifies the addition of corrosion protection.
NEMA 4	Indoor/Outdoor	Same as NEMA 3 but adds protection against hose directed water.
NEMA 4X	Indoor/Outdoor	Same as NEMA 4 but adds protection against corrosion.
NEMA 6	Indoor/Outdoor	Protects against the ingress of objects, fingers, and falling dirt, hose directed water and is undamaged by ice formation. What's more, it protects against occasional temporary submersion to a limited depth.
NEMA 6P	Indoor/Outdoor	Same as NEMA 6 but adds protection of prolonged submersion to a limited depth and adds corrosion protection.
NEMA 12	Indoor/Outdoor	Protects against the ingress of objects, fingers, falling dirt, settling dust and drips. It is similar to NEMA 3 but it is for indoor use, so instead of protecting against windblown dust it protects against settling airborne dust, lint, fibers, and flyings. It won't protect against rain, sleet, and snow, but it does protect against seeping oil and coolant as well as dripping and light splashing water. Despite the large number it is a basic level of protection. It may be helpful to think of it as NEMA 1.2 rather than NEMA 12.
NEMA 13	Indoor/Outdoor	Same as NEMA 12 but adds protection against oil and coolant splashing and spraying.

A.3. CIRCUIT CONFIGURATION

Following are five circuit configurations for ZEV installation [9 & 10]:

1. Dedicated Circuit: A dedicated circuit with demand factor of 100% is required to accommodate each charging stall. This configuration is compatible with majority of EV chargers. With this configuration charging is typically faster and non-interrupted as there is no impact from other chargers. The dedicated circuit, depending on the number of installed chargers, may require substantial increase in electrical infrastructure to accommodate all loads which is costly. This configuration is a good fit for high turnover stalls such as car sharing.

2. Circuit Sharing: Circuit sharing allows connection of multiple EV chargers to a single branch circuit from panel reducing electrical capacity upgrade cost. Following are three circuit sharing configurations:

    a. Static load management: This configuration provides control of charging based on equal power allocation to each EV charger. As an example, when two EV chargers are installed to one circuit, each EV charger receives 50% of the available capacity. One disadvantage is that it cannot distribute available capacity based on EV on-board charger capacity. For example, if one EV is equipped with a 10kW on-board charger and another EV is equipped with 3kW on-board charger, then each EV receives equal 5kW. As a result, the EV with 3kW capacity is wasting capacity. Also, it is not compatible with all EV chargers. This configuration is a good fit for small size installations such as visitor parking stalls.

    b. Time-shared load management (Also called Rotational): This configuration provides charging in accordance to a predefined schedule and duration. For example, charging is provided to one EV charger for one hour and then charging is provided to the next EV charger. Since control operates without communication with the EV charger, it is unable to identify required charging time for each ZEV. This is a good fit for corporate fleet ZEVs where required charging time for each ZEV is known and can be defined.

    c. Dynamic load management: This configuration is the most flexible and efficient circuit sharing configuration where power is delivered based on charging requirement at each EV charger. It allocates maximum available power to each ZEV and maximize the utilization of existing electrical capacity. Communication to a remote energy management system is required utilizing communication protocols as explained in Appendix A.1. Utilizing load management system may reduce charging performance since the system adjust charging rate of one EV charger based on charging requirement of other EV chargers. This can create a situation that full charging time to be delayed. The adjustment in charging rate can be communicated with the ZEV owner by text message/email. Only compatible EV chargers can be integrated with dynamic load management. This configuration is a good fit for workplace, street curbside or multi-unit residential buildings.

Appendix B—Charging Capacity of Various EV Models

TABLE 6. CHARGING CAPACITY OF VARIOUS EV MODELS [33]

Electrical Voltage	Electrical Current (Breaker / Delivered)	Nominal Wattage Consumed	Common EVs in category
208 – 240 V	20 / 16 A	3.3 – 3.7	Audi A3 PHEV, BMW 5 or X5 PHEV, Chevy Volt (pre2019) or Spark EV, Ford C-Max or Fusion Energy PHEV, Hyundai Sonata PHEV, Kia Niro PHEV, Mercedes C350 or S550 or GLE550e PHEV, Mitsubishi i-MiEV or Outlander PHEV, Nissan Leaf (some Gen1), Porsche Cayenne or Panamera PHEV, Smart ForTwo EV, Toyota Prius Prime, Volvo XC90 T8 PHEV
208 – 240 V (current varies with voltage as power limit is hit)	40 / 32-30 A (current varies with voltage as power limit is hit)	6.3 – 7.2	Chevy Bolt or Volt (2019), Chrysler Pacifica PHEV, Fiat 500e, Ford Focus EV, Hyundai Ioniq (Gen1), Jaguar I-Pace, Kia Soul (Gen1), Nissan Leaf (some Gen1, all Gen2), VW e-Golf
up to 240 V	40 / up to 32 A (see note)	7.7	BMW i3, Honda Clarity, Hyundai Kona EV or Ioniq (Gen2), Kia Niro EV or Soul EV (Gen2), Tesla Mod3 (some SR)
up to 240 V	50 / up to 40 A	9.6	Mercedes B-Class or EQC, Mini Cooper SE, Tesla Mod3 (SR, SR+), Toyota RAV4EV
208 – 240 V	60 / 48 – 50 A	up to 11.5 kW	Audi e-Tron, Porsche Taycan, Tesla Mod3LR, ModS, ModX, or ModYLR,
208 – 240 V	100 / 80 A	Up to 19.6 kW	Tesla ModS (1st Gen w/ optional dual chargers)
Note: while all cars have a current limit, they also have a power limit and above 208 V some cars hit power limit so they can't use full current. If charger can't provide the maximum the car will limit itself to what the charger can provide. Voltage is usually determined by the building electrical supply not the vehicle or charger.			

Appendix C—Applicable Standards

Following standards are applicable to Level 2 EV chargers:

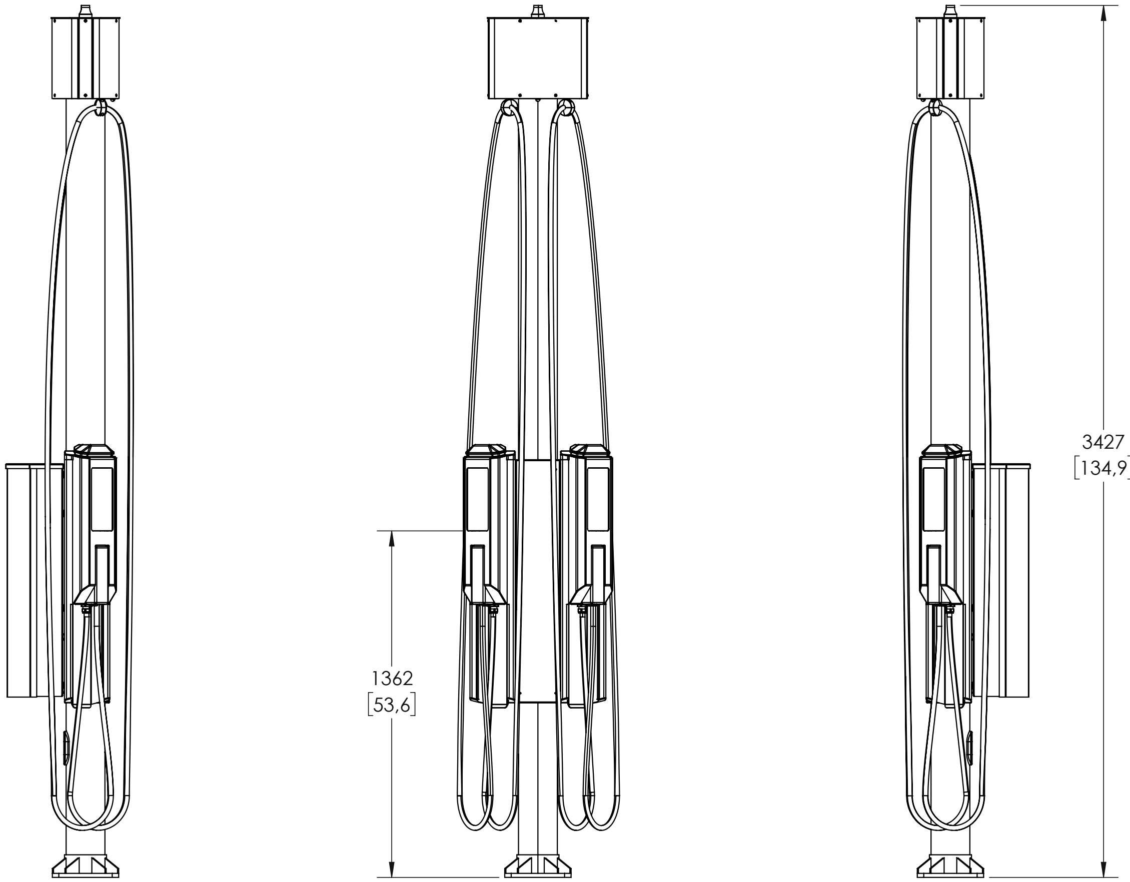
1. CEC 22.1–18: Canadian Electrical Code, Part I, Safety Standard for Electrical Installations (24th Edition)
2. CSA–C22.2 NO. 281.2–12 (R2017): Standard for safety for personnel protection systems for electric vehicle (EV) supply circuits: Particular requirements for protection devices for use in charging systems
3. CSA C22.2 NO 282: Plugs, receptacles, and couplers for electric vehicles
4. CSA C22.2 NO 280: Electric vehicle supply equipment

All metering installations for level 2 EV charging stations must be constructed to BC Hydro's Requirements for Secondary Voltage Revenue Metering [34].

Appendix D—Level 2 Charger Compatibility with BC Hydro Meter

The FLO SMARTTWO–BSR Level 2 charger comes in two models: One with a distribution panel (tuxedo panel) and one without distribution panel. The distribution panel is a metal enclosure on the rear side of charger providing required space to install meter and circuit breaker as shown in Figure 5.

FIGURE 5. FLO SMARTTWO–BS WITH/WITHOUT TUXEDO PANEL



FLO SmartTWO–BS without tuxedo panel

Front View

FLO SmartTWO–BS with tuxedo panel

When it is not possible to feed the charger from an existing distribution panel, a curbside master pedestal which is equipped with a distribution panel is required. This panel includes 2 separate sections, the first section to connect directly to the distribution grid (split phase 240V 200A service) includes a standard meter socket, the second section includes a main 200A breaker, along with all the hardware to host up to six dual 40A breakers capable of feeding up to six SmartTWO–BSR.

Powertech tested and verified that BC Hydro meter fits into SmartTWO–BSR enclosure and the meter integration with the charger was functional. If metering is required for street curbside charging station the above solution is a feasible and cost-effective one.

References

1. List of qualified BC Hydro EV chargers

   bchydro.com/content/dam/BCHydro/customer-portal/documents/power-smart/electric-vehicles/eligible-EV-charger-list.pdf

2. Zero Emission Vehicle Infrastructure Program, June 2019 – Office of Energy Efficiency - Natural Resources Canada

   https://www.nrcan.gc.ca/energy-efficiency/energy-efficiency-transportation/zero-emission-vehicle-infrastructure-program/21876

3. Electric Vehicle Charger Selection Guide, January 2018, State of California Energy Commission, Retrieved on March 30, 2020 from

   https://efiling.energy.ca.gov/GetDocument.aspx?tn=228787-43&DocumentContentId=60104

4. Types of Charging Stations at the Workplace, Oct 2016, US Department of Energy, Retrieved on March 17, 2020 from

   https://cleancities.energy.gov/files/u/news_events/document/document_url/228/types-of-charging-stations-at-the-workplace.pdf

5. The Different EV Charging Connector Types, Retrieved on March 11, 2020 from

   https://evcharging.enelx.com/no/news/blog/552-ev-charging-connector-types

6. Planning for Electric Vehicle Charging Infrastructure, June 2013, Community Energy Association, Retrieved on March 19, 2020 from

   https://pluginbc.ca/resource/planning-electric-vehicle-charging-infrastructure-toolkit/

7. ZAPBC Program Details,

   https://zapbc.ca/programdetails/

8. Capital & Installation Costs EV Condo – Metro Vancouver - Retrieved on March 29, 2020 from

   http://www.metrovancouver.org/services/air-quality/climate-action/transportation-programs/ev-strata-condo/key-info/chargers-installation-costs/Pages/default.aspx

9. Electric Vehicle Charging Infrastructure in Shared Parking Areas, City of Richmond, AES Engineering, Retrieved on March 13, 2020 from

   https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/power-smart/electric-vehicles/ev-charging-infrastructure-in-shared-parking-areas.pdf

10. Electric Vehicle Energy Management Systems, May 2019, CSA Group Research, Retrieved on March 27, 2020 from

    https://www.csagroup.org/wp-content/uploads/CSA-RR_ElectricVehicle_WebRes.pdf

11. Electric Vehicle Charging Stations as CEQA mitigation: Greenhouse Gas Reductions and Cost Effectiveness, March 09, 2018, accessible at:

    https://www.sccgov.org/sites/dnz/Documents/Task-3D-EV-Charging-Stations-as-GHG-Mitigation-Mechanism-under-CEQA_White-Paper.pdf

12. Province of British Columbia, Order of the Minister of Energy, Mines and Petroleum Resources,

    http://www.bclaws.ca/civix/document/id/mo/mo/2019_m104

13. Cable Management, Retrieved on May 01, 2020 from

    https://store.clippercreek.com/cable-management

14. Electric Vehicle Charging Stations, Government of British Columbia, Retrieved on July 2, 2020 from

https://www2.gov.bc.ca/gov/content/governments/services-for-government/bc-bid-resources/goods-and-services-catalogue/ev-charging-stations

15. Plug In BC, Planning & Hosting a Charging Station,

https://pluginbc.ca/charging-stations/planning-hosting-a-charging-station/

16. Plug In BC, EV Advisor Service,

https://pluginbc.ca/ev-advisor-service/

17. Choosing an EV charger,

https://electricvehicles.bchydro.com/charge/choosing-a-home-EV-charger

18. Electric Mobility Canada,

https://emc-mec.ca/evse-101/

19. Fortis BC, Installing networked electric vehicle charging stations

https://www.fortisbc.com/services/sustainable-energy-options/electric-vehicle-charging/installing-networked-electric-vehicle-charging-stations

20. Natural Resources Canada

https://www.nrcan.gc.ca/energy-efficiency/energy-efficiency-transportation/resource-library/3489

21. Electric Vehicle Charging Stations – Buyer Resources Guide

https://www2.gov.bc.ca/assets/gov/government/services-for-government-and-broader-public-sector/buy-goods-services-and-construction/goods-and-services-catalogue/csa-assets/electric-vehicle-charging-stations/buyer_resources_evcs.pdf

22. Station Location Process, Level 2 Charging

http://blogs.ubc.ca/tipslab/files/2019/01/12-06-27-Level-2-Station-Location-Process.pdf

23. EV Electrician Referral Request Form

https://electricvehicles.bchydro.com/ev-electrician-referral-request-form

24. Electric Vehicle Infrastructure Training Program

https://ejtc.org/industry-training/evitp-canada

25. Charging Station Equipment,

https://pluginbc.ca/incentives/manuf_list/

26. Electric Vehicle Charging Stations for Multi-Unit Residential and Mix-Use Commercial/Residential Buildings, BOMA British Columbia

https://www.boma.bc.ca/media/19602/EVCS%20Info%20Booklet%20For%20MURBs%20-%20BOMA%20BC%20.pdf

27. Strata Council and Property Manager Electric Vehicle Charging Checklist

www.metrovancouver.org/services/air-quality/AirQualityPublications/StrataCouncilPropertyManagerEVChargingChecklist.pdf

28. Installation of Electric Vehicle Charging Stations on Strata Properties in British Columbia

https://www.choa.bc.ca/wp-content/uploads/EVCS-Research-Study_updated-2019.pdf

29. Building Access Handbook 2014, Office of Housing and Construction Standards, British Columbia

https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/construction-industry/building-codes-and standards/guides/2014_building_access_handbook.pdf

30. Design Guidelines and Standards BC Public Electric Vehicle Charging Stations, August 2013, UBC, Retrieved on March 16, 2020 from

https://blogs.ubc.ca/tipslab/projects/design-guidelines-for-bc-charging-stations/

31. Communication protocol at

www.ChargeHub.com

32. Your Guide to NEMA Enclosure Ratings, Retrieved on April 16, 2020 from

https://www.budind.com/nema-rating-guide.php

33. What to Consider When Buying and Installing a Home Electric Vehicle Charging Station, Tom Konard, January 30, 2017, Retrieved on April 14, 2020 from

https://www.greentechmedia.com/articles/read/buying-and-installing-a-home-electric-vehicle-charging-station

34. BC Hydro meter installation requirements

https://app.bchydro.com/accounts-billing/electrical-connections/distribution-standards/LA-RM-Secondary-Voltage-750V-and-less.html

35. Electric Vehicle Charging Infrastructure in Shared Parking Area: Resources to Support Implementation & Charging Infrastructure Requirements

https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/power-smart/electric-vehicles/ev-charging-infrastructure-in-shared-parking-areas.pdf

About Powertech

EV Infrastructure group at Powertech Labs provides engineering support and consulting services to simplify the process for deployment of Level 2 and DCFC charging stations. The team is committed to provide excellent customer service and engineering solutions for the planning, design, procurement, installation, and commissioning of ZEV chargers stations.

BC Hydro
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