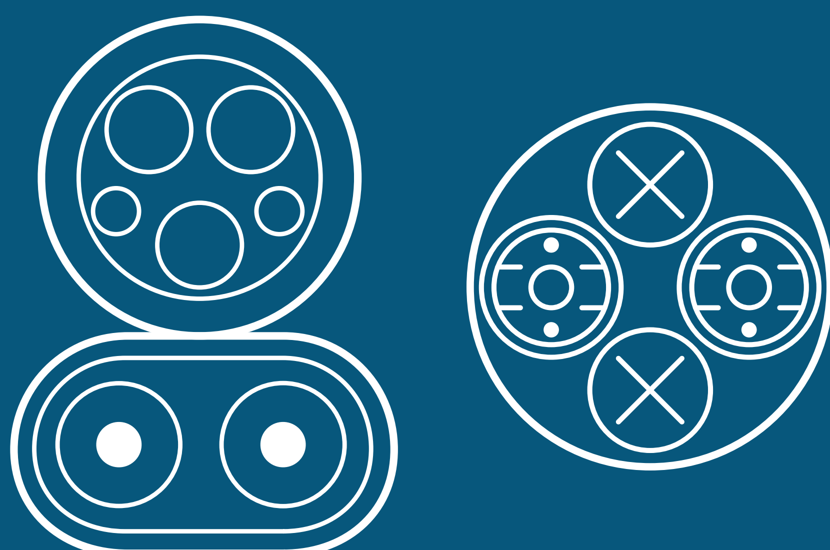
ELECTRIC VEHICLE CHARGING STATIONS

Technical Installation Guide



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Hydro Québec

This document is a collaborative effort of the Centre National du Transport Avancé (CNTA), the Régie du bâtiment du Québec (RBQ), the Ministère du Transport du Québec (MTQ), the Corporation des maîtres électriciens du Québec (CMEQ) and Hydro-Québec.

The terminology used herein is based on that recommended in International Standard IEC 61851-1, *Electric vehicle conductive charging system – Part 1: General requirements*, published by the International Electrotechnical Commission.

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DISCLAIMER

This document presents useful general information about the installation of electric vehicle charging stations. Given the newness of the technology, the wide range of products offered, the provisional nature of some standards and the constantly evolving regulatory environment, it is impossible to guarantee that the information herein is current, complete or exact. Even though the information is from reliable sources, the authors and Hydro-Québec disclaim all liability for any errors or omissions, or for the results obtained from using this Technical Installation Guide.

ABBREVIATIONS

A	ampere, a unit of electric current
AC	alternating current
ANSI	American National Standards Institute
AWG	American Wire Gauge, a North American unit of diameter of electric conductors
BEV	battery electric vehicle
CHAdeMO	Japanese fast-charge station standard. Short for "CHArge de MOve", CHAdeMO evokes the phrase "How about some tea?" in Japanese.
CMEQ	Corporation des maîtres électriciens du Québec
Code	*Québec Construction Code – Chapter V, Electricity. Canadian Electrical Code, Part 1 and Québec Amendments* (CSA C22.10)
CSA	Canadian Standards Association
DC	direct current
EPA	Environmental Protection Agency (United States)
EREV	extended range electric vehicle
EV	electric vehicle
GFCI	ground fault circuit interrupter
HEV	hybrid electric vehicle
Hz	hertz, a unit of frequency equivalent to one cycle per second
IEEE	Institute of Electrical and Electronics Engineers
JEVS	Japan Electric Vehicle Standard
kVA	kilovoltampere
kW	kilowatt, a unit of power
kWh	kilowatthour, a unit of energy
NEMA	National Electrical Manufacturers Association
ph	phase
PHEV	plug-in hybrid electric vehicle
RBQ	Régie du bâtiment du Québec
SAE	Society of Automotive Engineers (now SAE International)
TIL	Technical Information Letter, an interim standard put out by the CSA
UL	Underwriters' Laboratories
V	volt, a unit of electric potential
VAC	voltage in an alternating current
VDC	voltage in a direct current
wh	watthour

1. INTRODUCTION

1.1 Preface

The coming years will see more and more electric vehicles on Canadian roads. Since 2011, when plug-in vehicles* became available in Québec, sales have doubled each year. Though all of these vehicles can be charged from an ordinary 120-V outlet, charge time can be shortened with a 240-V charging station or a DC fast-charge station.

1.2 Purpose of this Guide

This Guide, written for master electricians, retailers, municipalities and the general public, presents the basics of installing EV charging stations.

1.3 Electric vehicles

Section 86 of the *Québec Construction Code, Chapter V – Electricity* (the Code) defines the electric vehicle as "an automotive-type vehicle for highway use that includes passenger automobiles, buses, trucks, vans, low speed vehicles, etc., powered by an electric motor(s) that draws current from a rechargeable storage battery, fuel cell, photovoltaic array, or other source of electric current [...]." [1]

This Guide uses the above definition of "electric vehicle" (EV), but limits the scope to passenger vehicles that draw current from a rechargeable storage battery. There are four types of EV: hybrid electric vehicles (HEV), plug-in hybrids (PHEV), battery electric vehicles (BEV) and extended range electric vehicles (EREV).

1.3.1 Hybrid electric vehicles

HEVs have two motors: an internal combustion engine and an electric motor. Their storage batteries are generally low-capacity, which greatly limits their range and top speed in electric mode. They cannot be recharged from the grid and are therefore not covered by this Guide. Examples: Toyota Prius and Honda CR-Z.

1.3.2 Plug-in hybrids

PHEVs are hybrids that can be plugged into the power grid for battery charging. In general, they have a medium-capacity battery that allows the vehicle, in all-electric mode, to achieve a range of several dozen kilometres, and rates of acceleration and top speeds comparable to those of gasoline-powered vehicles. Examples: Chevrolet Volt (often classified as an EREV), Ford C-Max and Fusion Energi, Cadillac ELR and Toyota Prius PHEV.

* Electric vehicle with an energy storage device that can be charged from an external power source.

1.3.3 Battery electric vehicles

BEVs operate solely on the electricity stored in a high-capacity battery, which can be recharged from the grid. Depending on battery capacity, they have a range of 100 to 400 km. Charging time varies by battery capacity and whether a fast-charge station is used. It is also affected by the ambient temperature and the remaining battery charge at the start of charging. Examples: Nissan LEAF, Mitsubishi i-MiEV, Tesla Model S and Kia Soul EV.

1.3.4 Extended range electric vehicles

EREVs are battery electric vehicles equipped with an internal combustion generator that produces enough power for the vehicle to reach a charging station when its battery is depleted. The BMW i3 is currently the only EREV available in Québec.

2. CHARGING MODES

Standard SAE J1772 defines six charging levels. In North America, only three are currently used for electric vehicles (see Table 1). Level 1 operates at 120 VAC, while Level 2 uses 208 or 240 V AC and fast charging requires 200 to 450 VDC. Although it is fairly common to refer to direct current fast-charge stations as Level 3, it is incorrect and not recommended.

The only standards that currently set out specifications for fast charging are CHAdeMO and SAE J1772 Combo. In parallel, Tesla has developed its own DC fast-charge system, "Supercharger", which can be used only by Teslas.

*Table 1 – **Summary comparison of charging levels***

	Level 1	Level 2	Fast charge
Voltage	120 V	208 or 240 V	200 to 450 V
Current type	AC	AC	DC
Useful power	1.4 kW	7.2 kW	50 kW
Maximum output	1.9 kW	19.2 kW	150 kW
Charging time[a]	12 h[a]	3 h[a]	20 min[b]
Connector	J1772	J1772	J1772 Combo, CHAdeMO and Supercharger

a. Charging time of a completely discharged 16-kWh battery at useful power.

b. Charging time to 80% charge, i.e., 12 kWh. Fast charging cannot be sustained to a full charge.

2.1 Level 1 (120 V)

All EVs are equipped with an on-board Level 1 charger that can be plugged into an ordinary power outlet (CSA 5-15R*). This has the advantage of not requiring any electrical work, or at least minimizes any installation costs. On-board 120-V chargers are found in every type of EV.

Table 2 shows charging time using a Level 1 charger based on distance driven. The charging times are for reference only. They are based on the average consumption of the most popular EVs in Québec in 2015. Power consumption and, by extension, distance traveled per kilowatthour (kWh) vary according to vehicle, road conditions and amount of heating or air conditioning used.

* A CSA 5-20R outlet (20-A branch circuit) is required if the outlet is dedicated to EV charging (see Section 86 of the Code).

Charging time is a function of the energy consumed by the EV since the last full charge. However, charging can be interrupted at any time with the sole impact being a reduction in range before the next charge.

Table 2 – ***Level 1: Charging time based on distance driven***

	Distance traveled (km)	Approximate energy consumption[a] (kWh)	Charging station power (kW)	Approx. charging time (h)
12-A charging cable[b] 120-V outlet	25	5.2	1.4	4
	50	10.4		8
	100	20.7		15

a. Combined city and highway driving averages for the three PHEVs and BEVs (Volt, i-MiEV and LEAF) in the EPA's *2011 Fuel Economy Guide*.

b. Charging cables rated less than 12 A require longer charging times.

2.2 Level 2 (208 V or 240 V)

Charging time at Level 2 charging stations can be limited by the specifications of the on-board charger and the state of the battery, irrespective of the charging station's rated power. In the future, charger capacity is expected to increase. For example, Tesla already offers on-board 10-kW and 20-kW chargers. Conversely, EV charge time can also be limited by the power rating of the charging station (see Table 3).

Table 3 – ***Level 2: Charging time based on distance driven and charging station power rating***

Type of station	Distance traveled (km)	Estimated energy consumption[a] (kWh)	Charging station power (kW)	Approx. charging time (h)
15-A station (240-V, 20-A two-pole circuit breaker)[b]	25	5.2	3.6	1.5
	50	10.4		3.0
	100	20.7		6.0
30-A station (240-V, 40-A two-pole circuit breaker)[b]	25	5.2	7.2	0.75
	50	10.4		1.5
	100	20.7		3.0

a. Combined city and highway driving averages for the three PHEVs and BEVs (Volt, i-MiEV and LEAF) in the EPA's *2011 Fuel Economy Guide*.

b. Rated current of the circuit breaker, not the branch circuit (see the Code).

2.3 DC fast charging

DC fast charging is governed by the North American SAE J1772 Combo standard and the Japanese JEVS G105-1993* standard. DC fast-charge stations generally support both standards. All carmakers adhere to one of these standards, except Tesla,** which has developed a higher-performance charging station, but offers a CHAdeMO adapter as an option.

The configuration of the charging plug and the EV socket (which together make up the coupling) and the communication protocol between the charging station and the EV differ between the standards, but the basic principles are the same. For example, both have two power pins (positive and negative), one ground pin, one pin to detect the presence of the connector in the socket and one pin for communication (see Sections 3.5, 3.6 and 3.7).

Since an external device manages the charging current, it needs to take into account a number of battery parameters. The communication protocol handles the sharing of data about the battery's voltage ranges and ampacity, which allows the charging station to supply the correct charging voltage and current level to the EV battery.

The maximum charging power specified by the CHAdeMO standard is 62 kW (125 A at 500 VDC), while the J1772 Combo standard sets the maximum power at 100 kW (200 A at 500 VDC). In practice, very few batteries support 500 V, and charging stations are commonly equipped with both standard connectors and limit the rated power to 50 kW.[3] In contrast, Tesla Supercharger stations are rated 120 kW,** and the automaker has announced even higher output levels in the near future.

Since most EV batteries have a rated voltage of around 350 V, they cannot take full advantage of fast-charge stations. Consequently, for comparison it is more useful to establish charging times using a feasible output of about 40 kW. Table 4 shows the time to charge a battery with a 100-km range to 80% of its full capacity.

Table 4 – ***Charging time to 80% charge based on distance traveled since the last 80% charge***

Distance traveled (km)	Estimated energy consumption[a] (kWh)	Power (kW)	Approx. charging time (min)
25	5.2		8
50	10.4	40	16
75	15.6		25

a. Combined city and highway driving averages for the three PHEVs and BEVs (Volt, i-MiEV and LEAF) in the EPA's *2011 Fuel Economy Guide*.

* Widely known as CHAdeMO, an acronym that evokes the phrase "How about some tea?" in Japanese,[2] which suggests how fast and easy charging is.

** See Section 3.7 for the specific case of Tesla.

3. CHARGING STATIONS

3.1 General information

A charging station (see Figure 1) is usually in the form of a fixture connected directly to an electrical distribution panel, or sometimes to an electrical outlet. It has one or more charging cables (see Figure 2) equipped with a connector that is similar to a gas-pump nozzle and is used in the same way: it simply connects to the EV's charging socket to charge the battery. The station has lights that indicate that the EV is connected and charging. It can also have a button for starting or stopping the charging operation. Some have additional features: energy meter, electronic payment system, card-controlled access system, Internet access, etc.

*Figure 1 – **Charging station***

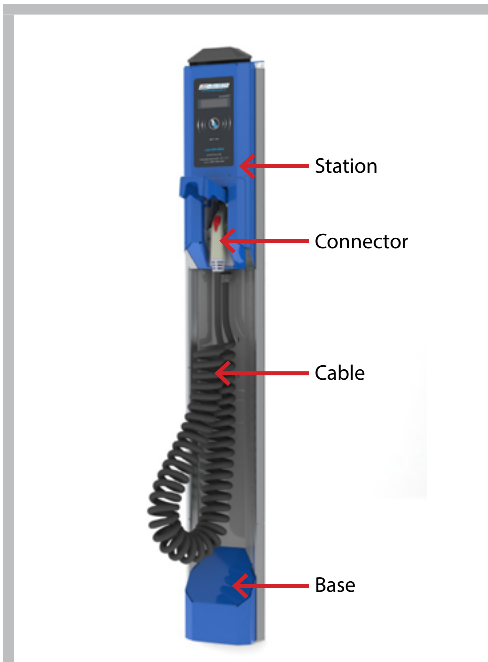
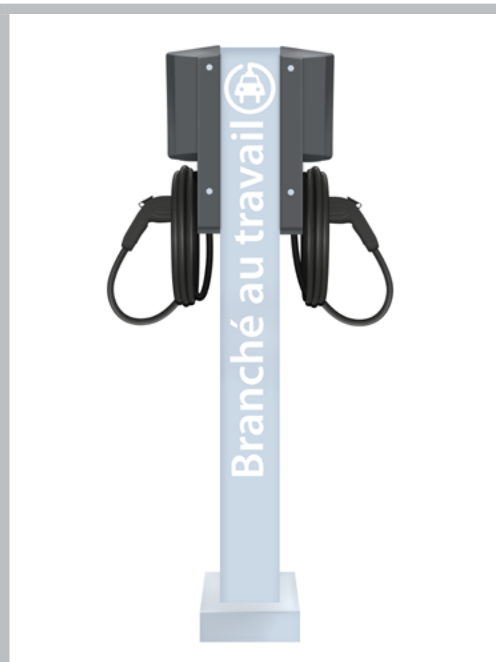


*Figure 2 – **Dual charging station***



Note: The images are provided for illustrative purposes and in no way constitute an endorsement.

3.2 Safety standards

3.2.1 Charging station safety devices

For user safety, all charging stations are equipped with a ground fault detector to reduce the risk of electrocution. Users are never exposed to dangerous voltages or currents, since connector pins are not energized until the connector is inserted properly in the EV charging socket and communication has been established between the vehicle and the charging station. In addition, the connector is sealed to protect the live components from the weather. Lastly, a locking mechanism (latch) (see Figure 3, Section 3.4.2) prevents accidental disconnection resulting from a tug on the cable.

Some charging stations are equipped with an emergency shut-off, but this is not required by the Code since it cannot replace a disconnect switch, which can also serve as a reset in the case of a problem. The output power of the charging station dictates whether a disconnect switch is required. Siting and the selection of associated electrical equipment for different types of stations are discussed in Chapter 5.

3.2.2 Certification of electrical equipment

Like all electrical equipment, charging stations are subject to safety standards, such as ANSI/UL 2202 "Electric Vehicle (EV) Charging System Equipment" and CSA-C22.2 No. 107.1 "General Use Power Supplies". In addition, the cable, connector, ground fault detector and charging station as a whole must comply with all Technical Information Letters (TIL) published by the CSA, including:

- TIL J-39 – EV cord sets
- TIL A-35 – EV cord sets and power supply cords
- TIL A-34 – EV connectors/couplers
- TIL D-33 – Ground fault circuit interrupter (GFCI)
- TIL I-44 – EV supply equipment certification

These were still interim standards at the time of writing of this Guide. The CSA is working on a joint UL/CSA set of standards for Canada and the United States.

3.2.3 Code-compliant installation

Various sections of the Code set out minimum requirements for the installation of EV charging equipment. The following list summarizes the main rules referred to in this Guide.

86-300 – Branch circuits: Electric vehicle charging equipment shall be supplied by a dedicated branch circuit that supplies no other loads except ventilation equipment intended for use with the EV charging equipment.

86-302 – Connected load: The total connected load of a branch circuit supplying electric vehicle charging equipment and the ventilation equipment permitted by 86-300 shall be considered continuous for the purposes of Rule 8-104.

86-304 – Disconnecting means: A separate disconnecting means shall be provided for each installation of charging equipment rated at 60 A or more or more than 150 volts-to-ground. It shall be located within sight of and accessible to the charging station. It shall be capable of being locked in the open position.

14-106 and 36-208 – Protection devices: Protection devices are used to open an electrical circuit in the case of the adverse effects of overcurrents and short-circuits. Where possible, they shall be grouped together and easily accessible.

86-306 – Plugs for AC Level 1 charging: Single-phase 120-V outlets dedicated to slow charging must be CSA configuration 5-20R (20 A) even if the SAE J1772 standard allows a connection to a CSA 5-15R (15 A) outlet. If it the outlet is installed outdoors, it must be protected with a Class A ground fault circuit interrupter (GFCI) or located at least 2.5 m above the ground. In cases where a GFCI is built into the charging cable, to prevent unwanted trips due to interaction between the two GFCIs, it is preferable to opt for a fixed installation.

86-102 – Hazardous locations: Where EV charging equipment or wiring is installed in hazardous locations as specified in Sections 18 and 20 of the Code, it shall comply with the applicable Rules of those Sections.

Section 6.1 of this Guide details the regulatory framework for installing charging stations.

3.3 Design standards

At present, all commercially available charging stations are conductive, that is, the electricity is transmitted through conductors, as in an electrical outlet. Conductive stations are covered by SAE Standard J1772.[4] The standards published by SAE International, though voluntary, are frequently adopted by automakers – in fact, all EVs, with the exception of Teslas, have SAE J1772 charging sockets. This standard covers AC charging using the on-board charger as well as DC charging.

Another standard for conductive charging stations is CHAdeMO,[5] which covers only DC fast-charge stations.

While there are other types of charging stations, this Guide only discusses those based on these two standards and briefly describes Tesla Supercharger stations.

3.4 SAE J1772 standard – AC charging

Strictly speaking, Level 1 charging does not require a special charging station. It uses a Level 1 charging cable, which looks like a large laptop power pack cable and plugs into a standard 120-V outlet (CSA 5-15R). If that outlet is dedicated to EV charging, it must be supplied by a 20-A branch circuit (see Section 86 of the Code).

Level 2 charging requires a fixed charging station supplied by a dedicated 208-V or 240-V branch circuit. All electric vehicles sold in North America are equipped with a J1772 charging socket, except Teslas, which require an adaptor.

The standard also describes Level 3 AC charging, but no compliant on-board chargers or charging stations are currently available on the market. At these power levels – up to 96 kW – automakers prefer to opt for an external DC charger connected directly to the EV battery.

Table 5 summarizes the characteristics of AC Level 1 and AC Level 2 devices in North America.

*Table 5 – **AC charging levels in North America***

Level	Single-phase voltage (VAC)	Maximum current (A)	Protection (A)
1	120	12	15[a]
1	120	16	20
2	208 or 240	up to 80	up to 100

a. A 15-A breaker is permitted only if the outlet is not dedicated to EV charging; otherwise, a 20-A breaker is required (see Section 86 of the Code).

3.4.1 SAE J1772 requirements

SAE J1772 requirements for EV conductive charging couplers define the configuration of the connector and the EV charging station communication protocol. The design standards for the electrical circuit are primarily based on NEC 625, UL 2231 and UL 2594. The SAE J1772 standard also requires protection against the risk of electrocution.

3.4.2 Operation of a J1772 charging station

When the charging connector (see Figure 3) is in its holster on the station, both it and the cable are completely de-energized and cannot be energized. When it is inserted into the EV socket (see Figure 4), the connection is detected by the charging station, which communicates its maximum current to the EV. The EV sends a response signal indicating that it is ready for charging. After this handshake, the connector and the cable are energized and charging begins. Charging is managed by the on-board charger.

*Figure 3 – **Detail of J1772 connector***

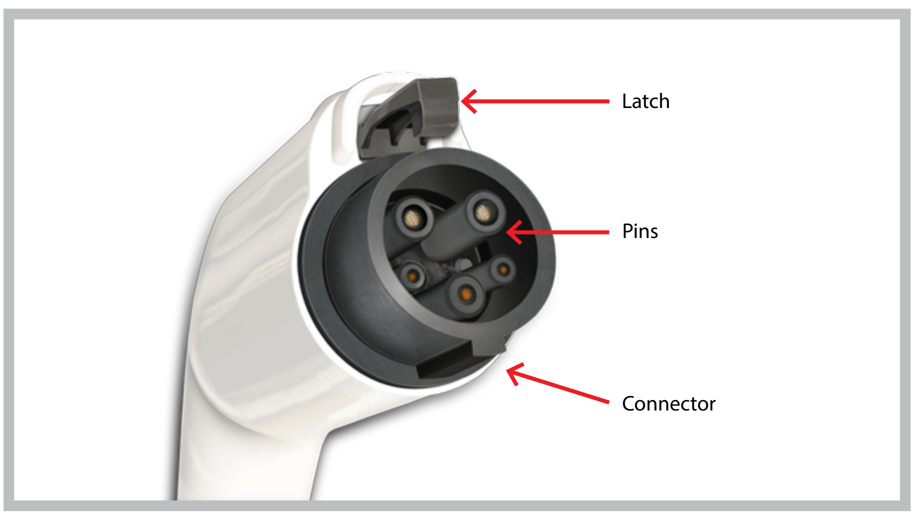
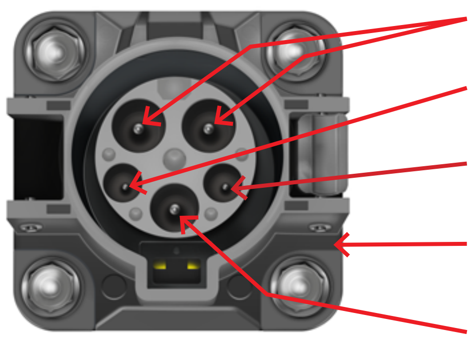


*Figure 4 – **Detail of J1772 EV socket***



3.5 SAE J1772 standard – DC fast charging

Essentially, DC charging differs from AC charging in that it uses a charger built into the charging station instead of the on-board vehicle charger and offers higher charging power. Since the charging station delivers power directly to the vehicle battery, it must be able to adjust the charging voltage and current to the EV's characteristics.

SAE J1772 defines two DC charging levels that use an external charger. DC Level 1 charging uses the same pins as AC Level 2, and supplies a maximum of 40 kW. To date, no automakers have implemented this configuration, in particular because it requires additional equipment in the vehicle and charging station.

DC Level 2 charging requires a combination connector that uses the communication and ground pins of the basic J1772 connector (see Figure 3 and Figure 4), plus two additional power pins that deliver DC power to the vehicle battery through the safety contacts. This Combo connector is shown in Figure 5.

Table 6 summarizes the specifications for DC Level 1 and Level 2 in North America.

*Table 6 – **DC charging levels in North America***

Level	Voltage (V)	Maximum current (A)
1	200–450	80
2	200–450	200

3.5.1 SAE J1772 Combo standard

The requirements for the J1772 Combo are much more complex. For example, the cable supplying DC power to the EV must have improved insulation (minimum 1.25 MΩ voltage isolation from the vehicle chassis). In addition, the EV/charging station communications protocol must be protected from transient phenomena such as short-circuits and electrostatic discharges.

The J1772 Combo socket is compatible with standard J1772 (AC) and Combo (AC/DC) plugs (see Figure 6 and Figure 7).

*Figure 5 – **Detail of J1772 Combo connector***

*Figure 6 – **Detail of J1772 Combo EV socket***

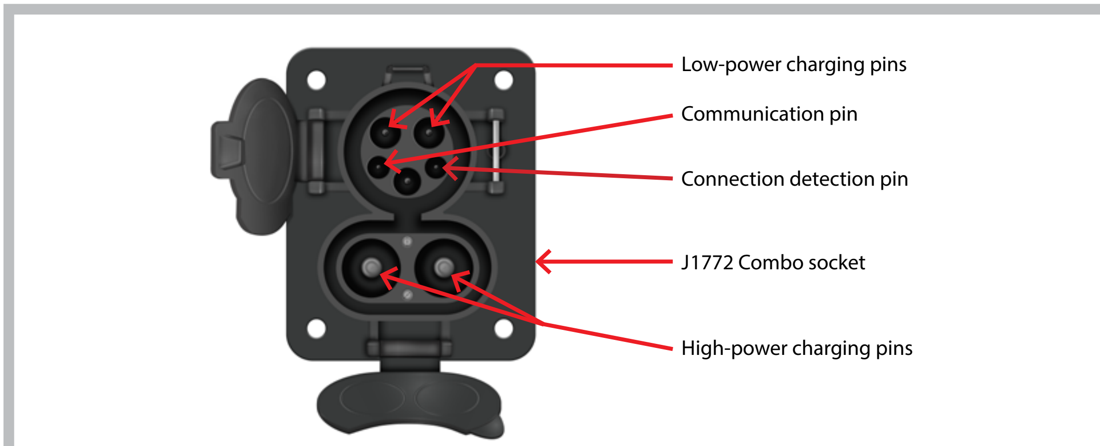
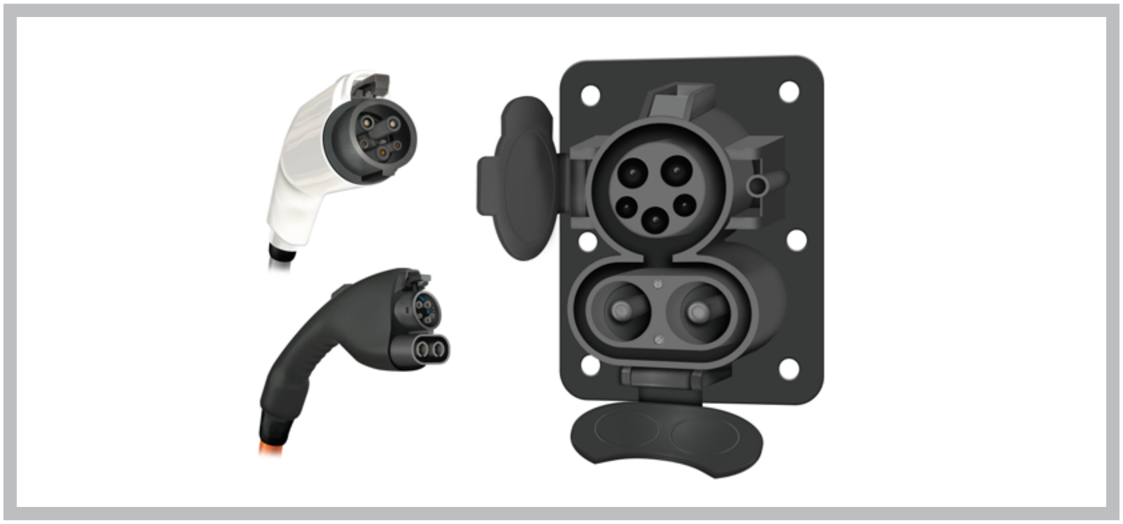


*Figure 7 – **Compatibility of the Combo socket with standard and Combo connectors***



3.5.2 Operation of a J1772 Combo charging station

Level 2 SAE J 1772 Combo DC fast-charge stations are equipped with a combination plug that uses pins from the standard J 1772 (AC) connector, plus two additional power pins for 200-A current (see Figure 5).

When the Combo plug is inserted into the EV socket (see Figure 7), the connection is detected by the charging station, which in turn signals to the EV that the DC charging circuit has been established over the high-power pins. The EV responds with its charge level and battery voltage, as well as the current its battery can accept. After this handshake, the connector and the cable are energized and charging begins. Charging is managed by the external charger based on the data communicated by the EV.

3.6 CHAdeMO standard – DC fast charging[6]

The Japanese CHAdeMO consortium developed a standard that specifies a plug (see Figure 8) and socket (see Figure 9) design, communication protocol and DC fast-charge station capacities. Similar to SAE Combo, CHAdeMO DC fast charging uses a charger built into the charging station to deliver DC power directly to the vehicle battery, and adjusts the charging voltage and current to the EV.

In Canada, CHAdeMO sockets are available as options on the LEAF, the i-MiEV and the Soul.

3.6.1 CHAdeMO standard

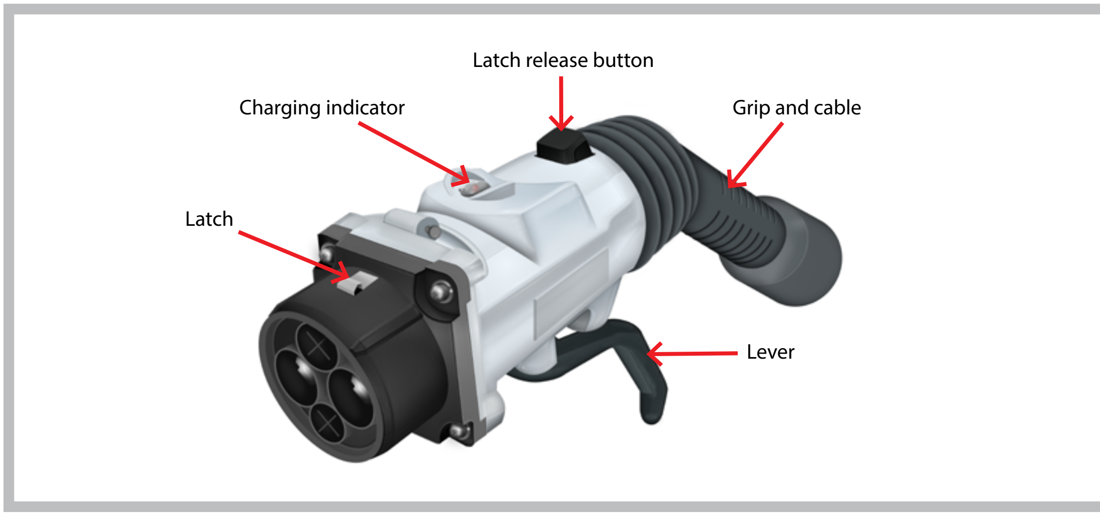
The CHAdeMO standard sets out simple but rigorous safety requirements to ensure risk-free operation at all times.

- Communication uses two redundant signal types: analog signaling and the CAN-bus protocol.
- The latching mechanism is designed to prevent the plug from ever being disconnected while energized and to de-energize all components once disconnected.

3.6.2 Operation of a CHAdeMO charging station

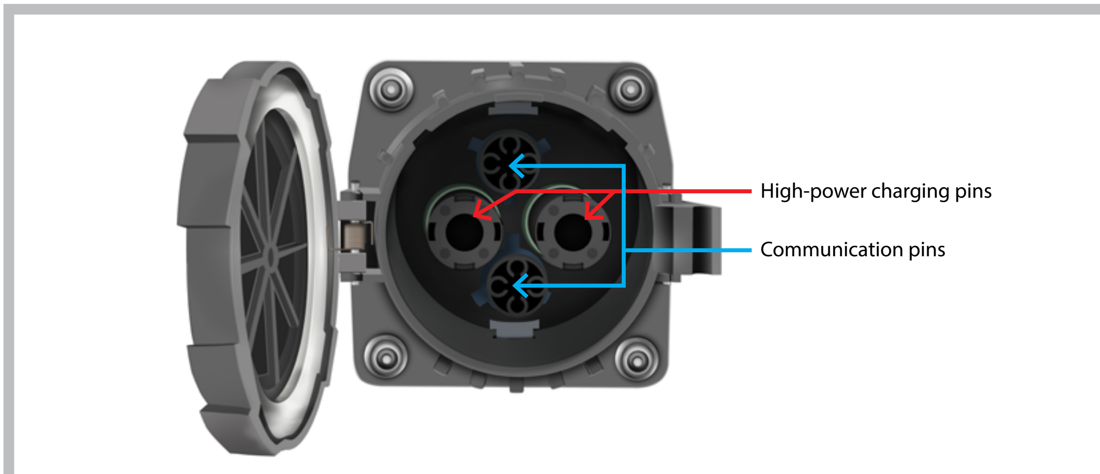
CHAdeMO DC Level 2 charging stations are equipped with a CHAdeMO plug designed for DC charging (see Figure 8).

*Figure 8 – **Detail of CHAdeMO connector***



When the plug is inserted into the EV socket (see Figure 9), the connection is detected by the charging station, which in turn signals to the EV that the DC charging circuit has been established. The charging station and the vehicle exchange data throughout the charging process. Charging is managed by the external charger based on the data communicated by the EV.

*Figure 9 – **Detail of CHAdeMO EV socket***



3.7 Tesla Supercharger stations

Given that there is no public standard for Supercharger charging stations, only a summary description is provided here. The distinguishing feature of Tesla connectors (see Figure 10 and Figure 11) is that they automatically support both AC and DC charging. Like the standardized charging stations discussed above, Tesla stations start the current flow only when the connector is plugged into the EV and communication has been established between the charging station and the vehicle.

Tesla is responsible for the installation of Supercharger stations, in partnership with the property owner. The automaker is nonetheless subject to Québec charging facility design regulations.

*Figure 10 – **Detail of Tesla Supercharger connector***

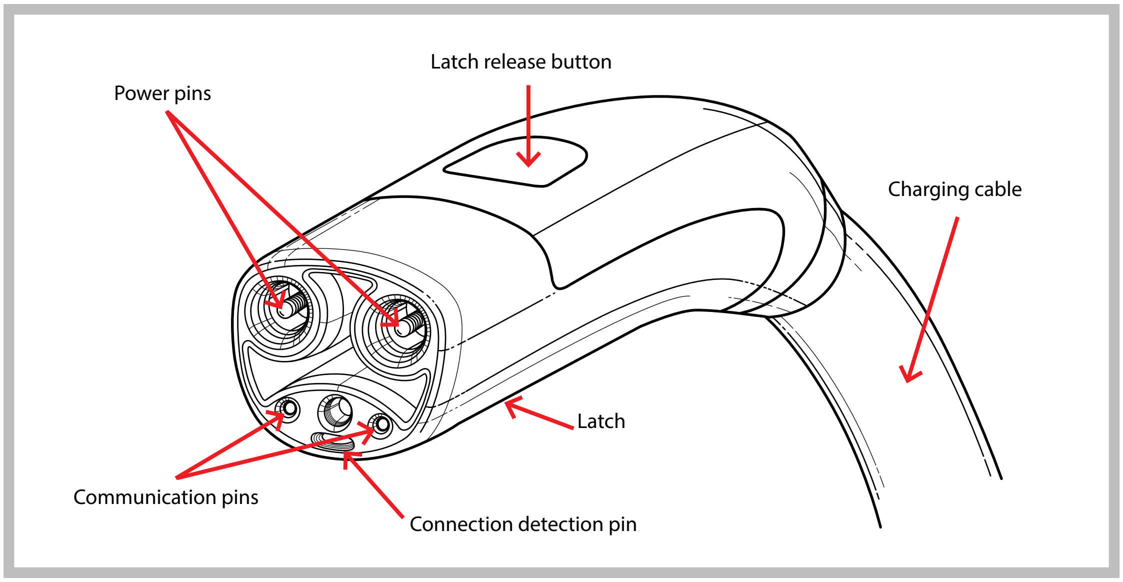
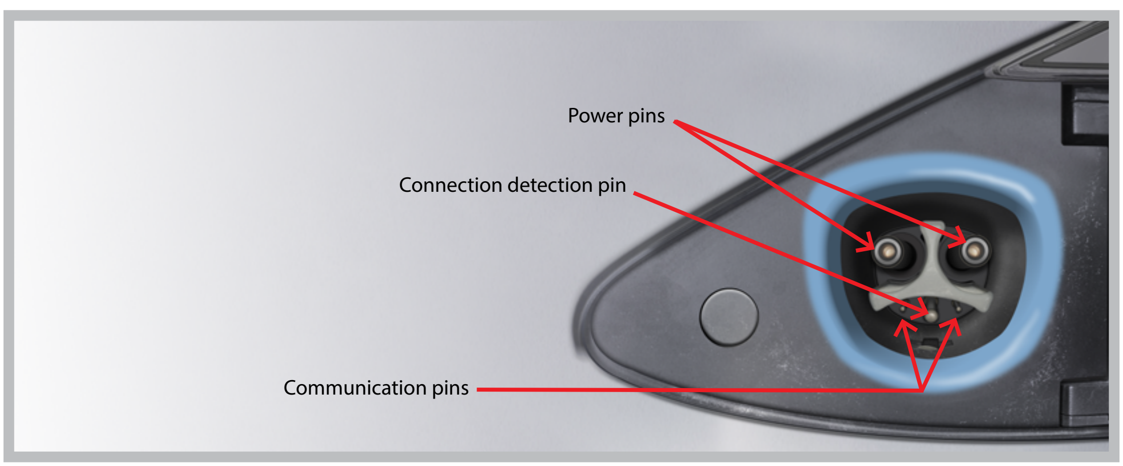


*Figure 11 – **Detail of Tesla Supercharger EV socket***



4. CHOOSING A CHARGING STATION AND LOCATION

4.1 Public and private charging stations

This section describes the different types of charging station installations to aid in selecting the most appropriate for your needs.

Since this Guide frequently mentions private and public stations, it is important to define these concepts.

- A private station is a station purchased by an individual for personal use.
- A public station is a shared station; it may be installed on public or private property by a public organization or a company.

4.2 Charging station selection criteria

A variety of models designed for different uses are available on the market. When selecting a charging station, consider these factors:

- The power required (charging time, vehicle capacity, pricing)
- The communication requirements (access control, payment system, help system)
- The number of cables and plugs (for shared-access stations)

Public stations may offer telecommunications features, which will vary by manufacturer. Some models have transmitters compatible with cellular telephone networks and require no additional infrastructure, while others will require a local wireless network,[7] such as a ZigBee protocol network,* which involves careful siting of stations and transmitters. Other stations communicate over a wired link, such as a twisted-pair or fibre-optic Ethernet network, which would have to be included in the design of the electrical installation.

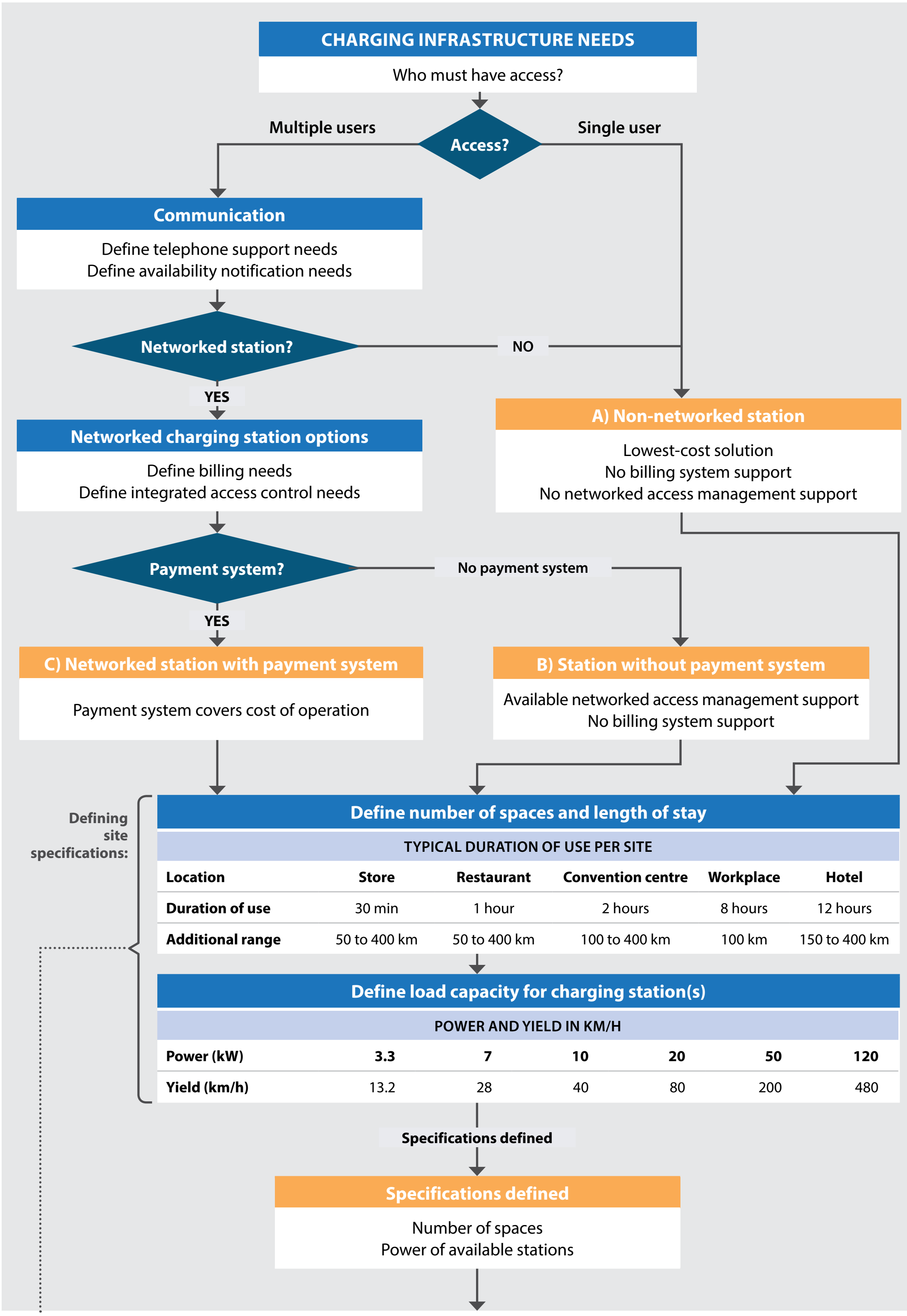
Some stations have multiple connectors and can charge several vehicles at a time, thus sharing the charging station's maximum output among the connected vehicles.

A power management system that manages several stations can be used to modulate the power they supply.

The diagram below (Figure 12) illustrates the charging facility selection and dimensioning process.

* Protocol compliant with the IEEE 802.15.4 standard.

*Figure 12 – **Decision flowchart for charging station installations***

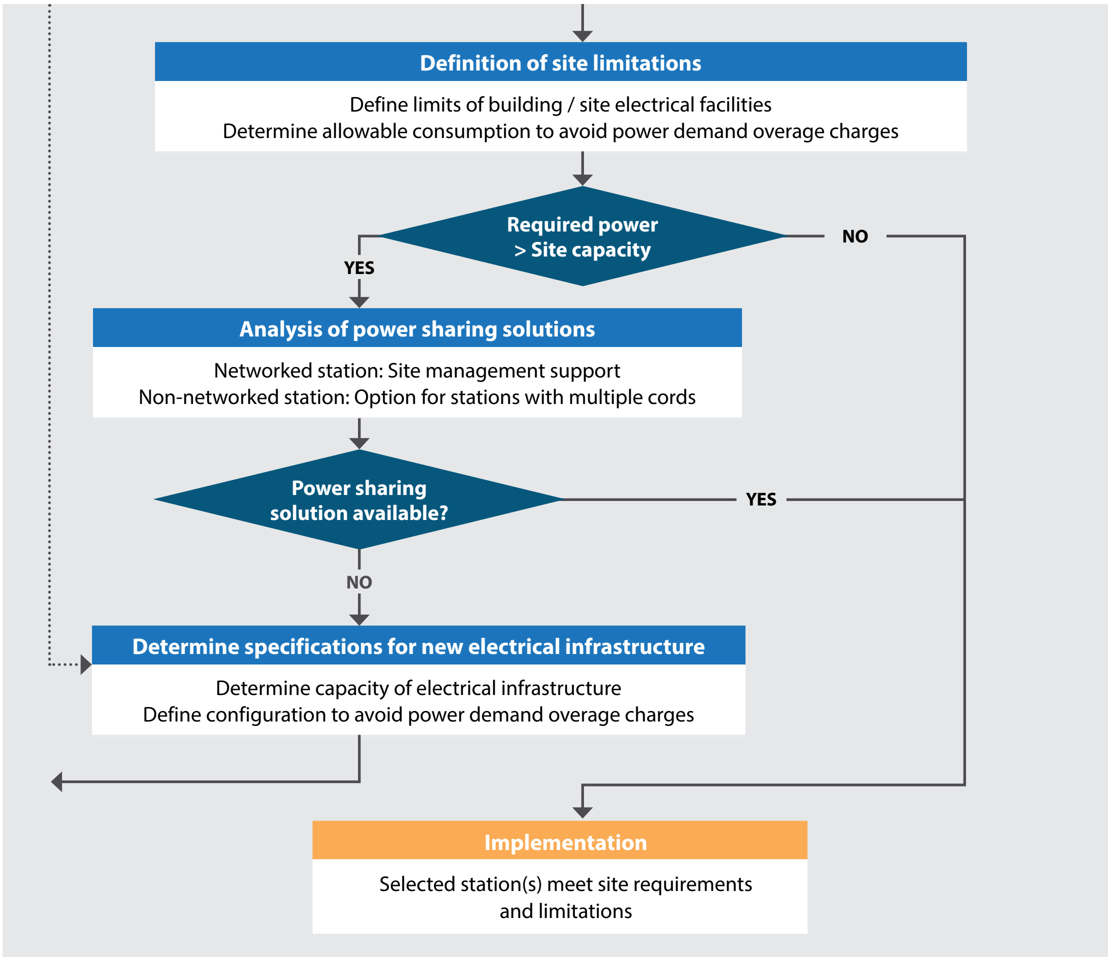


Define number of spaces and length of stay

TYPICAL DURATION OF USE PER SITE					
Location	**Store**	**Restaurant**	**Convention centre**	**Workplace**	**Hotel**
Duration of use	30 min	1 hour	2 hours	8 hours	12 hours
Additional range	50 to 400 km	50 to 400 km	100 to 400 km	100 km	150 to 400 km

Define load capacity for charging station(s)

POWER AND YIELD IN KM/H						
Power (kW)	**3.3**	**7**	**10**	**20**	**50**	**120**
Yield (km/h)	13.2	28	40	80	200	480



4.3 Rates for use

This section presents strategies for limiting the impact of charging stations on electricity bills. In particular, it looks at charging station management and how to select a station based on power requirements.

It is important to evaluate various implementation scenarios to ensure you benefit from the lowest rates while limiting rate constraints.

For this section, maximum power demand is defined as the highest real power demand over a 15-minute interval for a given billing period (see Chapter 1, Interpretative Provisions, in *Electricity Rates*).

4.3.1 Single residential charging station

A single Level 2 charging station planned for domestic use (Rate D) is unlikely to cause the maximum power demand to exceed 50 kW, the threshold beyond which demand is billed. Nighttime (off-peak) charging whenever possible is nonetheless recommended. If multiple charging stations are to be installed, it is important to evaluate potential demand peaks.

4.3.2 Bulk metering

In the case of a multi-unit building or a rooming house where bulk metering is used (Rate DM), the consumption of a Level 2 charging station is unlikely to result in increased costs related to maximum power demand. Consult the current Rate DM structure to determine the available power for the planned site free of any optimization (overage) charge.

4.3.3 Public or private charging stations in commercial zones

When installing Level 2 charging stations for the employees or customers of a business in a building that is subject to Rate G, avoid optimization charges by ensuring that the stations do not cause the maximum power demand to exceed 50 kW (switch to Rate G-9 or M if necessary).

If the maximum power demand already exceeds 65 kW and is therefore billed under Rate M or Rate G9, the power consumption of charging stations could result in an additional cost for each additional kilowatt. In this case, consider individual connections or a smaller number of charging stations, as discussed below.

Operating cost for a fast-charge station at business rates

Typically, customers in business areas are subject to Rate M, G9 or G. Adding a charging station could increase the maximum power demand. Since rates are subject to change by the power distributor, we recommend consulting them.

The least expensive strategy is to supply the charging stations from a dedicated connection (separate meter and billing) so as to avoid optimization charges associated with maximum power demand while complying with Hydro-Québec's *Conditions of Electricity Service*. Note, however, that this approach requires additional infrastructure investment.

Another way to avoid optimization charges when supplying a group of charging stations is to select a model that has a management system for controlling power demand. The charging station manufacturer will be able to provide additional details.

4.3.4 Charging station for heavy industry

Heavy industry companies subject to Rate L have billing demand of 5,000 kW or more. Installing Level 2 charging stations should not have a marked impact on their maximum power demand if vehicle charging is temporarily halted or limited during plant equipment startup. The low rate per kWh and the large amount of available power suggest the use of fast-charge stations outside the plant's peak hours.

See Section 4.6 for an overview of installing fast-charge stations.

4.4 Choosing the location – Public charging stations

Some locations are particularly suitable for the installation of public charging stations: for example, parking lots that serve train stations, shopping centres, restaurants, hotels and resorts.

Use the following criteria when selecting a location:

- Traffic, with the size of the installation to be based on the expected number of users
- How much time EVs will spend at the station
- Surrounding vehicle movement – vehicles stopped for charging must not hinder traffic flow
- Winter use – the location must be cleared and accessible during winter and not be used as a snow dump or hinder snow clearing operations
- Protection against collisions
- Impact on pedestrian traffic – must not hinder pedestrian traffic or be subject to high pedestrian traffic and the associated increased risk of vandalism
- Access to a cellular network, if required by the charging station
- Feasibility of required excavation work
- Proximity of distribution panel
- Visibility of the charging station to encourage its use by drivers

In addition, consider the mounting requirements (pole-mounted, anchored to a concrete base, etc.) and the length of the charging cable in relation to the typical location of EV charging sockets.

You may also want to consider accessibility for reduced-mobility users (see Section 4.8).

4.5 Precautions

Installing a public charging station involves a number of precautions. Here are a few examples:

- Check for hazardous locations on the site you are considering. Hazardous locations are defined in Sections 18 and 20 of the Code. Only certified charging stations with the relevant marking may be installed in a hazardous location (see Section 4.7). Station/vehicle coupling must occur outside any hazardous location.
- If the installation includes a concrete base, size it according to the Construction Code and consult the municipality beforehand to find out the frost depth (this is the contractor's responsibility).
- Before starting any excavation, call Info-Excavation to find out the locations of any underground infrastructure.
- When installing stations for reduced-mobility users, select the location accordingly. Section 4.8 below details the measures required for making installations accessible for reduced-mobility users.

4.6 Infrastructure – Fast-charge stations

Fast-charge stations usually require a concrete base, and their installation is similar to that of streetside locations (see Section 4.7.4). In choosing a location for this type of station, the following must therefore be considered:

- Configuration of the station
- Locations of any underground lines and tanks
- Distance from the street (the charging cable must never extend over the sidewalk)
- Required excavation work
- Proximity of distribution panel
- Planning of any underground conduits and excavation work
- Consultation with Info-Excavation before starting work
- Contractor expertise (must have appropriate RBQ and CMEQ licences)
- Possibility of installing a concrete base

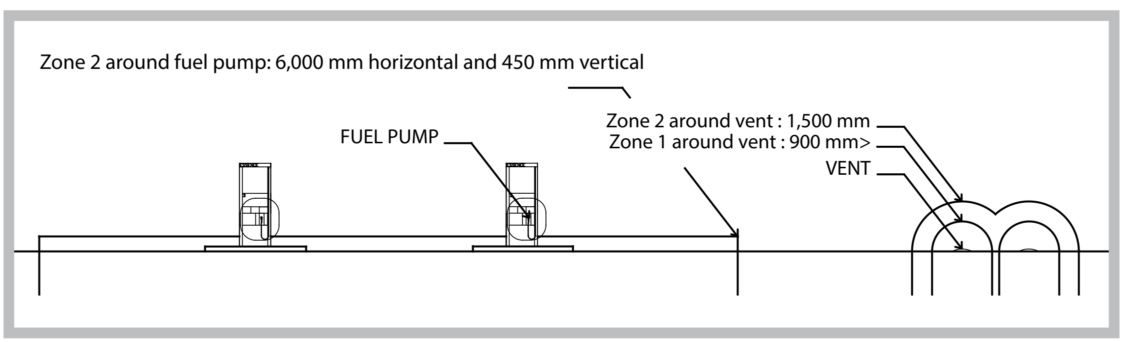
Section 5.4 details the requirements for installing this type of equipment and connecting it to the grid.

4.7 Locations requiring specific instructions

4.7.1 Service stations

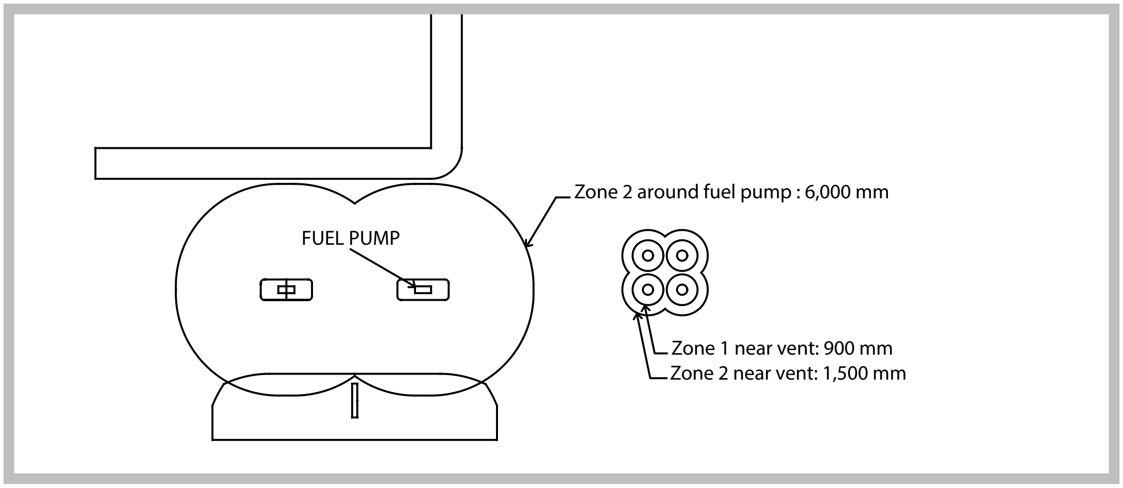
The installation of charging facilities at a service station or in a commercial garage requires specific precautions, which are prescribed in Sections 18 and 20 of the Code. Section 20 defines the areas considered hazardous around fuel pumps or fuel tank vents (see Figure 13 and Figure 14 below).* Installation outside these hazardous areas is of course recommended.

Figure 13 – ***Elevation view of areas classified as hazardous locations***



* For additional information, consult the explanations and Figures 20-1, 20-2 and 20-6 in the *CE Code Handbook: An Explanation of Rules of the CE Code, Part 1* (C22.1HB-09).

*Figure 14 – **Plan view of areas classified as hazardous locations***



Class 1 Hazardous locations are defined in Rule 18-006 of the Code based on flammability and risk of flames spreading to an area containing a more persistent explosive gas atmosphere.

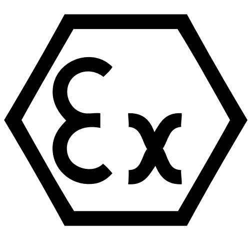
Vents can be a constant source of explosive vapor and present a risk of propagation into underground tanks, which increases the hazard.

Fuel pumps are a sporadic source of explosive vapor but the danger zone is larger due to the risk of spills.

Section 20 of the Code details the measurements shown in Figure 14.

If installing the station in a hazardous location cannot be avoided, the charging station must be approved for such use and must bear the appropriate marking, such as the "Ex" symbol (see Figure 15), which indicates that it is protected against explosions in accordance with the Code.

*Figure 15 – **"Ex" symbol***



4.7.2 Near flammable gas sources

In general, EV charging stations must be at least 3 m away from any flammable gas vent or exhaust. However, if the flammable gas is natural gas (methane), this clearance can be reduced to 1 m.

In general, the charging cable/EV coupling point must be at least 3 m away from any flammable gas vent or exhaust. However, if the only flammable gas present is natural gas (methane), this clearance can be reduced to 1 m.*

4.7.3 Near water

The installation of a charging station near water (swimming pool, hydro massage tub, spa, decorative pond, etc.) must comply with Section 68 of the Code.

4.7.4 Streetside

In addition to the general requirements for public charging stations (Section 4.4 of this Guide), the following must be taken into account for streetside installation:

- Availability of power supply at the required voltage
- Installation and connection of equipment and, if required, of a distribution panel with the necessary voltage
- Excavation work affecting the street or sidewalk
- Protection against being hit by vehicles or machinery (installation of bollards or bumper posts)
- Contractor expertise (e.g., if the charging station is anchored to a building or civil structure, the contractor must hold a subclass 11.2 licence, "Special equipment and products"[8])
- Municipal bylaws in effect

4.7.5 Condo/apartment building parking areas

Before installing a charging station in the parking lot or garage of a condo or apartment building, you must consider several factors related to location and to ownership of the parking area and grid connection facilities. In general, J1772 charging stations rated 208 or 240 V, 30 A are used.

In the case of a condo where the parking spot is on the owner's premises (e.g., a townhouse), the power supply to the charging station is often connected to the owner's electricity meter, in which case the installation is the same as for a detached house.

In a condo where each owner has a parking spot in the garage, the owner must agree with the condo association as to a suitable location for the charging station.

Power may be supplied to the station from the condo owner's meter or from the shared meter serving the common areas. In either case, the connection is made in the same way as for a block heater or lighting outlet in an underground garage or storage area.

Note that under certain conditions, the Code considers enclosed parking garages to be hazardous locations. Figure 16 provides a summary of the steps required to connect the charging station.

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* See Rule 2-322 in the Code for more information.

4.7.6 Workplaces

Dimensioning of charging facilities

Charging times are generally less of a constraint in the case of workplace installations, since employees have predictable work schedules.

Assuming that an employee drives less than 50 km to their workplace in an EV that consumes an average of 200 Wh/km, they consume approximately 10 kWh to get to work, which is the energy delivered by a 3-kW charging station in under 4 hours.

Level 1 chargers may not be fast enough to provide a full charge, since they take about 7 hours to deliver 10 kWh. However, AC Level 2 chargers rated 3.6 kW (240 V, 15 A) may be appropriate for this scenario, assuming that the EV remains connected for the entire work shift.

Charging stations rated 7.2 kW or even 19.2 kW may be required for high-mileage users, such as sales representatives and delivery people, as well as for short-stay users such as visitors and customers.

Management of maximum power demand

At industrial facilities, equipment start-up represents a significant power demand that can increase electricity costs. When the schedule of these power demands is known, it makes sense to choose programmable charging stations that can limit power delivered to vehicles during peak periods.

Implementing a load control strategy can help manage the impact of charging stations on maximum power demand and therefore on billing. By enabling smart management of power delivered to charging stations, it can also limit the size of the electrical installation. For example, based on detailed rules and available power, the system can be programmed to authorize or deny vehicle charging, limit charging to a set percentage, set charging priorities (e.g., company vehicles), encourage charging outside peak periods and adjust charging based on the vehicle's planned time of departure and desired charge level.

Some manufacturers offer multi-cable charging stations that limit the power delivered based on the number of vehicles that are plugged in. These charging stations make it possible to reduce installation costs since the dimensioning of branch circuits and power cables is the same no matter the number of EVs that are charging.

Any economic analysis for a charging station project must weigh the larger investment in multiple-connector charging stations (which would simplify peak power management and yield savings in branch circuit and power cable dimensioning) against installing a larger number of single-connector charging stations.

It would also be useful to contact the charging station manufacturer to discuss the project's specific power demand constraints, number of stations required and maximum allowable charging time.

4.8 Accessibility for reduced-mobility users

The installation of charging stations designed for people with reduced mobility must comply with Section 3.8.2.2 of the barrier-free design standards in the *Québec Construction Code, Chapter I – Building*. The types of buildings exempted from these requirements are listed in Section 3.8.1.1 of that document.

Accessibility can be improved by limiting the height of all user-manipulated components to 122 cm (48 in.) above ground level. This will allow reduced-mobility EV users to operate a charging station without difficulty. Low-mounted charging stations may also be selected for locations with little risk of snow accumulation and in parking lots that are compliant with Section 3.8.2.2 of the barrier-free design standards.

The use of certain symbols, colors or geometric shapes and high-contrast lighting should be considered to make the charging station easier to use for people with a visual impairment, such as color-blindness.

5. INSTALLATION AND CONNECTION TO THE GRID

This section contains information for master electricians connecting EV charging stations. It provides general information as well as examples of how various types of stations are connected.

5.1 General information

Charging station installation is subject to the same rules as any other electrical devices such as air conditioners and electric heating systems. The station must therefore be certified under the Code and bear one of the markings listed in Rule 2-028 of the Code: CSA, cETL, cUL, etc.*

The electrical installation must be compliant with the Code, including Section 86 (updated in the 2010 edition),[9] which deals with EV charging systems.

5.1.1 Multiple charging stations

The requirements for installing multiple stations are essentially the same as for a single installation, apart from the ones pertaining to the communication infrastructure between smart stations, if applicable. Each charging station must be supplied by a dedicated branch circuit, and the electrical installation must meet the following Code requirements:

- One breaker for each station
- One branch circuit for each station
- A distribution panel with the appropriate capacity

If the project includes plans for future expansion, it is strongly recommended that all civil engineering work for the second phase (concrete bases and underground conduits) be completed in advance, during the first phase. It is not, however, necessary to take future needs into account when dimensioning the electrical equipment.

Some manufacturers offer charging stations with multiple cords, which make it possible to charge more than one EV by sharing the available power. They should be considered when designing a charging station island for several EVs where the distribution panel has limited capacity and would be difficult to upgrade.

* See the RBQ Web site for more information.

5.2 Responsibility for installation

The laws and regulations stipulate the situations in which you must call in a professional (engineer or master electrician). They also prescribe application of the *Québec Construction Code, Chapter I – Building, the National Building Code of Canada 2010* (amended) and the Code. Section 6 provides a list of the main documents governing the installation of charging stations.

For a new construction, please see Hydro-Québec Standard E 21-10, *Low-Voltage Electricity Service* (the "Blue Book").

Figure 16 details the procedure for installing charging stations. It also specifies when to call in a professional.

*Figure 16 – **Flowchart for installing charging stations***

1- Determine potential sites

Customer responsibilities:
Define strategic locations
Contact a master electrician to supervise project

↓

2- Request confirmation of connection point(s)

Master electrician responsibility:
Submit request to Hydro-Québec

↓

3- Estimate implementation costs

Hydro-Québec responsibility **to customer**:
Provide customer with estimates based on connection point

↓

4- Select site

Customer responsibility:
Make final site selection based on estimates received

↓

5- Obtain engineering services

Customer responsibility:
Mandate one or more firms or a master electrician for design work

Master electrician or **engineer** responsibilities:
Issue plans and servitudes required by Hydro-Québec

↓

6- Execute work

Customer responsibility:
Hire firm to perform the work

Master electrician responsibility:
Oversee work if providing engineering services

Electrical contractor (tender bid winner) responsibility:
Carry out work in compliance with engineering plans

↓

7- Check connection facilities

Master electrician or **contractor** responsibility:
Contact Hydro-Québec to schedule a metering team site visit

Distributor responsibility:
Send a metering team to check compliance of the installation

↓

8- Connect installation to distribution system

Master electrician or **contractor** responsibility:
Contact Hydro-Québec to schedule a connection team site visit

Distributor responsibility:
Send a connection team to connect the installation to the grid

5.3 Installing Level 2 stations

5.3.1 Equipment

The choice of circuit components is determined by the ratings of the charging station (see Table 7). The station must be supplied from a separate branch circuit; this may require adding a breaker to the distribution panel. Since this type of apparatus is considered a continuous load, the existing service entrance must be able to support the additional load.

Otherwise, it may be necessary to change the panel and the service entrance. However, the station may be connected to an existing branch circuit of appropriate rating (e.g., the 40-A circuit supplying a kitchen range), if a locking mechanism is installed to prevent both loads from being supplied simultaneously, as indicated in the Code, Rule 8-106, subrule 3. Use the calculation methods in Section 8 of the Code and add the appropriate continuous load. If the current rating of the charging station exceeds 60 A, a disconnect switch that can be locked in the open position must be installed nearby.[10]

Conductor gauge must be selected so as to limit voltage drops in compliance with Rule 8-102 of the Code.

If the charging station has a power supply cord with a plug for an electrical outlet, you must install a compatible outlet in accordance with the Code. Standard outlet types are detailed in diagrams 1 and 2 of the Code.

*Table 7 – **Material recommended for installing a Level 2 charging station***

Type of station	2-pole breaker	Copper conductor gauge[a] (AWG)	Disconnect[b]	Max. circuit length[c] (m)
208/240 V – 16 A	20	12	Not required	29
208/240 V – 30 A	40	8	Not required	40
208/240 V – 40 A	50	6	Not required	47
208/240 V – 70 A	90	2	Mandatory	68
208/240 V – 80 A	100	2	Mandatory	60

a. For aluminum conductors, see the manufacturer's installation guide and Section 4 of the Code.

b. Additional disconnect installed near the charging station (see Section 86 of the Code).

c. Lengths are based on conductors insulated to 90°C, a voltage of 208 V and a voltage drop limited to 3% (see Rule 8-102 of the Code). They are for reference only and were calculated using the CMEQ voltage drop calculator.[11]

5.3.2 Execution of work

Construction work for an electrical installation must be done by a professional tradesperson with an RBQ licence (builder-owner or contractor belonging to the CMEQ). Installation time varies greatly depending on the length of cable run between the distribution panel and the station, the station location and whether the distribution panel has to be replaced.

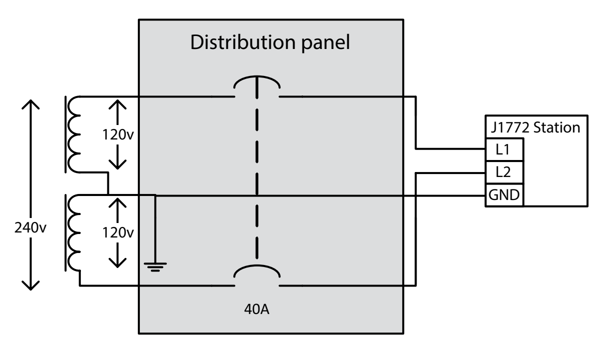
5.3.3 Installing a private station for a detached house

An individual may purchase a wall-mounted charging station from their automotive dealer, a master electrician or a hardware store. After choosing the station location, owners may perform the installation themselves or hire a CMEQ member. However, since the regulations require that the electrical connection work for the charging station power supply (see Figure 17) be done by a CMEQ master electrician, it is preferable to a have CMEQ member perform all the installation work.

The master electrician must proceed as follows:

- Read the manufacturer's installation instructions.
- Consult the nameplate in order to:
  - make sure the apparatus is approved (recognized certification marking), and
  - determine the ratings, e.g., 208/240 V, 30 A.
- Ensure that the distribution panel is capable of supplying the additional load, according to the prescriptions of Section 8 of the Code (each station is considered a continuous load).
- Install the wiring between the panel and the station using the appropriate method.
- Install a breaker with the appropriate rating in the distribution panel (40 A in this example).
- Anchor the station solidly to the wall.
- Make the connections and energize the charging station.
- Check whether the station operates correctly.

*Figure 17 – **Typical connection – Private station (240 V)***



5.3.4 Installing an outdoor public station

Installing outdoor public charging stations requires a number of precautions to be taken in addition to those in Section 4.5:

- Read the manufacturer's installation instructions.
- Make sure the station has the appropriate weather resistance rating (enclosure classified to Rule 2-400 and Table 65 of the Code).
- Calculate the total load according to the Code and ensure there is an adequate 208-V or 240-V distribution panel nearby; otherwise, budget for the cost of upgrading the distribution panel and service entrance.
- Plan for any required conduits and excavation.
- Provide for appropriate surfacing around the station so that users have unhindered access to it.
- Obtain the necessary municipal permits.
- Make sure that all hired contractors have the appropriate licences for the work.
- Provide physical protection from vehicle impacts, e.g., bumper posts, safety clearance or a raised platform.
- In the case of a smart charging station, provide for access to the appropriate telecommunications infrastructure, if required.
- Provide for adequate lighting of the station and the surrounding area.
- Clearly identify where charging vehicles are to park, using both ground markings and signage (see Section 7).

5.3.5 Connecting a public station to a 208-V or 240-V supply

For Level 2 stations, Standard J1772 provides for a 208-V or 240-V supply, less power being available in the case of 208 V to achieve an equal charging current. Some stations have an internal device (jumper or switch) for selecting the voltage level. In all cases, please refer to the manufacturer's installation manual.

Equipment

The equipment needed to install a public charging station is more or less the same as for a residential installation (see Table 7). A separate branch circuit is installed for each station (see Figure 23), so a two-pole breaker must be provided for each device. In the case of a 208-V installation, loads must be distributed equally among the three phases, as specified in Section 1.2.4.3 of the "Blue Book".

In addition, the voltage drop at the station must not exceed the limit stipulated in the Code. Rule 8-102 and Table D3 of the Code give the conductor gauges to be used.

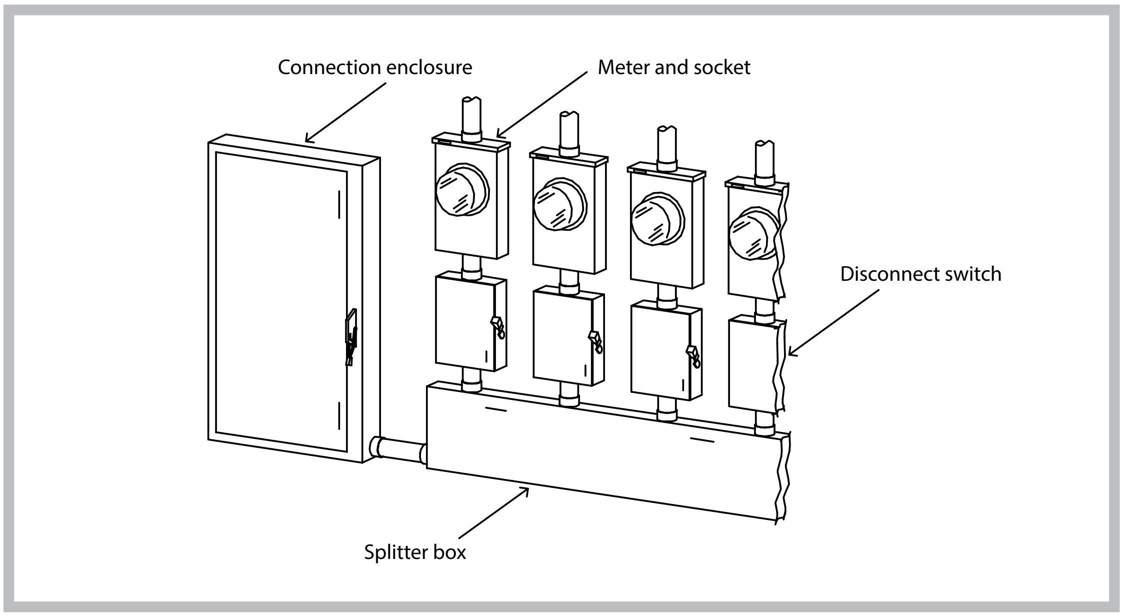
5.3.6 Connecting a public station to a 600-V supply

According to the "Blue Book", any new hookup must be either 120/240-V two-phase or 347/600 V three-phase.[12] If the existing electrical installation does not include a 600/208-V transformer of adequate capacity, one must be installed in accordance with the Code. In the case of a 600-V three-phase supply, use of a 120V/208-V transformer, wye-connected (120 V line-to-ground), is recommended. This configuration obviates the need for a disconnect near each station, as prescribed by the Code for equipment rated over 150 volts-to-ground, as long as the rated power of the station is not more than 12 kW (see Rule 86-304).

The "Blue Book" specifies that an electrical distribution room with a 347/600-V supply must be designed as shown in Figure 18, with the negative booster located after the meter. Consequently, if more than one meter is used, there must be an equal number of boosters.

An additional service loop is required if the capacity of the distribution transformer exceeds 600 A, in compliance with Section 2.1.1 of the "Blue Book".

Figure 18 – ***Electrical distribution room for a 347/600-V service entrance***



Equipment

In addition to the equipment required for a 208-V or 240-V installation (see Figure 22 and Figure 24), this type of installation – whether for one station or several – requires the following equipment:

- A three-phase transformer, 600-V delta/208-V wye, or a single-phase 600/240-V transformer with a centre tap
- An appropriate 208-V distribution panel, wye-connected
- A dedicated two-pole breaker for each charging station over 12 kW

Figure 19, Figure 20 and Figure 21 diagram the connection of a charging station to the grid. The single-phase distribution and wiring are detailed in the following section and illustrated in Figure 22, Figure 23 and Figure 24.

Figure 19 – ***Connection of a 12-kW station to a 347/600-V service entrance***

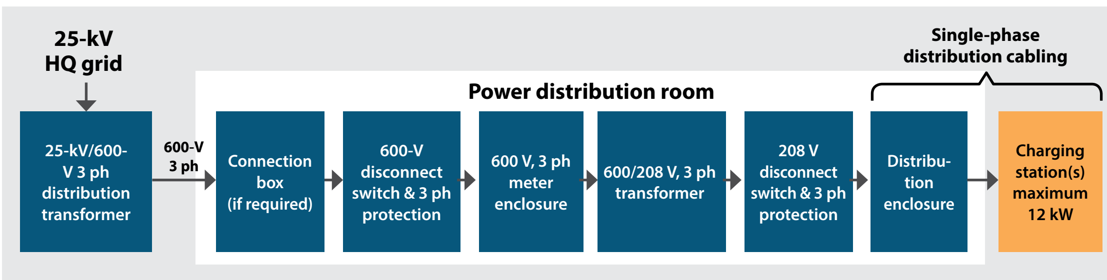
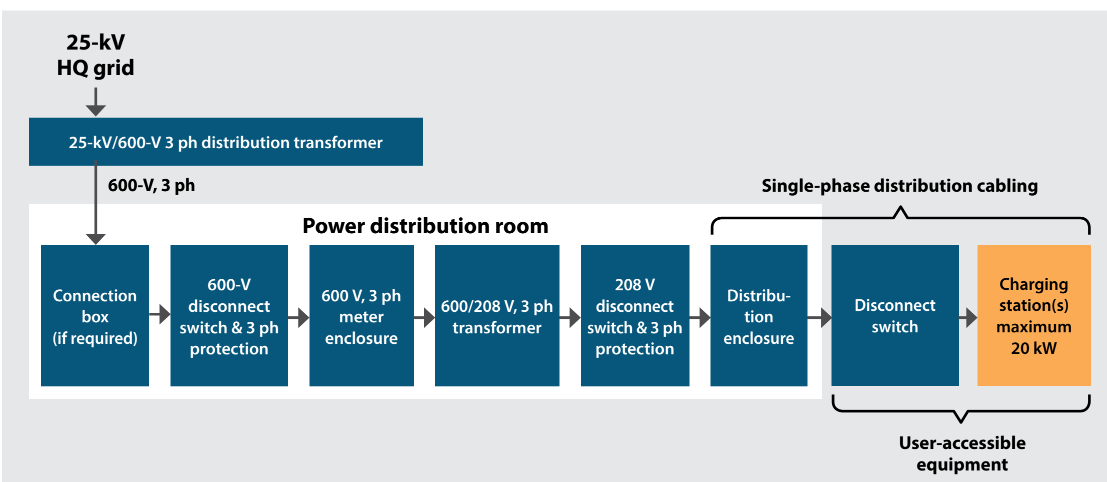
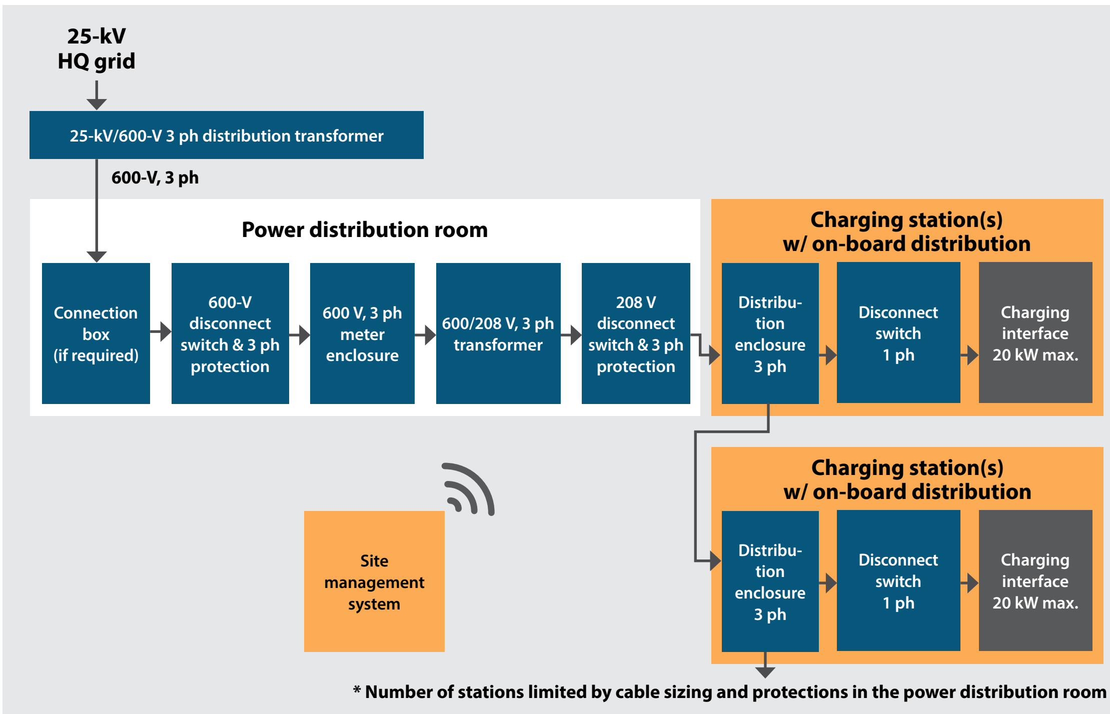


Figure 20 – ***Connection of a 20-kW station to a 347/600-V service entrance***



Some charging station models have built-in distribution and protection systems, which simplify installation and reduce costs, particularly with regard to underground conduits.

Figure 21 – ***Connection of a 20-kW station with on-board distribution system to a 347/600-V service entrance***



Smart charging stations managed by a charging power control system offer a low-cost solution to the constraints of making connections on the supply side of charging stations while limiting power demand.

Single-phase distribution wiring

Figure 22, Figure 23 and Figure 24 illustrate the wiring for single and multiple stations connected to a single meter. For clarity, only 12-kW station installations are shown, as they do not require separate user-accessible disconnects.

Figure 22 – **Typical connection (600-V service) for three 208-V stations**

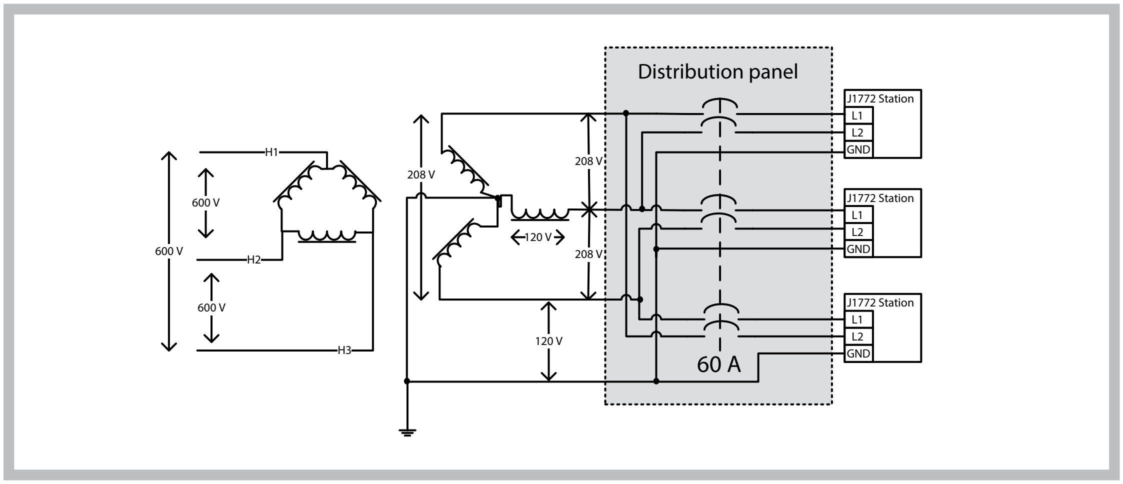


Figure 23 – **Typical connection (600-V service) for two 208-V stations**[13]

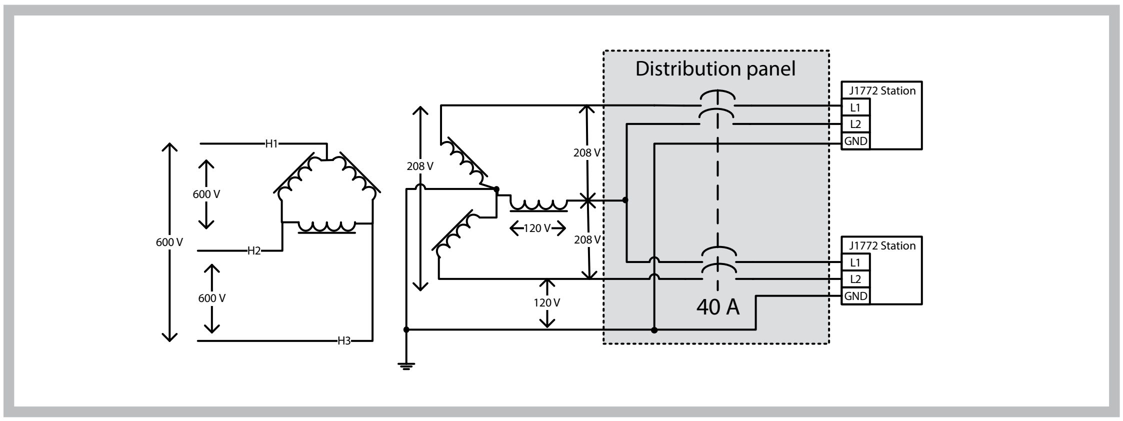
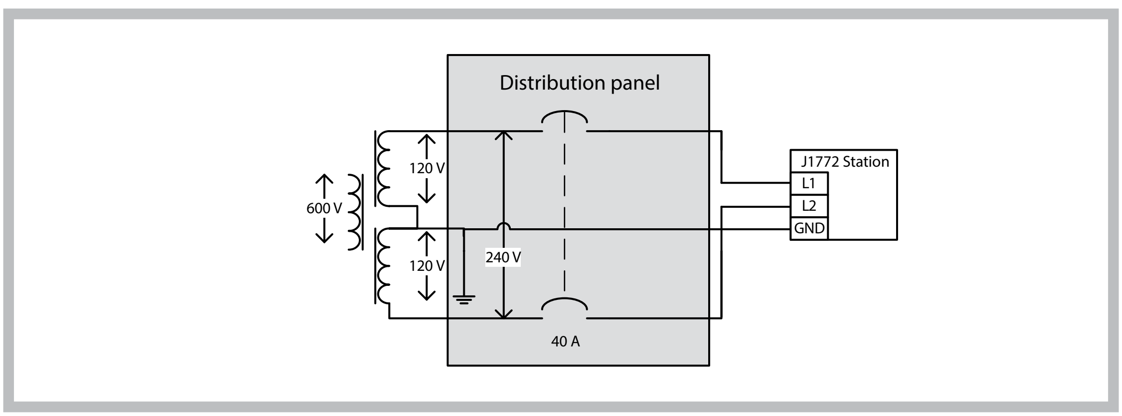


Figure 24 – **Typical connection (600-V service) for one 240-V station**



5.4 Installing a DC fast-charge station

DC fast-charge stations are intended for locations where vehicles will be parked for short periods of about 30 minutes, such as service stations, fast-food restaurants, cafés and some urban parking areas, primarily near major roads.

5.4.1 Equipment

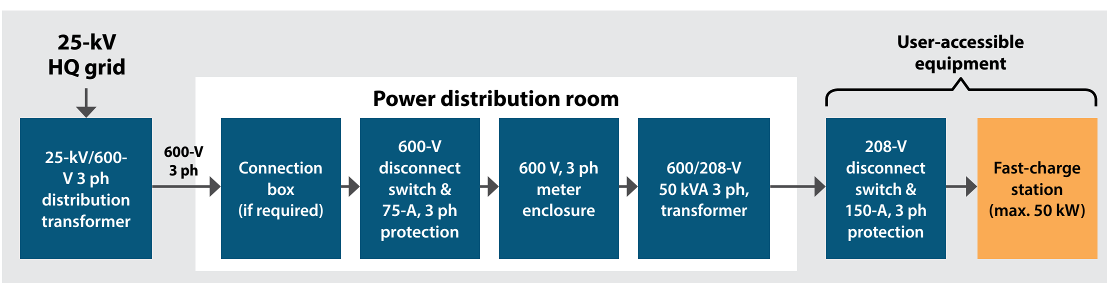
Generally speaking, fast-charge stations available today have an output of 50 kW and a rated three-phase voltage of 208 V, or 480 V in the U.S. According to Rule 86-302 of the Code, charging stations of this type are considered a continuous load for the purposes of dimensioning electrical installations. The electrical equipment required varies according to the model and number of charging stations and the available nearby electrical facilities.

If three-phase supply is not available or if the power at the building service entrance is insufficient for the load, consider the following:

- Install a three-phase service entrance
- Change the capacity of one or more transformers
- Increase the gauge of the main supply conductors

Figure 25 diagrams the connection of a single fast-charge station to the grid. Although the fast-charge standards (see Sections 3.5 and 3.6) specify a maximum continuous power of 62 kW per station, in practice the manufacturers limit power to 50 kW. As a result, the latter value is used for calculating ratings for the electrical equipment shown below.

*Figure 25 – **Connection of a DC fast-charge station to a 208-V three-phase supply***



Electrical distribution equipment may be located inside the building or outdoors in a NEMA 3R enclosure.

In the case of a customer with an underground 347/600 V service, only the transformer and the disconnect are outdoors.

In a single-station installation, locating the power components close to the charging station will reduce the component count, given that a visible user-accessible disconnect switch is required. Rule 26-402 of the Code specifies that the disconnect switch lever must be installed at most 1.7 m above ground level.

The main purpose of the disconnect described above is to ensure that the device is de-energized before any electrical work is carried out, but it may serve other purposes. For example, it can act as an emergency stop if the station itself does not have one, and it can restart the charging station.

The installation costs for a fast-charge station can be broken down as follows:

- Fee for connection to the Hydro-Québec system, which varies by type of service entrance (underground, overhead-underground or overhead)
- Purchase and installation costs for electrical equipment (customer pole, conduits, conductors, connection enclosure if the equipment is outside, transformer, protective devices, switching equipment, cabinet, grounding, etc.)
- Cost of civil engineering work (excavation, concrete base, etc.)
- Cost of installing the charging station itself

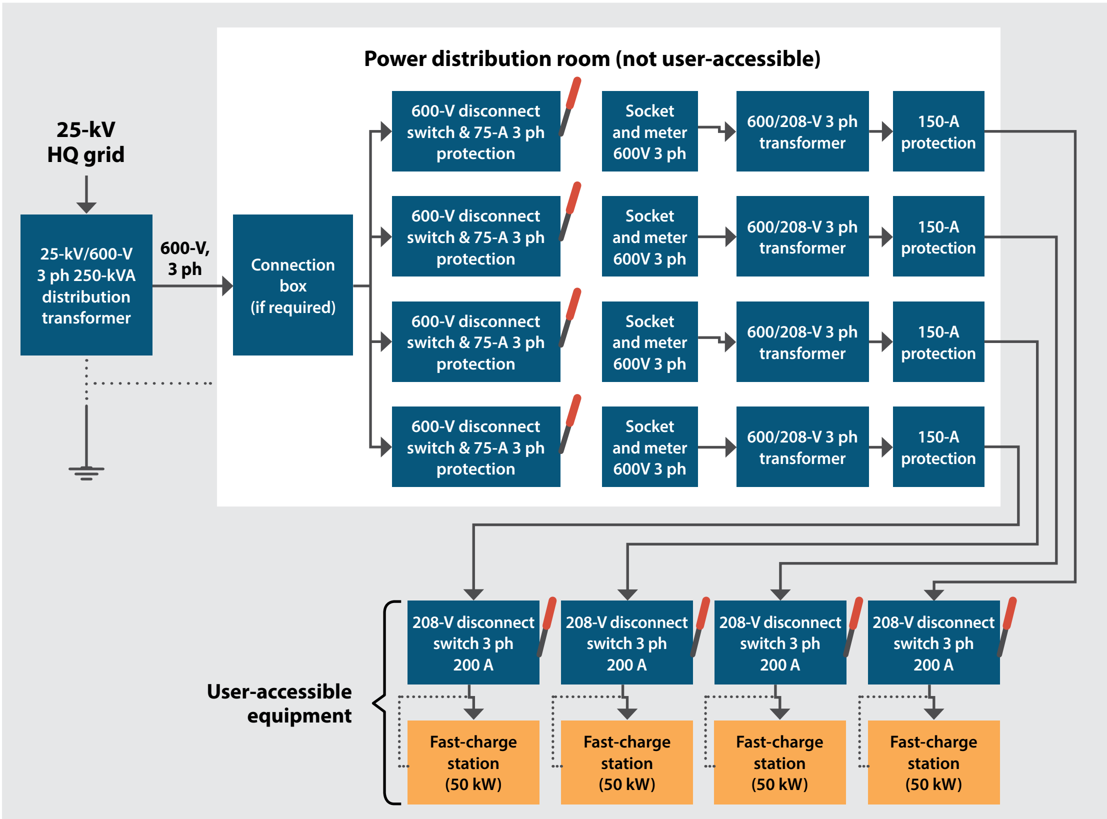
These costs can vary between $20,000 and $50,000, or more depending upon site layout, and are in addition to the cost of the charging station itself. To reduce these costs, install the electrical equipment inside an existing building and limit the distance from there to the station. Alternatively, install the station close to a Hydro-Québec low-voltage line.

Drawings and specifications are not required for installation of equipment under 200 kW, according to Rule 2-014 of the Code. For more information about modifications to distribution system connections, refer to Chapter 16 of Hydro-Québec's *Conditions of Electricity Service*.

According to Rules 10-204 and 10-504 of the Code, the charging station may be grounded by bonding it to the distribution transformer outside the building, if both the primary and secondary windings of the 600/208-V transformer are also bonded to it, and if the bonding conductor connections are made in an appropriate enclosure (a distribution panel, in the case of a multi-station installation). If the cables exiting the distribution panel are metal sheathed, ensure that the sheath is bonded to ground at least every 15 m (see Rule 12-2208 of the Code) right up to the charging station disconnects, which should not themselves be grounded.

For multiple charging stations with the same power rating, Rule 14-106 of the Code states that the overcurrent fuses must be arranged together in a distribution panel that is installed in a location in compliance with Rule 26-402 of the Code. Rule 26-210 of the Code requires that a set of fuses built into a disconnect (see Rule 14-402 of the Code) must be installed in proximity to the transformer to comply with Rule 26-258 and Rule 14-414 of the Code, which cover transformer conductor gauge and the distance between the transformer and disconnect, respectively. Note that, as specified by Rule 12-3032 of the Code, the disconnect switch enclosure may not be used as a distribution panel.

*Figure 26 – **Connection of multiple DC fast-charge stations to a 208-V three-phase supply***



The following steps are required for all installations:

- Consult with Hydro-Québec to add or modify a service entrance with several individual installations or a multiple installation
- Add a dedicated meter to comply with the *Conditions of Electricity Service* and limit the costs associated with exceeding the maximum power demand
- Purchase fused disconnect switches for the three-phase service entrance
- Purchase a medium-voltage three-phase distribution panel
- Complete wiring from the distribution panel to the charging station disconnect switches
- Install a mechanical disconnect (preferably fused type) to protect each charging station
- Construct a shelter for the charging stations, if required by the manufacturer

5.4.2 Example: Installing a charging station near a building

The owner of a building with a power demand of 175 kW has decided to install a 50-kW fast-charge station. Since this installation will increase his total power draw to 225 kW (i.e., over 200 kW), drawings and specifications are required. **If the installation is to be in a location subject to the *Building Act* (CQLR c B-1.1)**, an engineer should be consulted. However, if the construction work is to be performed by a contractor who holds the specialized contractor subclass licences required for the work (see Schedule II of the *Regulation respecting the professional qualification of contractors and owner-builders*), the owner-builder is exempted from the application of Chapter IV of the *Building Act*. Consequently, in order to obtain and perform the installation contract, master electricians may have drawings made at their own expense, irrespective of the nature of the building or the project cost.

Planning and execution of work

Here is an outline of how such an installation would be planned and executed:

- Review current rates in the Hydro-Québec document *Electricity Rates*
- Check that an adequate power supply at the correct voltage is available nearby. Most 50-kW stations imported from the United States are rated 480 V, 70 A
- Check that the unit is approved for the planned usage
- Read the manufacturer's installation guide
- Draft the required drawings and specifications
- To plan the work or for more information, consult Section 2, Nouveaux besoins sur une ligne existante (new requirements on an existing line), of the Hydro-Québec guide for filing a service request, *Faire une demande de service* [available in French only]
- Identify any hazardous locations in accordance with Sections 18 and 20 of the Code. Call in an expert to mark out and classify such locations
- Avoid installing the station in a hazardous location. If the station absolutely be must installed in a hazardous location, make sure it is specifically approved for such use ("Ex" symbol or equivalent – see Figure 15)
- Make sure EV/station coupling cannot take place in a hazardous location
- Study drawings locating underground infrastructure, and contact Info-Excavation before starting any excavation
- Use the appropriate cabling method to supply power to the station
- Install the charging station

5.5 Charging station maintenance

All charging stations require more or less the same maintenance; see the manufacturer's manual for any specific requirements. Maintenance usually includes the following points:

- Regular inspection of connector contacts
- Inspection of charging cable (look for signs of wear)
- Inspection of the connector (look for cracks, breaks or exposed metal)
- Inspection of the holster (the connector must rest firmly in the holster)
- Replacement of filters (DC charging stations only)

6. REGULATORY FRAMEWORK

6.1 Laws, regulations, codes and standards

The installation of charging stations is subject to several laws, regulations, codes and standards. The laws and regulations stipulate the situations in which you must call in a professional (engineer or master electrician). They also prescribe application of the *Québec Construction Code* (Chapters I and V).

The main documents that regulate charging station installation are:

- *Engineers Act*, chapter I-9
- *Master Electricians Act*, chapter M-3
- *Building Act*, chapter B-1.1
- *Québec Construction Code*, Chapter I – Building, and *National Building Code of Canada –2010 (amended)*
- CSA Standard C22.10-10 2010: *Québec Construction Code, Chapter V – Electricity*
- CSA Standard C22.1HB-09: *CE Code Handbook: An Explanation of Rules of the Canadian Electrical Code, Part I*
- Hydro-Québec standard: *Low-Voltage Electrical Service ("Blue Book"). Standard E.21-10,* 10th edition
- Municipal bylaws

Municipal bylaws, including those on land use and development, must be taken into account in the installation of charging stations.

The *Québec Construction Code* is prescribed by the *Building Act*, and Chapter V on electricity is particularly relevant to EV charging station installation. Rule 2-014 of the Code lists the situations requiring the production of drawings and specifications. The Code and the "Blue Book" are essential tools for charging facility designers.

Depending on the nature of the work, other documents such as the *Building Code* may also apply.

The "Blue Book" specifies the voltages and methods for connecting Hydro-Québec customers.

The following is a non-exhaustive list of Code sections and Rules relevant to charging station installation.

Section or rule	Topic
8	Determining circuit loading and demand factors
8	Dimensioning of conductors to take into account ampacity, length and maximum allowable voltage drop (Rule 8-102 and Table D3)
18 and 20	Installation in hazardous locations (service stations, indoor garages and automotive repair shops, etc.)
26	Installation of electrical equipment
86-100	EV – Special terminology
86-102	EV – Hazardous locations
86-104	EV – Voltages
86-200	EV – Warning signs
86-202	EV – Marking
86-300 to 86-306	EV – General provisions regarding installation of EV charging equipment
Tables 1 to 4	Allowable ampacities of conductors (especially Table 2)

Equipment installed in a hazardous location, as defined in the Code, may be subject to the following standards:

- CAN/CSA-C22.2 No. 157-92: *Intrinsically Safe and Non-Incendive Equipment for Use in Hazardous Locations*
- C 22.2 No. 213-M1987: *Non-Incendive Electrical Equipment for Use in Class I, Division 2 Hazardous Locations*
- C22.2 No. 60079-0-07: *Electrical Apparatus for Explosive Gas Atmospheres – Part 0: General Requirements*
- C22.2 No. 60079-1-07: *Electrical Apparatus for Explosive Gas Atmospheres – Part 1: Flameproof Enclosures "d"*
- C22.2 No. 60079-2-02: *Electrical Apparatus for Explosive Gas Atmospheres – Part 2: Pressurized Enclosures "p"*
- C22.2 No. 60079-5-02: *Electrical Apparatus for Explosive Gas Atmospheres – Part 5: Powder Filling "q"*
- C22.2 No. 60079-6-02: *Electrical Apparatus for Explosive Gas Atmospheres – Part 6: Oil-Immersion "o"*

- C22.2 No. 60079-7-02: *Electrical Apparatus for Explosive Gas Atmospheres – Part 7: Increased Safety "e"*
- C22.2 No. 60079-11-02: *Electrical Apparatus for Explosive Gas Atmospheres – Part 11: Intrinsic Safety "i"*
- CAN/CSA-E79-18-95 (R2009): *Electrical Apparatus for Explosive Gas Atmospheres – Part 18: Encapsulation "m"*

SAE Standard J1772 on AC charging stations encompasses all applicable UL and CSA standards, but is not mandatory.

For fast-charge stations, the following electromagnetic compatibility parameters must additionally be considered:

- Immunity to interference in accordance with CAN/CSA-C61000-6-1-09 – EMC – Generic standards – Immunity for residential, commercial and light-industrial environments
- Emission of disturbances at 347/600 V
  - Voltage fluctuations and flicker: Inrush current of less than 100 A
  - Unbalanced load: Phase-to-phase current imbalance must be limited to 10% of rated ampacity
  - Harmonic emission: Levels according to IEC 61000-3-12 (2011) Electromagnetic compatibility (EMC) – Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current >16 A and ≤ 75 A per phase, for a charging station supplied at 347/600 V, 60 Hz, notwithstanding any indication to the contrary in the standard, such as "defined limits apply to 230/400 V, 50 Hz systems."

NOTE: The minimum short-circuit ratio (*Minimum Rsce*), indicated in particular in the tables in Chapter 5 of the Standard, must be 66 or less.

6.2 Charging station approval

The installer's responsibility is limited to checking whether the apparatus is approved by a recognized organization for the planned use. The "Approval of electrical equipment" section of the RBQ Web site lists the organizations authorized to grant such approval.

7. SIGNS FOR PARKING AREAS WITH EV CHARGING STATIONS

The Québec government has developed a pictogram that illustrates an EV and a charging station (see Figure 27). It appears on the green licence plates issued to electric vehicle owners by the Société d'assurance automobile du Québec. It also identifies public parking areas equipped with charging stations.

*Figure 27 – **Pictograms***

In the United States, the Federal Highway Administration developed a pictogram that represents a charging station (see Figure 28). It is sometimes used in public parking areas equipped with charging stations.

*Figure 28 – **Charging station pictogram used in the U.S.***

8. REFERENCES

1 Canadian Standards Association, 2010. *Québec Construction Code, Chapter V – Electricity. Canadian Electrical Code, Part One with Québec Amendments* (C22.10-10), 21st edition, Section 86.

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4 SAE International, January 2010 *SAE Electric Vehicle and Plug In Hybrid Vehicle Conductive Charge Coupler*. SAE Standard J1772-2010.

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