ELECTRIC VEHICLE CHARGING FOR MULTI-UNIT RESIDENTIAL BUILDINGS

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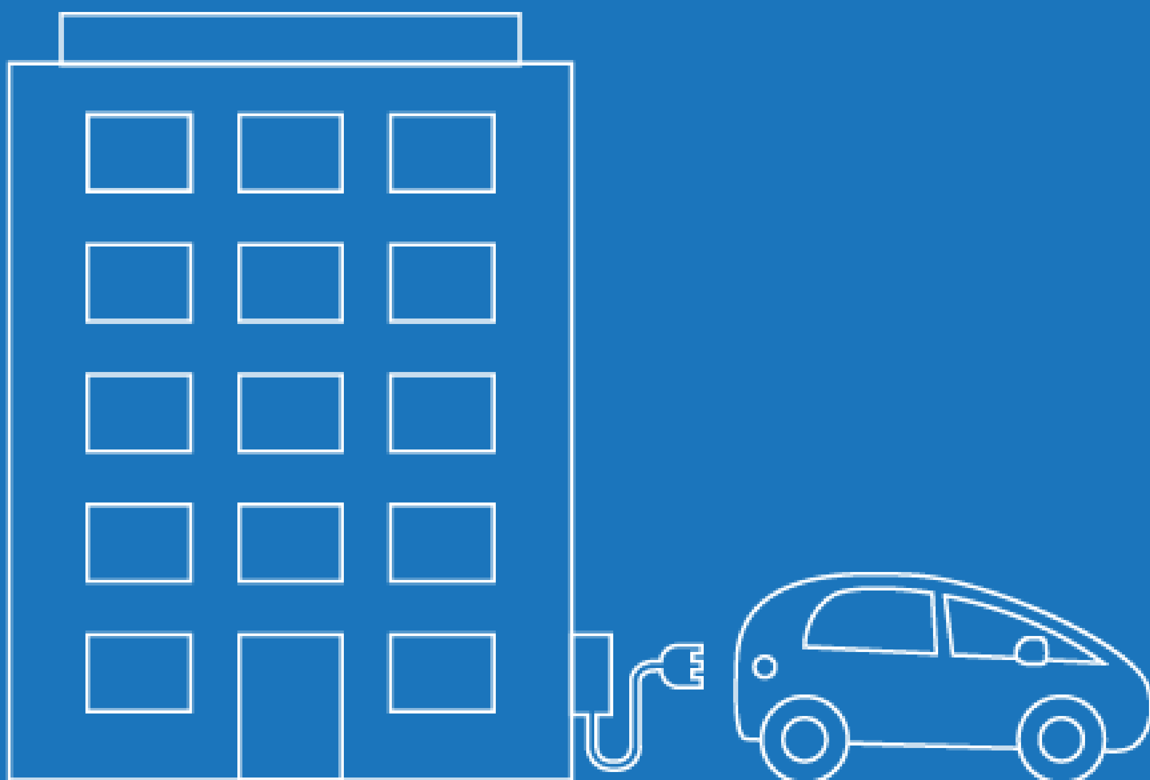

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Disclaimer

In August 2015, Hydro-Québec published ***Electric Vehicle Charging Stations – Technical Installation Guide***. It provided useful information about charging station installation in general.

The present document is more specific and focuses on installation in a multi-unit residential building (MURB). Given the newness of the technology, the wide range of products offered, the provisional nature of some standards and the constantly evolving regulatory framework, it is impossible to guarantee that the information presented here is current, complete or exact. Even though it comes from reliable sources, the authors and Hydro-Québec disclaim all liability for any errors or omissions, or for the results obtained from using this guide.

Ce document est également publié en français.
Original text written in French.

Abbreviations

Abbreviations	Meaning
A	Ampere
Code	CSA Standard C22.10-18[1]: Québec Construction Code, Chapter V – Electricity
GFCI	Ground fault circuit interrupter
V	Volt
ICEV	Internal combustion engine vehicle, commonly known as a gasoline-powered vehicle
EV	Electric vehicle (all-electric or plug-in hybrid)
W	Watt
Wh	Watthour

1. https://store.csagroup.org ; reference: C22.10-F18.

1 Introduction

1.1 Preface

In Québec, the number of electric vehicles (EVs) is growing exponentially, doubling every 12 to 18 months. By 2026, it's expected there will be more than 300,000 EVs on Québec roads. What's more, many automakers have announced they will eventually cease production of gasoline-powered vehicles. This is no longer a niche market aimed at a small number of users, nor is it a fad.

The transition to electric vehicles is real, and it's happening quickly. That's why it's a good idea to start equipping multi-unit residential buildings (MURBs) with EV charging stations.

1.2 Purpose of this Guide

This guide addresses specific questions related to EV charging in new and existing MURBs, whether apartment buildings or condominiums. For technical aspects not related to MURBs, please see Hydro-Québec's ***Electric Vehicle Charging Stations – Technical Installation Guide***.

In the case of new buildings, according to Section 86 of the *Québec Construction Code, Chapter V – Electricity* (hereinafter the "Code"), minimal charging infrastructure must be installed for each new dwelling where there is a garage, carport or parking area for a detached, semi-detached or row house or for a duplex, triplex or quadruplex. The Code does not require that the full installation be completed immediately, but only the basic infrastructure (cable or conduit) between the distribution panel and the outlet box near where a 240-V (Level 2) EV charging station would be installed. Inclusion of this infrastructure during construction would mean the occupants would not have to open up walls (and possibly floors) if they later wished to install a charging facility than allowing charging at more than 120 V (Level 1). This requirement does not apply to MURBs with more than four units.

At the time of writing, at least one major municipality in Québec had adopted a bylaw covering new buildings with five or more units. The bylaw requires electrical installations similar to the infrastructure required under the Code in order to accommodate 240-V stations for 20 to 25% of the parking spaces. MURB developers and builders who want to increase or even preserve the value of their units must now provide for this type of charging infrastructure at the design stage.

In this Guide, we'll be looking at three types of questions:

1. Technical considerations
2. Economic considerations
3. Operational and legal considerations

This Guide is for:

1. Current and future EV owners who live in a MURB and would like to be able to charge their vehicle
2. Landlords and condominium associations
3. Electrical contractors who install charging stations in MURBs
4. Real estate developers who want to integrate charging infrastructure in their building

1.3 Actors

A MURB is a condo building or an apartment building.

Most of the considerations discussed in this Guide apply to both types of MURB; however, the two types are distinguished where necessary.

The various actors involved are presented below.

1.3.1 Condo building

- **Condo association:** the legal entity responsible for managing the condominium. To make the text easier to read, we've used "condo" rather than "condo association."
- **Condo owner or simply "owner":** in this document, each owner of a unit in the condo building. This term is never used to refer to the owner of an apartment building (see 1.3.2).
- **Electrical contractor:** the electrical contractor involved in the installation of charging equipment.

1.3.2 Apartment building

- **Landlord:** the owner(s) of an apartment building. The plural form "landlords" is used to designate both single and multiple landlords. "Landlords" must be distinguished from "owners" as defined in 1.3.1.
- **Tenant:** a person who rents a unit in an apartment building from a landlord. Someone who rents a unit from a condo owner is not included in this definition.
- **Electrical contractor:** the electrical contractor involved in the installation of charging equipment.

1.4 Organization of this Guide

This Guide is aimed at several types of readers with varying intentions and levels of knowledge about EV charging station installation. Some of the inset boxes may be of less interest to certain readers.

The "ATTENTION" boxes contain information that should be noted by all readers, either because it touches on a topic of importance or because it clears up sources of confusion or misunderstanding.

The "TECHNICAL" boxes will be of greater interest to readers who are already technically well-informed; electrical contractors, for example.

The "BASICS" boxes explain the basic principles of EV charging. Though not essential to an understanding of the Guide, these boxes provide general technical information that some readers may appreciate.

These boxes highlight aspects that are important or not well known, or that can often be a source of confusion.

2 Process

There are four stages in the deployment of EV charging stations in a MURB.

2.1 Stage 1: Find out who the actors are and contact them

The actors are the landlord/condo association, the tenants/condo owners, and the electrical contractors, as defined in Section 1.3. Ideally all these actors should be involved, even those who don't plan to buy an EV in the near future.

In getting people involved, the initiative may come from the condo association or the landlord. However, it often comes from a condo owner or a tenant who would like access to a charging station.

If you are such a condo owner or tenant, you must make a formal request to the condo association or landlord. Your request should be made in writing. Your letter should request the adoption of an official policy for access to charging facilities in the building, listing the benefits for the condo or the landlord. One of the most compelling reasons for adopting such a policy is the preservation of resale or rental value.

Here's an example of a letter to a condo association:

> Saint-Fabien, June 1, 2019
>
> Ms. Lise Tremblay, President
> Syndicat des copropriétaires des Berges du fleuve
> 999, rue du Volt, Laprise (Québec) L1A 3H6
>
> Dear Ms. Tremblay:
>
> The purpose of this letter is to ask the condo association to take steps toward adopting a policy ensuring access to EV charging facilities in our building.
>
> I will soon be purchasing an electric vehicle and want to be able to charge it in my parking spot. Such a policy would make it easier to accommodate my request, along with similar requests that will no doubt arise, given the proliferation of EVs. Access to charging facilities would benefit all the condo owners—even those who don't plan to buy an EV any time soon—by protecting the resale value of all units.
>
> I'm enclosing a copy of Hydro-Québec's guide to *Electric Vehicle Charging for Multi-Unit Residential Buildings*. In Section 2 you will see a summary of the steps we need to follow. I would appreciate it if you would call an initial meeting with everyone concerned so that we can study the project.
>
> Yours truly,
>
> Françoise Benhabib

2.2 Stage 2: Study the project

After determining and contacting the actors, gather them together to study the project as it applies to your building. Section 4 lists what to consider in your analysis.

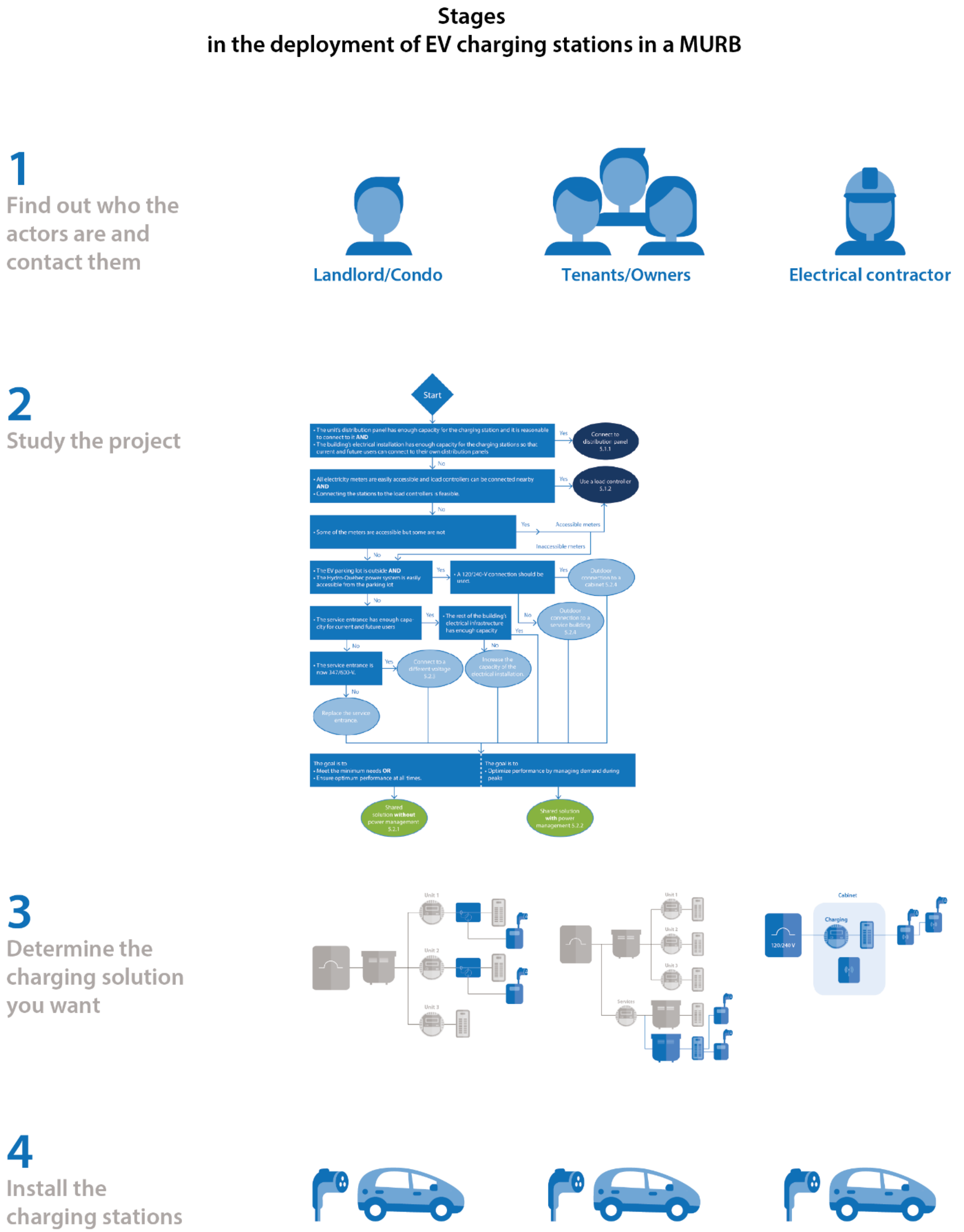
2.3 Stage 3: Determine the charging solution you want

After you've studied the project, select a charging solution. Section 5 lists the main solutions possible, and Section 3 shows a simplified decision tree.

2.4 Stage 4: Install the charging stations

Finally, work with experienced electrical contractors to implement the charging solution chosen.

Figure 1: Approach to EV charging station deployment in a MURB



3 Decision Tree

Figure 2 (page 15) illustrates the decision tree process. The parts of the tree are described in Table 1 below:

Table 1: Decision tree parts

Part	Meaning
Start	Starting point
• First criterion • Second criterion Yes → No ↓	Each rectangle in the tree represents a test: ○ Whenever the test answer is “no,” you continue straight down. ○ Whenever the test answer is “yes,” you continue to the right. There’s one exception: the square at the bottom (binary choice).
Individual solutions 4.1.0	A dark blue oval indicates an individual solution. The number shown refers to a section in this Guide dealing with such solutions.
Shared solutions 4.2.0	A green oval indicates a shared solution. The number shown refers to a section in this Guide dealing with such solutions.
Alternative solutions 4.2.0	A light blue oval indicates an alternative solution. The number shown, if there is one, refers to a section in this Guide dealing with such solutions.

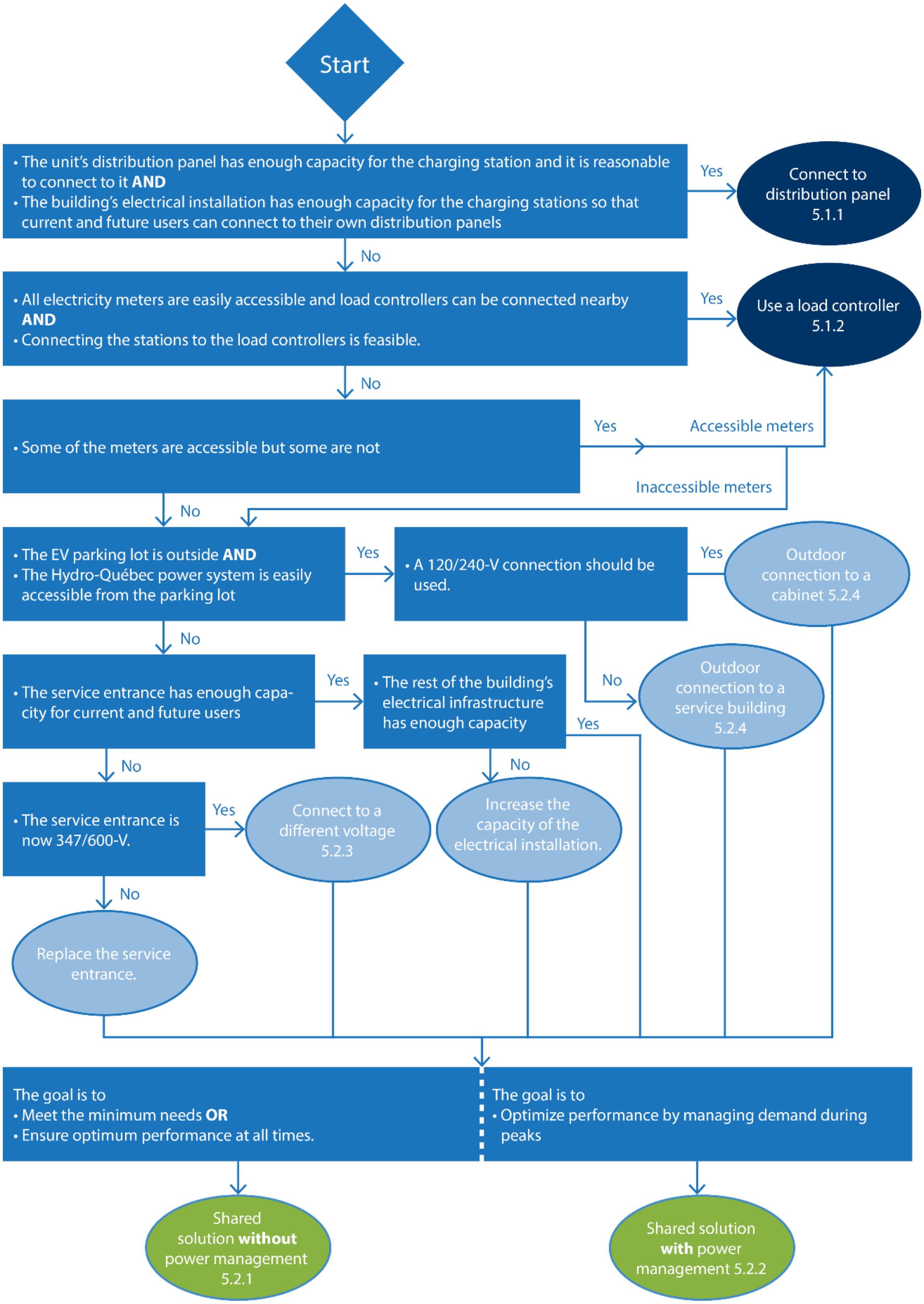
This decision tree does not include all the elements of a proper analysis. It would be impossible to show all the possible combinations since the resulting tree would be crowded and unreadable.

This tree shows one decision-making approach among many. Depending on the situation and issues, the best decision could be different from the solution shown.

This decision tree does not replace a full analysis of each situation and of all the options presented in this Guide.

The decision tree uses the definitions in the Basics box (💡) on page 17, and in Table 5 on page 34.

Figure 2: Decision tree



4 Project Study

In this section, we'll talk about the technical, economic, operational and legal considerations around the installation and deployment of charging stations in a MURB.

4.1 Technical considerations

The technical considerations have to do with electrical and physical configurations.

4.1.1 Safety

When it comes to installing EV charging stations, safety of property and people is non-negotiable.

One of the primary safety aspects is staying within the capacity of the building's electrical installation[2]. Charging stations place large electrical loads on the system over long periods. Apart from light bulbs perhaps, no electrical devices will operate for 3, 5 or even 10 hours straight, as an EV charging station will do.

If an appliance's power draw exceeds the installation's capacity, there is a risk of fire or skin burn. The overload can also damage electronics.

> ⚠ Although overcurrent protective devices such as breakers and fuses are indispensable, they do not obviate the need for an authorized electrical contractor to calculate the loads and ensure adherence to the Code. Breakers and fuses are a last-resort protective barrier and should never be used to manage load.

A qualified electrical contractor will know all the rules applicable to EV charging facilities.

> ⚠ According to Section 86-304 of the Code, a charging station of 60 A or higher must have a separate disconnect.
> A separate disconnect must also be used for a charging station of more than 150 V to ground. This is a rare case, since 208-V and 240-V stations have a phase-to-ground voltage of only 120 V.

2. We'll look at this in greater detail in Section 4.1.2.

4.1.2 Power demand

In a MURB, the most problematic issues have to do with power draw.

Electrical current flows through a wire or device because it is driven by an electrical tension. This tension, or voltage, is measured in volts (V).

The amount of current flowing through the wire or device – current intensity or amperage – is measured in amperes (A).

A current flowing through a device is capable of performing work (running a motor, charging a battery, illuminating a light bulb). The quantity of this work, multiplied by the time unit, is called "power", and it's measured in watts (W).

Power is calculated by multiplying current by voltage. A light bulb in a 120-V outlet with a 3-A current will consume 360 W (120 × 3).

The power drawn by all the devices and equipment is called the load. For example, if a power transformer supplies power to devices at 2 kW, 3 kW and 5 kW, then their load on the transformer is 10 kW.

The "capacity" of a piece of equipment means its ability to be subjected to a certain load. For example, a 7.2-kW transformer cannot supply three 3-kW loads at the same time.

During construction, a building is wired to supply the various appliances and equipment. Sizing of this equipment by trained people is a very important exercise, because it must meet the demand. The Code stipulates a series of load calculations designed to ensure that the electrical infrastructure meets the needs of the building users.

Before a new device is connected to an electrical installation,[3] the load calculations must be redone. There is no grandfathering.

To do this, para. 8 of Section 8-106 of the Code states that the actual maximum load of the past 12 months can be used as the basis for calculation.

Although the Code stipulates minimum electrical capacities for meeting user needs, it does not state any maximum. However, excess capacity is not usually added since it can be very costly.

Moreover, electrical appliances in a home are never used all at the same time; that's why the Code rules provide for some variation in load. The capacity installed is therefore usually less than the sum of all the possible loads in a building.

In a home electrical distribution panel, the sum of the circuit capacities is usually much greater than the main breaker capacity. That's because not all the circuits are used at once or to their fullest capacity. It's the same for a building.

3. This excludes devices plugged into an electrical outlet. Electrical outlets are considered devices and are included in the calculation of initial load.

The Code describes all the detailed calculations to be done by the electrical contractor and states all the rules about what is allowed and what is not allowed in terms of connections. Some rules are specifically aimed at EV charging equipment (see Table 2).

In the case of a MURB, paragraph 1) a) vii) C) of Section 8 202 of the Code sets out rules for calculating the load of an EV charging station indicated in Section 8-200.

Table 2: Load calculation rules

If the dwelling has: ○ an electric stove **AND** ○ an electric hot-water tank **AND** ○ on-centralized (baseboard) heating rated **at least** 14 kW,	the anticipated load is: ○ 35% of the power draw of the first charging station; ○ 70% of the power draw of the second charging station.
If the dwelling has: ○ an electric stove **AND** ○ an electric hot-water tank **AND** ○ non-centralized (baseboard) heating rated **less than** 14 kW,	the anticipated load is: ○ 70% of the power draw of the first charging station; ○ 80% of the power draw of the second charging station.
For cases not covered above,	the anticipated load is 90% of the power draw of all charging stations.
If a charging station is not connected to the electrical installation of a unit,	the anticipated load is 100% of the power draw of all charging stations.

So as not to inflate construction costs, electrical installations are sized to meet the building's current needs, and do not necessarily include large margins to accommodate future requirements. This makes sense because, generally speaking, residential power consumption tends to decrease as technology advances.

In the case of MURBs, the occupants' needs are added up. Margins with regard to capacity of the electrical installation are therefore often kept to a minimum during the design phase. But when the time comes to install one or more charging stations, the electrical installation doesn't always have the necessary capacity.

In fact, the capacity available for each unit in a MURB is less than that of a single-family home. The margin is also usually smaller. A charging station typically uses 30 A; however, in some MURB units, the electrical panel might have only 100 A. The margin is therefore smaller than in a single-family home, which will often have a 200-A panel.

And in a MURB, as more and more charging stations are added, electrical capacity will soon become an issue. Each station could potentially become a problem. That's because each station adds to the load on the building's electrical installation.

The electrical installation in a building consists of all the equipment that makes it possible to distribute power throughout the building. This usually includes:

- the customer service entrance, that is, the service box and the conductor or cable connecting it to the power system operated by Hydro-Québec (or other electric power distributor);
- transformers, in some cases, which step down the voltage;
- distribution panels, which distribute the electricity to many different circuits;
- disconnect switches, which can be used to cut off the electricity for safety or maintenance;
- wiring, which carries the electricity throughout the building.

The entire installation, including the wiring, is protected by overcurrent devices such as circuit breakers or fuses, which will cut off the current if the load exceeds the rating of the equipment they are protecting.

In some cases, adding capacity to one or more parts of the electrical infrastructure is the best solution to allow the installation of charging facilities. However, it's possible to install equipment – load controllers and power management devices – that will modulate the power, which can eliminate or reduce the need for more capacity.

Load controller

A load controller will, if necessary, interrupt a vehicle charge by temporarily disconnecting the charging station to prevent the permitted load from being exceeded.

It also makes it possible to take advantage of unused capacity outside peak periods. In a typical dwelling, consumption peaks add up to only a few hours per year: basically mornings and evenings in the winter. Electrical installations are designed to meet these peak needs. Outside those peak periods, therefore, there's a lot of unused capacity, and this is what the load controller can recover.

In practical terms, the load controller allows EV charging most of the time. However, on a cold winter evening, the situation might be a bit different:

1. When the unit occupants get home, they connect the vehicle to the charging station.
2. They will probably turn on several appliances at once: heating, oven, dryer, water heater, etc.
3. The load controller detects an excessive load and temporarily interrupts the EV charging.
4. Later in the evening, when the load controller detects sufficient electrical capacity, it resumes EV charging.

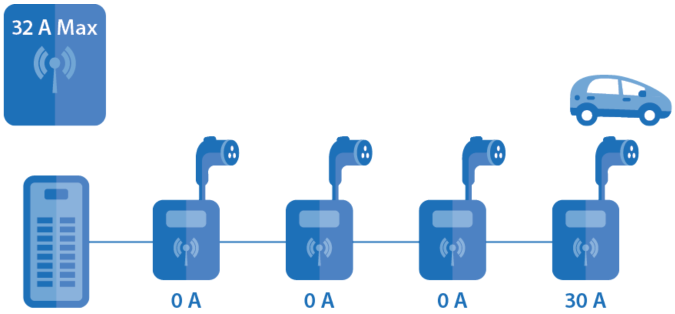
According to an interpretation by the Régie du bâtiment du Québec (RBQ) of a provision of the Code (Section 86 300, paragraph 2), a load controller cannot be used to supply an EV charging station without taking into account its own load in calculating the total load. For more information, consult the ***Cahier explicatif sur les principaux changements au chapitre V, Électricité, du Code de construction du Québec*** published by the RBQ, page 134.

Power management device

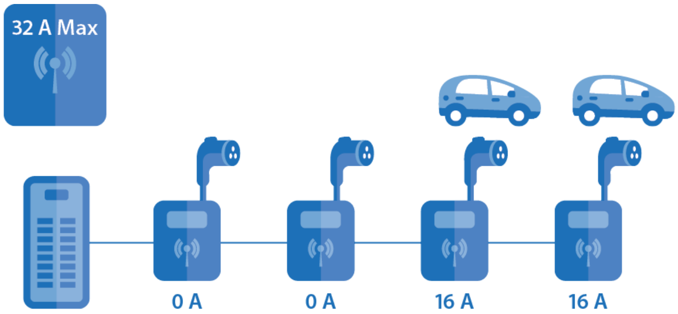
A power management device[4] modulates the power used by a charging station according to the power used by the other stations connected to the same electrical installation.

By sharing electrical capacity among several appliances or pieces of equipment, it's possible to reduce the size of each. For example, take four 30-A charging stations designed to share a 32-A circuit. The power management algorithm could look like this:

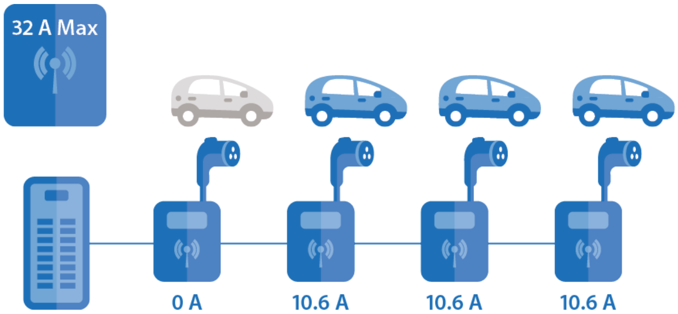
1. When only one EV is connected, the station supplies its maximum capacity, 30 A.



2. When two EVs are connected, each station supplies half its available capacity, or 16 A each.

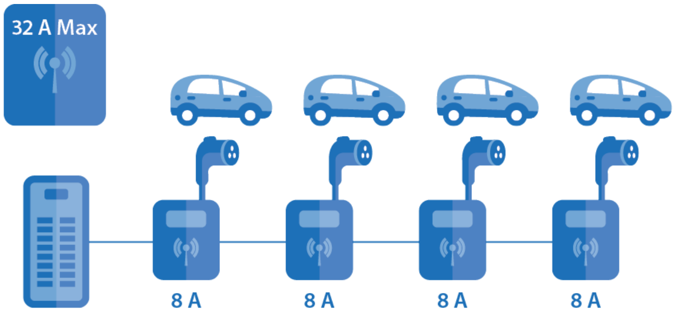


3. If four EVs are connected but one of them has finished charging, the other three will share the available 32 A, for 10.6 A each.



4. Theoretically, a load controller can be considered a power management device. But to simplify, and because we're talking about transportation electrification, discussions of power management devices in this Guide will exclude load controllers.

4. If all four EVs are charging, each will receive only 8 A.



It can be seen that in all cases, the load on the electrical installation will not exceed 32 A, whereas without a power management device, the four stations would have created a load of up to 120 A.

A power management device can greatly reduce the demands on the electrical installation: wiring, transformers, distribution panels and even the service box. This could make it possible to eliminate or at least reduce capacity increases. In general, an effective power management strategy can reduce capacity requirements by a factor of three.

Unlike a load controller, most power management devices will never completely interrupt a charge; they only slow the charge rate when several EVs are charging at once.

But power management devices don't take advantage of unused off-peak power as load controllers do. That's because the available capacity to be shared among stations is limited by the capacity of the electrical installation during peak periods. Table 3 compares the differences between the two devices.

Table 3: Comparison between load controller and power management device

	Load controller	Power management device
Peak (evening)	Charging of several EVs is suspended.	All EVs keep charging, but at a lower rate.
Off peak (night)	Most (probably all) stations operate to maximum capacity.	All EVs keep charging, but at a lower rate. The rate increases as some of the EVs finish charging. The last EVs then finish charging at full power.

The two strategies can be combined: for example, a family with two EVs could install a load controller supplying two stations sharing their portion of the power modulated by a power management device.

Stations that allow power sharing are sometimes called "smart stations". But that term is not used in this Guide.

To enable sharing and management of available capacities, the stations must be able to talk to each other. This communication uses can use any of various wireless (Wi-Fi, ZigBee, cellular, etc.) or wired technologies. This is something that must be kept in mind when choosing a solution.

Wireless communication may be a technical challenge in situations involving an underground parking garage, large distances or a very large number of charging stations. If a charging station is no longer able to communicate with the others, it will usually limit its charging capacity to the most cautious scenario (i.e, the level that assumes all EVs charging). A communication breakdown could therefore result in partial paralysis of the charging facilities.

Communication over wired lines is generally robust; however, it imposes constraints in terms of the maximum distance between stations. If you plan to use a wired communication system, please see the manufacturer's specifications.

Some stations can be connected to the Internet, making it possible to perform online updates and diagnostics and to consult data on usage.

4.1.3 Electrical connection

Charging stations can be hardwired or plugged into an electrical outlet.

Hardwiring, or permanent connection directly to the electrical installation, is a reliable, robust solution. It can be used to supply higher-capacity stations, usually 240-V stations with an amperage of 15, 30 or 32 A.

Some companies offer 240-V stations rated up to 80 A (19.2 kW). However, the charging capacity is limited not only by the station but also by the EV's internal charger. It's pointless to buy an 80-A (19.2 kW) station to charge a vehicle that can only accept 30-A charging (7.2 kW).

It should also be remembered that the higher the amperage of the charging station, the greater the load it puts on the electrical installation.

Charging stations with a power cord can simply be plugged into an electrical outlet. This is considered a less robust solution than hardwiring, especially if the station is frequently unplugged and plugged back in. In addition, it does not allow the use of a load management device. The station can, however, be equipped with a load controller.

If you choose this solution, you can easily move your charging station to another location (for example, to the cottage). But it's important to have a locking mechanism to prevent theft.

Electrical outlets in North America have to comply with the standards of the National Electrical Manufacturers Association (NEMA). Table 4 shows the main types of outlets covered in this Guide.

Table 4: Types of electrical outlets

Type of outlet		Meaning
CSA 5-15R		These are the outlets typically found in homes. They usually come in duplex (i.e. pairs) and supply a 125-V current of up to 15 A. Continuous use – which is the case for EV charging – must not exceed 12 A. For this reason, they are not suitable for daily EV charging.
CSA 5-20R		This outlet resembles the CSA 5 15R, but with a notch on one of its openings. It can supply 125 V to a device requiring a maximum current of 20 A, or 16 A in the case of continuous use. It too is available as a duplex outlet, but the single-outlet version shown here is the configuration suitable for EV charging. It can also accommodate ordinary CSA 5 15R-type plugs. See Section 86-306 of the Code.
CSA 6-50R		This type of outlet, often used to power welders, supplies 250 V to devices requiring a maximum current of 50 A, or 40 A in the case of continuous use.
CSA 14-50R		This outlet has the same configuration as most kitchen stove outlets. It supplies 250 V to devices requiring a maximum current of 50 A, or 40 A in the case of continuous use. The neutral opening (at the bottom) is not used for EV charging.

Some 240-V stations have a power cord enabling connection to an electrical outlet. Nearly all 120-V stations are designed to be plugged into a standard outlet. This includes the portable chargers that come with the purchase of an EV.

Some automakers offer portable chargers with removable plugs, enabling connection to either a 120-V outlet (CSA 5 15R) or a 240-V outlet (CSA 14 50R).

Manufacturers of 240-V stations generally offer models with a CSA 14 50R plug and sometimes a CSA 6 50R plug. Since the industry seems to be tending toward CSA 14 50R type outlets, it might be wise to do the same.

Section 86-306 of the Code sets out a number of requirements for 120-V outlets to be used for EV charging. They include the following:

A) It must be a single outlet with the CSA 5-20R configuration supplied by a separate circuit (not shared with any other loads).

B) It must have a capacity of at least 20 A, even if the load is usually only 12 A.

C) If located outdoors at less than 2.5 m from the ground, it must have a class A ground fault circuit interrupter (GFCI).

All charging stations have a GFCI. There have been rare cases where this GFCI interferes with the operation of the GFCI on the outlet (required under Section 86 306 of the Code, see point C above), causing inadvertent tripping.

This is why it's preferable, if the outlet is outdoors, to use a GFCI built into the outlet, rather than into the distribution panel breaker. In this way, if the circuit is tripped, you can reset it without having to go to the distribution panel.

4.2 Financial considerations

In this section we'll look at the financial aspects you need to consider before installing EV charging stations in your MURB.

4.2.1 Connection and infrastructure costs

In a MURB, the cost of installing a charging station (i.e., connection and any necessary modifications to the electrical installation) is generally two to ten times the cost of the station itself.

This may seem like a wide range, but each situation is unique and is influenced by a multitude of parameters.

Inadequate capacity of the existing electrical installation – in relation to the calculated requirements – will have a huge impact on the project cost. Modifying existing infrastructure is quite expensive in both materials and labor. And the farther toward the line side the bottleneck is located, the more costly the work will be.

To illustrate this, let's look at two examples at opposite ends of the spectrum.

- Example 1: Low power requirement

  A seniors' residence wants to install EV charging facilities for its occupants. These are EVs that remain parked for long periods of time and travel only short distances. The charging capacity requirements are therefore very minimal. Management decides to install 120-V single outlets in the underground garage.

  The electrical contractor finds the distribution panel in the garage and calculates 26 kW of available capacity, taking into account the margins stipulated in the Code. Eighteen 120-V outlets can therefore be installed (1.44 kW each). The project will not cost much in materials (mainly breakers, outlets and wiring) or in labor.

- Example 2: Maximum power requirement

  The condo association of a condo building, concerned with protecting the value of the owners' units, wants to implement a high-quality, trouble-free solution that will meet the needs of current and future unit owners.

  Unfortunately, the building's service entrance is already saturated and must be replaced. This is a very expensive project that will take many years to pay for itself.

These two examples show the importance of looking at the solutions discussed in Section 4.1.2.

A load controller would avoid having to upgrade the electrical installation, because it would optimize the existing capacity. Its purchase cost would be much less than the cost of replacing equipment.

A power management device, too, would make it possible to avoid or limit equipment replacement, since the available capacity would be shared – but only if there's enough capacity to share.

Limited capacities of parts of the electrical installation bring up another financial reality: Costs do not increase linearly with capacity requirements; rather, they jump each time the capacity of a piece of equipment is exceeded.

Moreover, when a piece of equipment has to be changed, the capacity of the new equipment will not necessarily match the requirements. For example, if the capacity requirement is 213 A but the distribution panel has only 200 A, a 300-A[5] panel, or two panels with a total of 300 A in capacity, will have to be installed. This will add a jump in cost.

In cases like this, load control and power management strategies can become very attractive from a financial viewpoint.

4.2.2 Charging station cost

In the planning of an EV charging station project, the cost of the stations themselves must also be considered.

If 120-V outlets are installed, users will mostly be able to use the portable charger that came with the vehicle. In that case, no cost is incurred for a charging station.

In the case of 240-V outlets, some automakers provide purchasers with a compatible charger. If not, users can purchase a 240-V charger with the appropriate plug. The charger can be used elsewhere, making it all the more practical.

A hardwired 240-V station will generate some savings; however, it can only be used in one place. If it has a power management system, it will be more costly.

The more powerful stations are not necessarily much more expensive than the lower-capacity ones. But they can require large investments in connection and equipment replacement, as we saw in the previous section.

4.2.3 Civil engineering

Civil engineering work will be needed in some cases. Examples include excavation, earthwork, installation of poles or a concrete slab, or the penetration, removal, modification or addition of a wall.

If wires have to be run under a paved lane, for example, that could cause a jump in the project cost.

5. The panel or panels will then have to be connected to a 320-A socket.

4.2.4 Subsidies

The purchase and installation of EV charging stations may be eligible for various subsidies.

At the time of writing, Transition Énergétique Québec (TEQ) was offering a subsidy of up to $600 for the purchase and installation of eligible charging station.

The subsidy is paid to the EV owner and, at present, will not be paid to a condo or landlord who pays for the installation of a charging station that will be used by another person.

TEQ also offers a subsidy for landlords and condo associations who install charging stations in a MURB. At the time of writing, the subsidy was:

- 50% of purchase and installation costs up to $5,000 for each charging station purchased;
- $500 plus 50% of installation costs up to $5,000 for each charging station leased.

4.2.5 Capital cost management

The capital costs include:

- charging station purchase;
- charging station connection;
- cost of modifying the electrical installation if necessary;
- cost of civil engineering work if necessary.

How these capital costs are managed depends on the solution chosen and the type of MURB.

Condo building (condo)

In the case of an individual solution (see Section 5.1 below), there are usually no shared expenses between users. The capital costs are therefore assumed by the unit owner in question. The equipment installed remains the property of that owner, who will sell it along with the condo unit when such occasion arises.

In the case of a shared solution (see Section 5.2 below), some costs may be shared among several users. The condo assumes them and then finds an equitable way to pay for them. Here are three possible approaches:

- **Cost assumed by the condo**: The condo decides that providing EV charging is a benefit to all the unit owners, even those who do not yet have an EV. The condo council therefore decides to assume the entire cost of the project.
- **User pays**: The condo decides that the cost must be assumed by the users alone. It must then determine the maximum number of unit owners who will be entitled to a charging station. When a new unit owner requests an EV charging station, that owner must pay a share equivalent to the total project cost divided by the number of unit owners entitled to use a charging station. In this approach, the condo association must advance the funds needed to carry out the project.

- **Hybrid approach**: The expenses incurred to enable users to connect their own charging stations (modification of service entrance, transformer addition or replacement, distribution panel addition, excavation for installation of cable raceways, etc.) are assumed by the condo. This infrastructure benefits all the unit owners, since it enables everyone, including future owners, to connect their charging station. The connection costs and the station purchase cost are assumed by the unit owners who wish to prevail themselves of this service.

In all cases, the condo should include the charging stations project in its contingency fund. It might increase contingency fund contributions in order to pay for the implementation and maintenance of the charging infrastructure, or it might set up a separate fund devoted to that purpose.

Apartment building

It would be difficult to ask a tenant to assume the cost of installing EV charging stations since any equipment installed will be left behind when the tenant leaves. Regardless of the type of solution chosen – individual or shared –, these costs are generally assumed by the landlord. The landlord can recover all or some of the amounts invested by incorporating them into operating costs (see Section 4.2.6) or into the rent.

As for the cost of purchasing the station itself, there are two possible approaches:

- The landlord purchases the station, retains ownership of it, and recovers the cost in the same way as the other capital expenditures; or
- The tenant purchases the station and assumes the maintenance and repair costs including those arising from any damage or vandalism. When the tenant moves out, the station will go with them.

4.2.6 Operating costs

Operating costs consist of electricity and maintenance.

In the case of **individual stations**, these costs are paid by the unit owner or tenant.

In the case of **shared stations**, there are several ways of managing the operating costs. They're presented below in the order of increasing complexity.

Included service

In this approach, the charging stations are treated as an included service available to all occupants, just like a swimming pool or an exercise room. The operating costs are factored into the rent or condo fees.

This approach has the advantage of simplicity. It can also accelerate the adoption of EVs, since people are more inclined to make use of something when it's "free." In the case of an underground garage, such a policy is justifiable because it will improve the air quality in the building, which everyone will benefit from.

It can nevertheless cause some disgruntlement on the part of those occupants who do not have an EV. But the same is true of a swimming pool, recreation room or exercise room.

When each unit is assigned a specific parking stall, as is the case in most condo buildings, this approach can pose an additional difficulty, since criteria must then be established to determine which stalls will have charging stations.

Fixed fee

In this approach, all charging station users have to pay a monthly fee which is the same across the board. This method is quite simple, since it doesn't involve individual calculations.

However, "light" users may be unhappy about having to subsidize the "heavy" users. That said, it's worth putting the numbers into perspective. Let's take two very different users: one who drives 6,000 km a year in a small EV, and who has energy-efficient driving habits, will consume about $7.50 in electricity per month;[6] whereas someone who drives 24,000 km a year in a large EV, is a fast driver and is heavy on the brake and the accelerator will consume about $50[7] a month. Most EV drivers are somewhere between these extremes, using between $20 and $30 worth of electricity per month.

Hourly rate

This approach attempts to provide a better picture of actual consumption by applying an hourly rate, which may be adjusted according to the maximum output of the station; for example, $0.75/hour for a 240-V, 30-A station and $1.80/hour for a 240-V, 72-A station.

This gives the user an accurate picture of the EV's actual consumption. It also provides a price signal and discourages users from installing stations with excessive amperage, which helps keep installation costs at a reasonable level.

> The size of the vehicle or battery should not be used as input in determining the hourly rate, because these factors have nothing to do with the vehicle's actual consumption.
> A small EV with a low-capacity battery that is used a lot will consume much more than a large EV with a high-capacity battery that sees infrequent use.

Calculating the hourly rate is quite complicated, as it involves:

- having charging stations with a feature for measuring usage time;
- being able to access the usage data periodically;
- spending significant amounts of time on billing.

Some stations can measure usage time and produce periodic reports. There are also centralized meters that can be installed in the electrical room. The data are uploaded to a Web platform where the reports can be consulted and used for producing invoices.

The hourly rate approach is based on the assumption that the power delivered by the charging station is relatively constant over time. However, if a power management device has been installed, this is not at all the case. Such a device is therefore incompatible with the hourly rate approach.

If you have decided to apply an hourly rate, we suggest you consider a billing period that's in line with the amount of time you have available to manage the billing. As we saw earlier, the actual cost of the electricity will be only $20 to $30 a month, per vehicle. Perhaps quarterly, semi-annual or even annual billing would be more practical than monthly.

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6. 6,000 km/12 months × 0.150 kWh/km × $0.10/kWh
7. 24,000 km/12 months × 0.250 kWh/km × $0.10/kWh

Billing of consumption

This user-pays method consists in tracking actual consumption and billing the user for it.

Although it's the most equitable approach, it's also the most complicated by far. When a consumer is billed for electricity, it must be metered according to the rules set out in the Electricity and Gas Inspection Act (R.S.C. (1985), c. E-4). Section 4.2.8 contains an overview of these rules.

> ⚠ Hydro-Québec treats EV charging as a service; allocation of the energy costs is therefore allowed.
> However, if the cost allocation is based on actual consumption, under federal law consumption **must** be metered according to the standards in effect, regardless of whether or not an administrative fee is added to the cost of the power.

This approach therefore requires the purchase of electricity meters approved and inspected by Measurement Canada—another capital expenditure to be added to the project cost.

There will also be costs involved in reading the meters and managing the billing.

If the meters have to be read manually, it's preferable to place them all in one location; in the electrical room, for example.

If the meters are equipped with remote-reading capability, they will need a communications network nearby. Again, it's better to have them all in the same location for this reason.

In both cases, the electrical room can become crowded if many electricity meters have to be installed in it.

As was mentioned for the hourly rate, it's important to set up a billing cycle that's in line with your ability to manage that administrative aspect.

Charging as a service

A service provider will assume the cost of the station along with the maintenance and electricity costs. It will then bill a monthly amount directly to the user.

In some cases it will also assume part of the installation and infrastructure costs, usually conditional on a guarantee as to the initial number of users.

The landlord or condo is thus relieved of the task of billing management. In addition, some of the technical and financial risk is transferred to the service provider, which may be advantageous for the landlord or condo association.

However, some users might not be happy with the rate charged by the service provider.

4.2.7 Electricity rates

Charging station operating costs are largely made up of electricity costs.

> Section 4.2.1 showed how expensive it can be to add electrical capacity to a building. This is also true for Hydro-Québec: the greater the power demand from customers, the more facilities the company has to build to meet those demands – which means costs to generate, transmit and distribute the power.
>
> Like many electric utilities around the world, Hydro-Québec applies a rate structure that factors in the cost of meeting the demand and encourages customers to manage their own power requirements.
>
> Many of our rates have energy and demand as the main components:[8]
>
> **Energy** is the power used by an appliance or device over a given length of time. It's measured in kilowatthours (kWh).[9] The energy billed is therefore the product of the power used and the time over which it was used.
>
> **Power demand** is the customer's total power draw at a given moment. It's measured in kilowatts (kW). Hydro-Québec bills customers for their maximum power demand during the consumption period.[10] For example, a maximum power demand of 100 kW costs the same whether it lasts 15 minutes, 1 hour or 24 hours.

Some rates do not have a demand component: for example, Rate D, which applies to most of Hydro-Québec's residential customers. The majority of people don't know about the demand component.

The demand charge only applies above a certain level of demand. Rate D applies to residential customers whose power demand does not exceed 65 kW (270 A at 240 V). Above 65 kW, the customer is then at Rate DP, which includes a demand charge.

Section 6 lists the rate conditions most likely to apply to a MURB.

Usually rates don't influence the choice of charging station solution. In fact, it's the opposite: the rate depends on the solution chosen.

That said, it's important to remember the general principle underlying all electricity rates: the installation of capacity gives rise to costs not only to build facilities (Section 4.2.1), but also to operate them (Section 4.2.6). That capacity should therefore be planned and utilized as judiciously as possible.

4.2.8 Metering

If you decide to bill electricity based on actual consumption, you must comply with the *Electricity and Gas Inspection Act* (R.S.C. (1985), c. E-4).

These provisions apply if consumers are invoiced on the basis of energy consumed (kWh),[11] irrespective of the calculation method.

> Electricity metering and billing is a complicated task requiring significant management capabilities. If your building has a small number of units, you may find it difficult to manage these obligations.

8. Some rates have other components such as a system access charge or a monthly minimum.
9. One kWh is the energy consumed by a device drawing 1 kW for one hour.
10. Rules about billing of power demand are not discussed in this Guide. More information can be found in the Hydro-Québec document ***Electricity Rates***.
11. They also apply if the calculation is based on demand (kW or kVA), but this is unlikely to occur in the case of a MURB.

Nevertheless, if you want to pursue the avenue of electricity metering and billing, you should consult the Web site of Measurement Canada. Here's an overview of the steps to follow.

- Apply to Measurement Canada for a registration certificate under paragraph 6(2) of the *Electricity and Gas Inspection Act*.
- Electricity metering must be done by a meter approved and inspected by Measurement Canada. Each meter must have a sticker confirming that it has been calibrated and deemed compliant.

Note, however, that certification expires after a certain number of years, after which the meter must be re-certified. The condo association or landlord must designate someone to manage meter certification. Certification renewal will probably require the equipment to be uninstalled and then reinstalled so that it can be run through a series of tests on an approved test bench.

The service standards regarding calibration, certification, approvals and inspections can be found on the ***Measurement Canada website***.

Some charging stations measure the amount of electricity consumed for each charge. However, at the time this Guide was published, none of the EV charging stations on the market had a built-in metering feature that met the Measurement Canada requirements. **The reading from the station therefore can't be used for consumption billing**.

That said, the readings provided by these stations do yield interesting data that provide a better understanding of how the stations are used. They could also be used to improve the planning of charging station installation.

If your charging stations don't have a metering feature, you can purchase meters and install them in the electrical room. They'll monitor the consumption of several stations and upload the data to a Web platform.

4.3 Operational and legal considerations

In this section, we'll look at the operational and legal considerations you should take into account when installing EV charging stations in a MURB.

4.3.1 Choosing an electrical contractor

In Québec, all work on an electrical installation must be done by a contractor holding an appropriate license and whose employees are qualified. Charging stations must thus be installed by an electrical contractor who is a member of the Corporation des maîtres électriciens du Québec, with whom you will enter into a contract and who will bill you for the work done.[12]

Of course, the licensed electrician may employ other electricians, but the latter will remain entirely under the responsibility of the licensed electrician. You may not deal directly with a non-licensed electrician.

Before hiring anyone, make sure they have a valid specialized contractor license in the "16 Électricité" category on the website of the ***Régie du bâtiment***. You must also make sure they are a member of the Corporation des maîtres électriciens du Québec (CMEQ) by checking the **CMEQ website**.

EV charging in a MURB has specific characteristics. It would be wise to find out whether the licensed electrician has the relevant expertise. Apartment building owners and condo associations looking for a contractor can consult the list of **CMEQ members who offer charging station installation services**. They can also consult the list of **charging station installers provided by the *Association des véhicules électriques du Québec*** (AVEQ).

12. If the charging station installation is eligible for a subsidy, an invoice from a licensed electrician will be required.

Under the Code, drawings and specifications are mandatory for any electrical installation rated over 200 kW. These may be done by the licensed electrician, but only for their own portion of the work.

If you, as the condo or landlord, wish to have the drawings and specifications prepared by an independent professional, you must hire an engineer. This could be advantageous if you want to put out a tender, since the engineer will produce drawings and specifications that can be sent out to various bidders. In this way, you ensure that the bids will be comparable because they'll all be based on the same technical solution.

If you adopt this approach, you should make sure the engineer belongs to the **Ordre des ingénieurs du Québec**. You should also ask questions about the engineer's experience with EV charging stations in MURBs.

Under the Code, a licensed electrician may only connect a device or appliance if it has been approved by a competent Canadian body. If you, as an individual, purchase a charging station, you must check with a licensed electrician to determine whether the station has the necessary approval. For example, some stations sold online are not approved for use in Canada. Though the price may be attractive, there's no point buying a charging station that no one will install.

4.3.2 Installation

In single-family homes, the charging station is usually connected directly to the distribution panel. But in a MURB, the user's distribution panel is not always accessible.

It's usually located within the unit, while the vehicle is parked in the underground garage or outdoor parking lot. Running a cable over several stories from the unit to the parking stall can be a very costly endeavor, or even impossible.

Often it's easier to install a load controller on the cable connecting the distribution panel to the meter. The load controller will then continuously measure the load generated by the distribution panel and redirect any unused capacity toward the charging station.

However, this can't be done unless the meter itself is accessible, i.e., near where the EV is parked. If the meter is on an upper floor, it's no more accessible than the distribution panel, and the problem remains. In that case, a shared solution should be considered (see Section 5.2).

4.3.3 Deployment strategy

For a MURB, the deployment strategy must also be considered. As we saw in Section 1.1, the trend toward EV adoption is irreversible. It's therefore important to take scalability into account, that is, to look at the various possible solutions in terms of their ability to accommodate future users.

So when estimating the electrical capacity of the infrastructure required, you should look beyond your immediate needs. If you try to push away work that is inevitable in the long term, it will end up being the most expensive solution.

One of the most underestimated issues in long-term planning is the physical configuration. It's critical to plan solutions that will still work when the number of users rises. Rules around charging station installation and deployment should be agreed on as early as possible. The rules must be fair: they must not penalize the initial users (e.g., by making them bear the financial burden of installing a cable duct that future users will benefit from) or future users (e.g., by letting initial users install charging stations in a location that would block access for future users).

Regardless of the solution chosen, it would be wise to document the rules in the condo agreement or lease.

4.3.4 Other operating considerations

The amount of physical space available for electrical equipment can be a major issue. Expanding the electrical room may be difficult or costly. If it's adjacent to the underground garage, one parking stall could be sacrificed. In the case of a condo building, this would require the agreement of whoever owns the stall in question.

The parking lot location will also greatly impact the choice of solution. If the parking is underground, there will be high costs for civil engineering, and the room available for equipment will often be limited. If it's an outdoor parking lot, the charging stations will be more vulnerable to damage, theft or vandalism.

The solution will vary according to whether the parking stalls are assigned or not. If a stall is assigned to a specific user, there can be individual solutions. But if stalls are not assigned, only shared solutions can apply.[13] You must then plan a sufficient number of stations to accommodate everyone, or develop a system for sharing them.

13. In the latter case, consumption-based billing could be very difficult to implement.

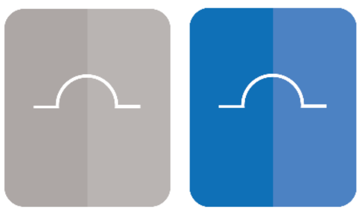
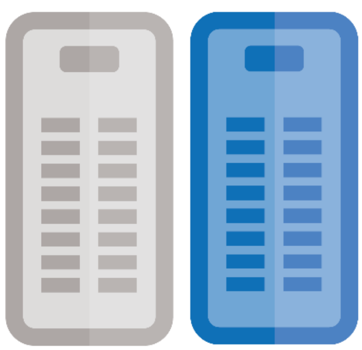
5 Solutions

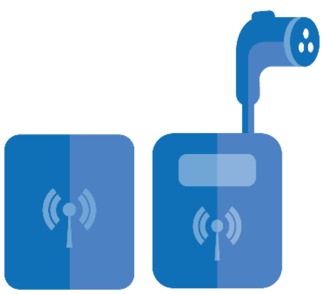
In this section we'll look at various solutions for installing charging stations in a MURB. Each solution is illustrated by one or more figures. We've also summarized the main factors to take into account for each solution. The numbers in parentheses refer to sections or subsections in 4 – Project Study.

> In the following section, each solution is presented individually. However, a building might require more than one solution.
> For example, within one building, some users could decide to hardwire their station to their unit's distribution panel (5.1.1), others might choose a load controller (5.1.2), while still others might adopt a hybrid solution (5.2).

Table 5 shows the symbols used in the solution figures:

Table 5: Meaning of symbols used in figures

Symbol	Meaning
 Grey: existing service entrance Blue: new service entrance	**Customer service entrance:** The service box and the cable connecting it to the Hydro-Québec system.
 Grey: existing panel Blue: new panel	**Distribution panel:** For a unit or for the building.
 Grey: existing transformer Blue: new transformer	**Transformer**

Symbol	Meaning
 Grey: existing meter Blue: new meter	**Electricity meter:** Only solutions with Hydro-Québec meters are shown.
	**EV charging station *without* power management:** This could be a station that is hardwired or plugged into an outlet.
	**EV charging station *with* power management:** This is a model using wireless communication. The symbol on the left is the communication gateway[14] icon.
	**Load controller:** The circle on the right is the current reader through which the load controller controls the switch (lower circle).

The figures shown in this Guide are only outlines of possible solutions. To keep the figures simple, several components have been omitted. In individual solutions, for example, the building's shared electrical installation was not shown in order to simplify the drawing.

Moreover, the drawings don't show all the possible solutions. Where there are several possible combinations, the choice of a drawing must not be interpreted as a better or recommended solution.

The figures show only the electrical installations of three apartments and the connection of two charging stations.

14. For purposes of clarity, the figures do not show the communication gateway wiring.

There are two basic solutions: individual solutions and shared solutions.

5.1 Individual solutions

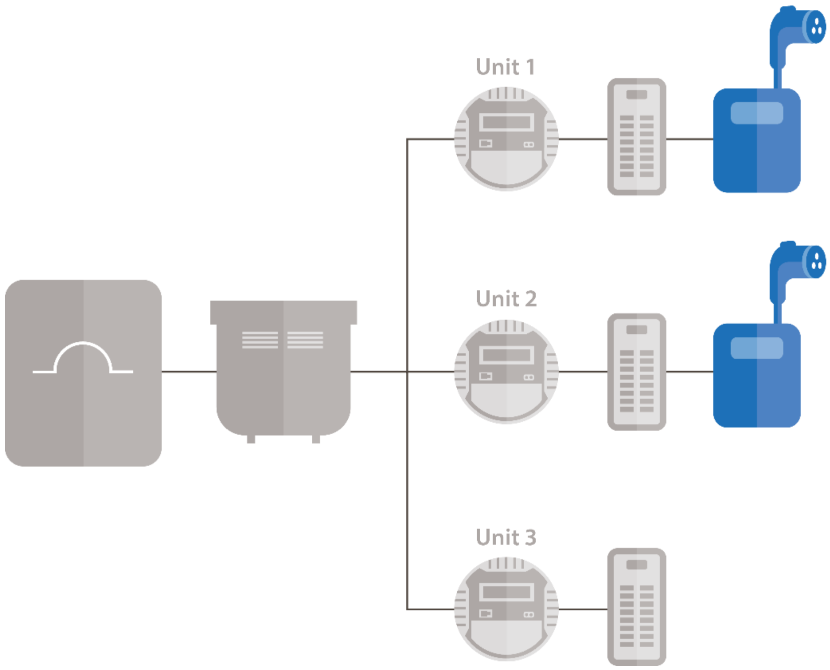
In all individual solutions, the charging station of the user (i.e., the tenant or condo owner) must be connected on the load side of the user's meter. Hydro-Québec therefore bills the user directly for the electricity use.

> ⚠ Although a user can apply an individual solution, the landlord or condo should nevertheless study the issue of EV charging installation infrastructure and avoid case-by-case management.

5.1.1 Connection to distribution panel

In this solution, the user's charging station is directly connected to the user's distribution panel (see Figure 3). This is the solution most frequently adopted in single-family homes. But for a MURB, it would be difficult or impossible to apply.

Figure 3: Connection to distribution panel



Technical considerations

Load (4.1.2): The solution adds new load to the user's panel, which will require a new load calculation. Moreover, the panel might not be able to accommodate the charging station. Generally speaking, distribution panels in MURBs have only the minimum number of breakers and don't have much extra space for installing more load.

If your distribution panel is unable to accommodate a charging station, you could change it. However, that could be a complicated undertaking and could have a domino effect on the whole building's electrical installation.

Type of connection (4.1.3): The charging station can be hardwired or plugged into an outlet. Plugging into an outlet is an attractive solution for apartment buildings, since the landlord pays to have an outlet installed and the tenant buys a charging station with an electrical plug. Then when the tenant moves out, the station goes with them, but the outlet remains available for the next tenant.

Financial considerations

Connection costs (4.2.1): If the panel is readily accessible and can accommodate more load, this solution is quite inexpensive. The only equipment required is a breaker and an electrical outlet. The main costs are cable and labor, and the amount will depend on the distance to be covered and the obstacles to be worked around.

Charging station cost (4.2.2): This solution doesn't require a particular type of station. You can use an inexpensive station or even the charger that came with the EV, if it's going to be plugged into an outlet.

Civil engineering (4.2.3): Civil engineering work might be required, for example if a trench has to be dug to run the cable under asphalt.

Subsidies (4.2.4): The portion to be paid by the user could be eligible for a grant.

Capital costs (4.2.5): In a condo building, capital costs are generally assumed by the user; in an apartment building, they're assumed by the landlord (except the charging station, which can be paid for by either the landlord or the tenant).

Operating costs (4.2.6): In general, all operating costs are assumed by the user. The electricity consumption is included in the user's electricity bill.

Electricity rate (4.2.7): The rate is the same, i.e., Rate D (except in the unlikely event the demand exceeds 65 kW, in which case Rate DP would apply).

Metering (4.2.8): Metering is done by the Hydro-Québec meter.

Operating considerations

Installation conditions (4.3.2): Often, the distribution panel is not accessible from the parking area, or is so far away that the solution would be prohibitively expensive.

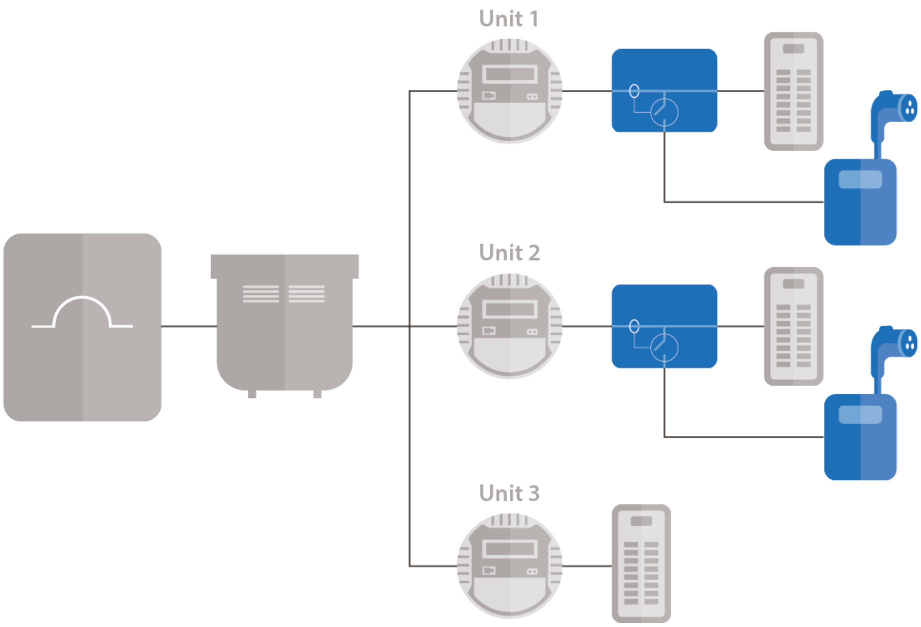
Deployment strategy (4.3.3): Generally speaking, this is an appropriate solution for all users. However, in the future, the distribution panels of some users may be inaccessible, too far from the charging station or already saturated, making this solution unfeasible for them.

Your building should establish connection rules for current and future users, if it hasn't already done so.

5.1.2 Load controller

This solution involves installing a load controller between the user's meter and distribution panel (see Figure 4). The charging station is then connected to the load controller.

Figure 4: Connection to load controller



The load controller can also be installed between the distribution panel and the charging station if the panel is easily accessible but doesn't have enough capacity to accommodate the station.

Technical considerations

Load (4.1.2): This is the only solution that has no impact on load for either the customer's or the building's electrical installation. The load controller makes use of already available, unused capacity. It's a very compelling advantage.

Type of connection (4.1.3): The charging station can be permanently connected or plugged into an outlet. Plugging into an outlet is an attractive solution for apartment buildings, since the landlord pays to have an outlet installed and the tenant buys a charging station with an electrical plug. Then when the tenant moves out, the station goes with them, but the outlet remains available for the next tenant.

Financial considerations

Connection costs (4.2.1): If the user's meter is readily accessible, this solution is of moderate cost, since the main piece of equipment to be purchased is the load controller. Usually this type of connection costs between $2,000 and $6,000, not including the charging station and any applicable grants.

Charging station cost (4.2.2): This solution doesn't require a particular type of station. You can use an inexpensive station or even the charger that came with the EV, if it's going to be plugged into an outlet.

Civil engineering (4.2.3): Civil engineering work might be required, for example if a trench has to be dug to run the cable under asphalt.

Subsidies (4.2.4): The portion to be paid by the user could be eligible for a grant.

Capital costs (4.2.5): In a condo building, capital costs are generally assumed by the user; in an apartment building, they're assumed by the landlord (except the charging station, which can be paid for by either the landlord or the tenant).

Operating costs (4.2.6): In general, all operating costs are assumed by the user. The electricity consumption is included in the user's electricity bill.

Electricity rates (4.2.7): The rate is the same, i.e., Rate D (except in the unlikely event the demand exceeds 65 kW, in which case Rate DP would apply).

Metering (4.2.8): Metering is done by the Hydro-Québec meter.

Operating considerations

Installation conditions (4.3.2): Generally speaking, the meter is closer to the parking area than to the distribution panel. This is usually the case in underground garages. Using a load controller is then more advantageous than connecting to the distribution panel.

In other situations, the user's electricity meter isn't accessible from the parking area or is so far away that the solution would be prohibitively expensive.

Another factor is the location where the cable going to the distribution panel will be tapped.

Deployment strategy (4.3.3): Generally speaking, this is an appropriate solution for all users.

However, in a given building, some meters may be accessible while others are not. In that case, it's impossible to have a single solution for all users. There will have to be two solutions: use of a load controller (5.1.2) for those whose meters are accessible, and a shared solution (5.2) for the others.

In an apartment building, the meters are generally grouped together in the same location (as opposed to the distribution panels). Load controllers take up space; as they proliferate, there could be crowding issues. The deployment should therefore be planned as early on as possible.

Another possibility: install only the load controller housing, without the device. The housing costs about a quarter of the price of the load controller, but contains the terminals for connecting the meter and the distribution panel. This is especially practical for new buildings, because a load controller box can be installed for each dwelling. Then, when a tenant or unit owner wants to install a charging station, they simply buy a load controller, install it in the box and have the station connected to it. This pre-emptive strategy can save a lot of money over the medium or long term.

It could also be applied to an existing building to facilitate the future installation of charging stations.

Other operating considerations: Some vehicles have an alarm that's triggered when the power supply to the charging station is interrupted during charging. If a load controller is used, it's important to make sure this alarm is deactivated.

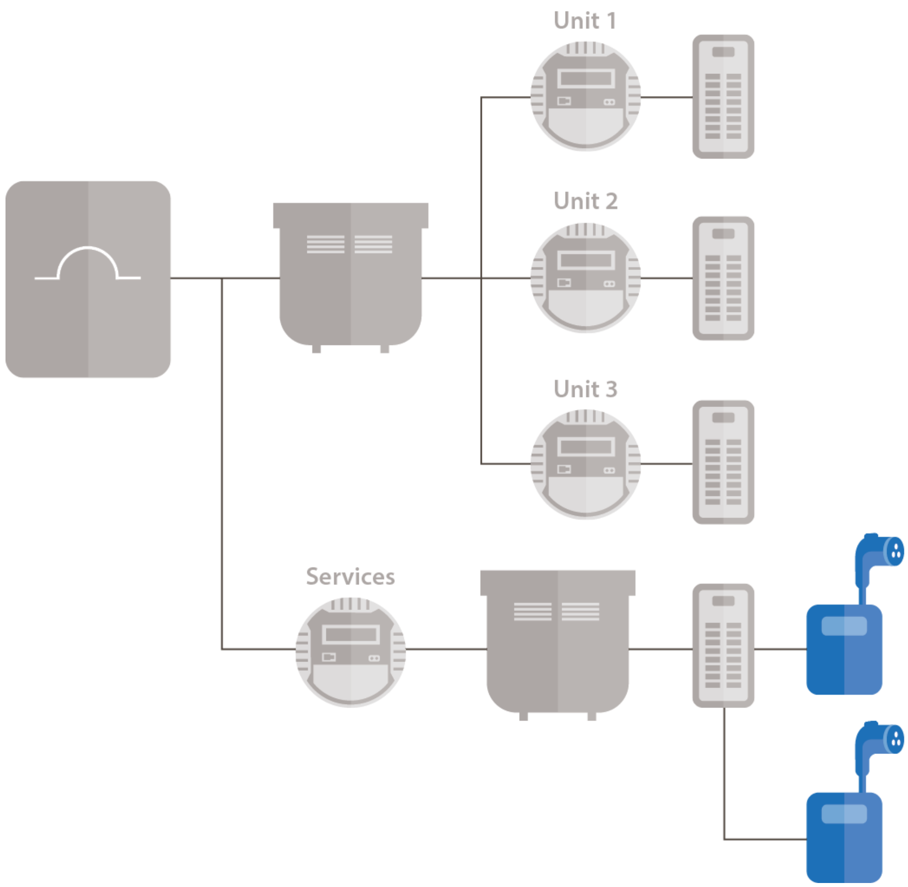
5.2 Shared solutions

All the shared solutions require the user's charging station to be connected to a shared meter in the building (whether the user is a tenant or a unit owner). The electricity is then billed to the condo or to the landlord, as the case may be.

5.2.1 Connection to electrical installation with no power management device

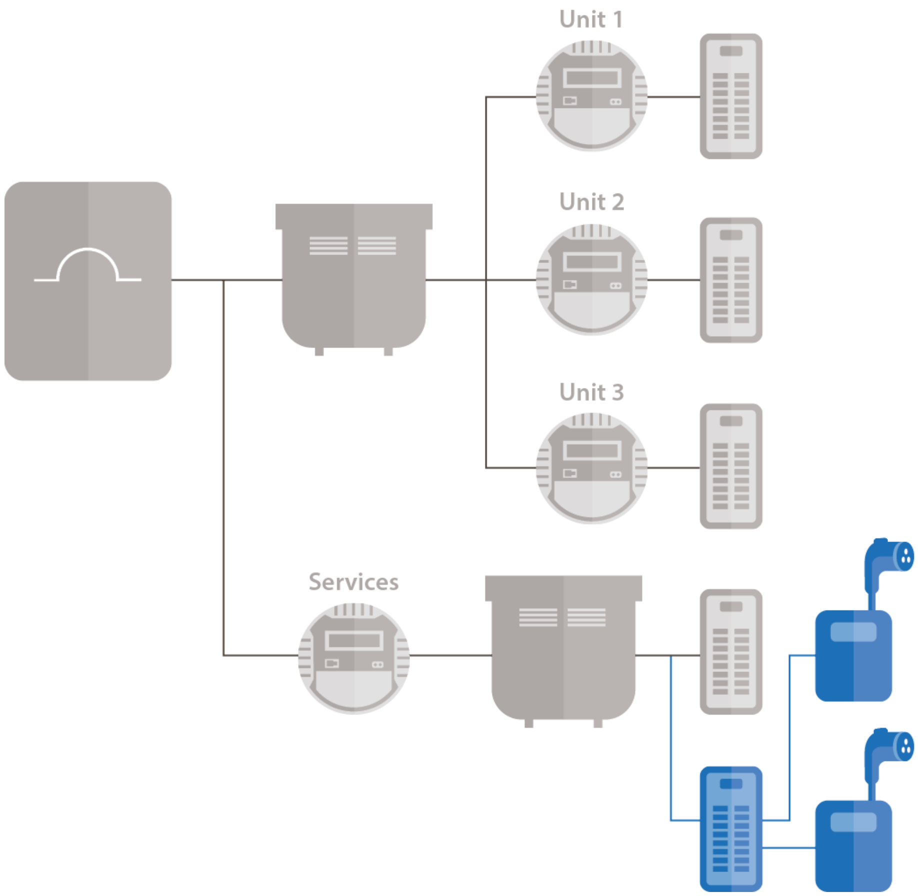
The charging stations are connected directly to the building's general service panel (see figure 5). This solution does not involve power management.

Figure 5: Connection to general service panel



The panel will probably not be able to accommodate new charging stations. A new service panel will then have to be connected to the transformer[15] (see Figure 6).

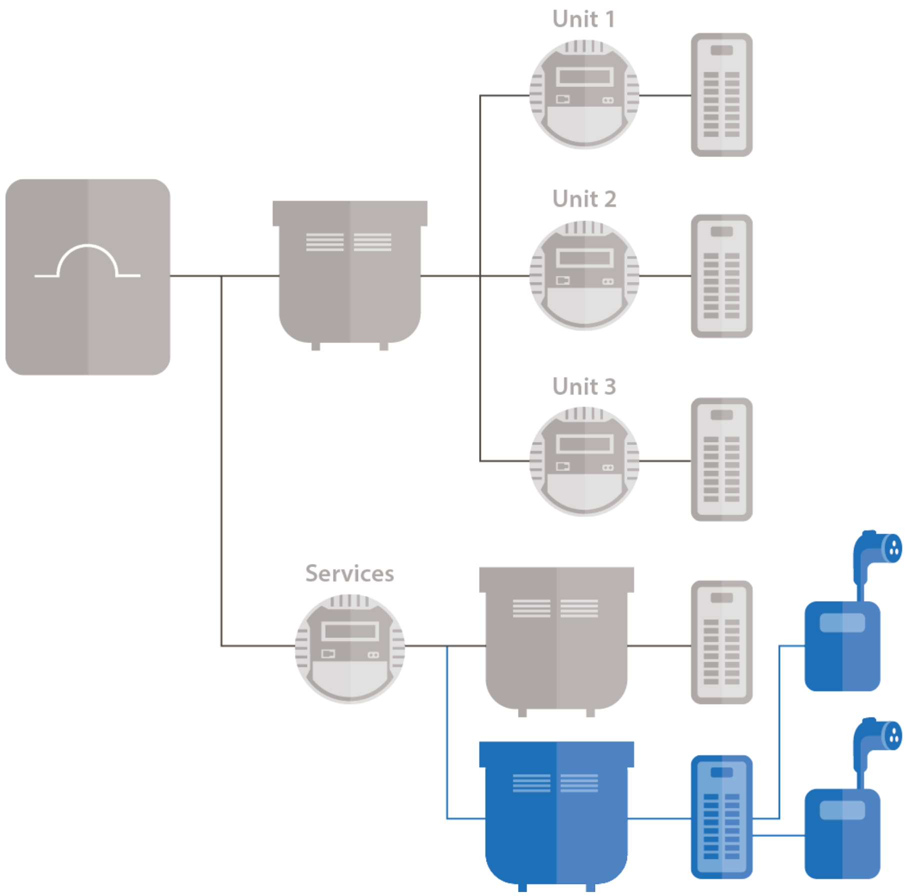
Figure 6: New distribution panel



15. In some cases, it might be better to replace the panel than to add a new one – for example, if space is at a premium. This scenario is not shown.

The transformer might not be able to accommodate these new loads. A new transformer must then be connected to the customer service entrance[16] (see figure 7).

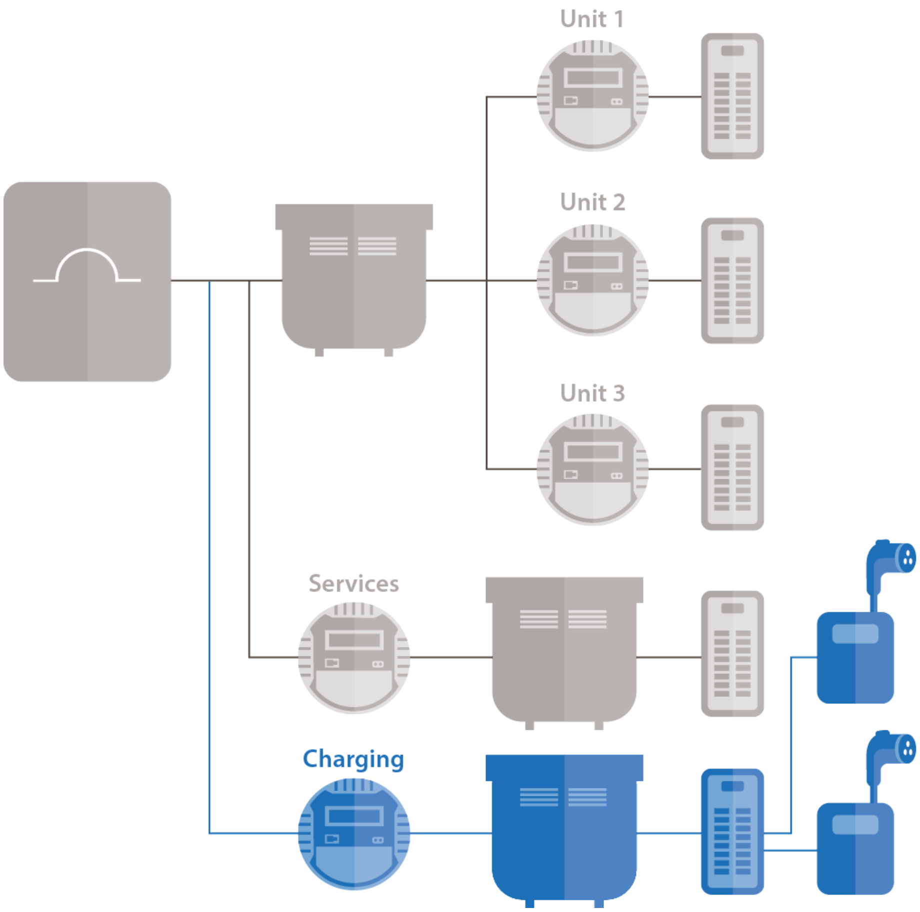
Figure 7: New transformer



In some cases, it could be more advantageous to install a new meter for the charging stations (see Figure 8). It should feed all charging stations – current and future – in a given location.[17] However, an existing meter could still supply one or more charging stations, for example a user's own meter.[18]

16. In some cases, it might be better to replace the existing transformer than to add another one; for example if space is at a premium. This scenario is not shown.
17. "Location" means a parking lot or a floor of a parking garage.
18. In the same building, therefore, you can have some charging stations using an individual solution while others are based on shared solutions.

Figure 8: EV charging meter

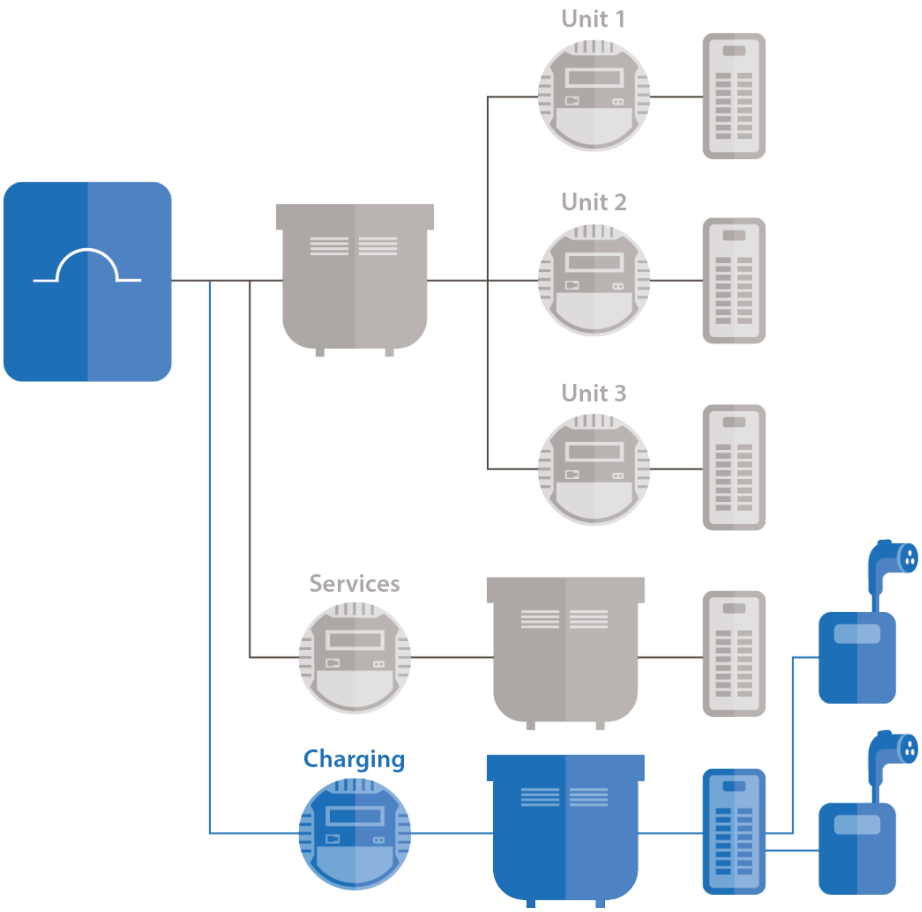


There could be several charging-station meters for different areas.[19] For example, you could have a meter for the outdoor parking lot and another for the underground garage. You could even have three meters for a three-storey parking garage, and so on.[20]

In some cases, it might be necessary to add a customer service entrance to supply meters for the EV charging stations (see Figure 9).

19. In figure 8, there's only one meter for EV charging.
20. If necessary, you may contact Hydro-Québec to find out the maximum number of meters allowed.

Figure 9: New service entrance



Technical considerations

Load (4.1.2): Since there's no power management, this solution might require the replacement or addition of several electrical installation components.

Type of connection (4.1.3): The charging station can be permanently connected or plugged into an outlet. Outlets are advantageous for apartment buildings or for limiting power draw.

Financial considerations

Connection costs (4.2.1): This is influenced by the existing capacity and the capacity of the equipment to be installed. This solution is therefore interesting for the following extreme cases:

- If you want all users to have access to **maximum output** at all times; then it's better to invest in the electrical installation than in power management devices.
- If you want a **low-power** charging solution; for example, if you decide to install single 120-V outlets, the capacity will be limited to 1.44 kW per charging station. By comparison, power management systems are generally designed not to go below 1.66 kW per station. In such as case, it's obviously pointless to invest in stations with power management features.

Charging station cost (4.2.2): This solution doesn't require a particular type of station. You can use an inexpensive station or even the charger that came with the EV, if it's going to be plugged into an outlet.

Civil engineering (4.2.3): This solution may require civil engineering work.

Subsidies (4.2.4): In the case of a condo building, the portion assumed by the unit owners could be eligible for a grant. The condo must then bill the unit owners for their share of the cost of installing the equipment. The condo must also provide copies of the original bills for proof of expense eligibility.

Capital costs (4.2.5): In an apartment building, capital costs are usually assumed by the landlord (except the charging station, which can be assumed by either the landlord or the tenant).

In a condo building, the condo must choose one of the approaches in Section 4.2.5.

Operating costs (4.2.6): The unit owner or the condo must choose among the approaches outlined in Section 4.2.6.

Electricity rate (4.2.7): The domestic rate is applied in most cases. If the demand power is less than 50 kW, Rate D applies; beyond 65 kW, it's Rate DP. Between the two, Hydro-Québec will select the most advantageous one for the customer. Sometimes, another rate might be better.

Metering (4.2.8): Metering is done by the Hydro-Québec meter. If the landlord or the condo association decides to bill electricity consumption on the basis of actual consumption, then meters must be installed on each charging station, according to the legal provisions.

Operating considerations

Installation conditions (4.3.2): Adding new equipment can be an opportunity to move part of the electrical installation to somewhere more practical for charging station connection. For example, if the parking area is far away from the electrical room, it might make more sense to install a new transformer near the parking area, connect it to the service entrance with a single cable, and supply the charging stations from there. In other words, adding equipment is not always the most costly solution.

Deployment strategy (4.3.3): This solution can be implemented in cases where there are a large number of users. Nevertheless, the number of potential users must be determined from the start, to avoid having to modify the electrical installation yet again. Since there's no power management, adding even one user could make it necessary to resize the whole electrical infrastructure.

Other considerations: In the case of a condo building, this solution could require more discussion and negotiation than an individual solution. In addition, selecting and deploying the solution could be long and arduous.

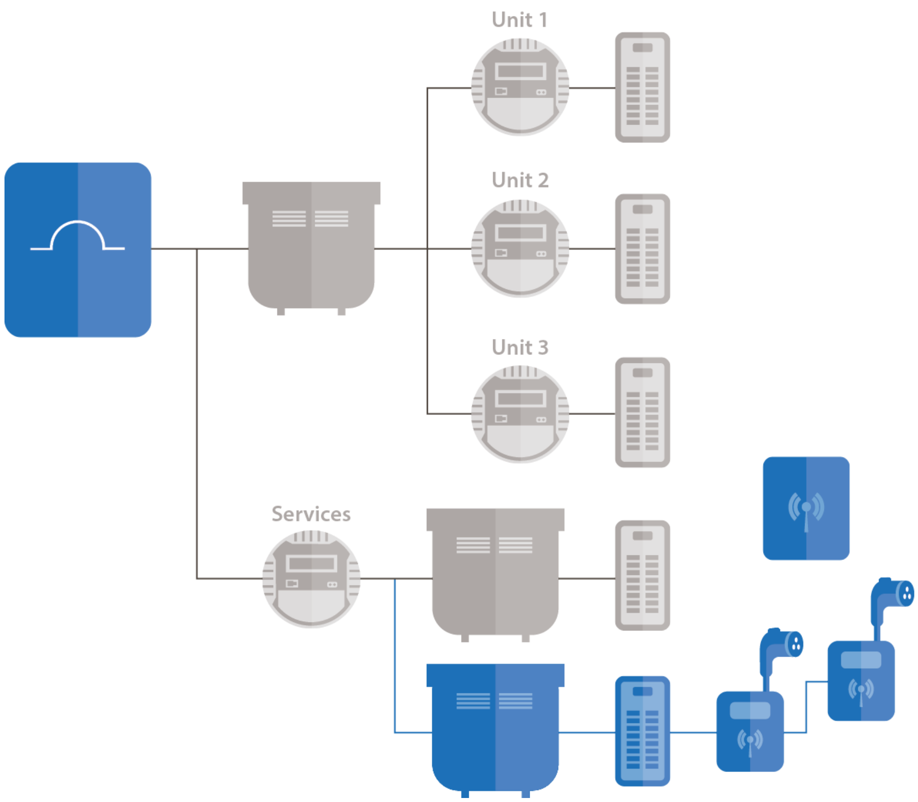
5.2.2 Connection to a building's electrical installation with power management

This is similar to the previous solution, but in this case the stations have a power management device.

It will probably require the electrical installation to be modified or equipment added. As was the case in the previous solution (5.2.1), changes to the distribution panel, transformer, meters or even the service entrance may be necessary.[21]

However, it's possible to group the stations on the same circuit so they can share the available power. In figure 10, the stations are connected in pairs to a single circuit.

Figure 10: Configuration with power management



Technical considerations

Power (4.1.1): As explained earlier, power management optimizes the system, since the available power is shared. This solution therefore requires less modification of the electrical installation than the solutions proposed in Section 5.2.1, as a rule.

Type of connection (4.1.3): Only a permanent connection is possible.

Other technical considerations: The stations must be able to communicate with each other, as explained in Section 4.1.2.

21. This last possibility is shown in Figure 10, but all the configurations presented in Section 5.2.1 can be used with power management.

Financial considerations

Connection costs (4.2.1): The required modifications to the electrical installation – and the associated costs – should be halfway between those necessitated by the maximum-output and low-power ends of the scale in solution 5.2.1, since the power needed will likely be somewhere between those two extremes.

However, this solution has additional advantages that could bring the price tag down.

The power management device would make better use of the available power. A slight limitation of the available power has a negligible impact on users but can eliminate the need for costly modifications to the electrical infrastructure.

For example, if you wanted to install ten 7.2-kW stations with no power management, you would need a transformer with a residual capacity of at least 72 kW.[22] If your existing transformer has only 70 kW of residual capacity, you must replace it with a more powerful unit or add another one.

A power management device would limit the consumption of all ten stations to 70 kW, so the transformer would not have to be replaced. In this example, the reduced performance of the stations would not be noticed by the users; it would be a power reduction of only 3% (0.2 kW on 7.2 kW) and would occur only when all ten stations are used at once.

And since the stations can be grouped on the same circuit, more savings will be achieved on cabling and breakers.

Another approach would be to group the stations on the same circuit rather than in the same distribution panel. A single cable supplies several charging stations, each equipped with its own breaker. In a large parking area where the stations are far apart, this will greatly reduce the amount of cabling needed.[23] The cable will of course have to be thicker, but its exact capacity will be known, thanks to the power management device.

Charging station cost (4.2.2): In this solution, stations must have a power management device. Such stations are generally more expensive. And they must come from the same manufacturer, since they have to communicate with one another.

Civil engineering (4.2.3): This solution may require civil engineering work.

Subsidies (4.2.4): In the case of a condo building, the portion assumed by the unit owners could be eligible for a grant. The condo must therefore bill the unit owners for their share of the cost of installing the equipment. The condo must also provide copies of the original bills for proof of expense eligibility.

Capital costs (4.2.5): In an apartment building, capital costs are generally assumed by the landlord; this includes the charging station, which must be permanently connected to the electrical installation.

In a condo building, the condo must choose one of the approaches in Section 4.2.5.

Operating costs (4.2.6): The unit owner or the condo must choose among the approaches outlined in Section 4.2.6.

Electricity rates (4.2.7): Usually the domestic rate applies. If the demand power is less than 50 kW, Rate D applies; beyond 65 kW, it's Rate DP. Between the two, Hydro-Québec will select the more advantageous one.

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22. 7.2 kW × 10
23. In addition, this approach would not cause crowding in the electrical room, since it doesn't require the addition of another distribution panel or a multitude of cables.

Metering (4.2.8): Metering is done by the Hydro-Québec meter. If the landlord or the condo decides to bill for the electricity on the basis of actual consumption, then a meter must be installed on each charging station, as stipulated by law.

Operating considerations

Deployment strategy (4.3.3): This solution can be implemented in cases where there are a large number of users. Because the solution includes power management, new users can easily be added. Although it's still preferable to determine the number and needs of future users, the consequences of underestimation are not as critical. Usually more users can be added than originally estimated; there will just be more people sharing the same power. But it should be remembered that power-sharing has its limits. It's a good idea to size the electrical infrastructure so that, in a worst-case scenario, all stations will have at least 8 A for charging.

Other considerations: In the case of a condo building, this solution could require more discussion and negotiation than an individual solution. In addition, selecting and deploying the solution could be long and arduous.

5.2.3 Connection to a separate service entrance at a different voltage

As explained earlier, charging station deployment often requires augmenting the capacity of the electrical installation.

A transformer or distribution panel can usually be replaced by one with a higher capacity, or another one can be added. This flexibility makes it possible to optimize the solution according to the specifics of the existing electrical infrastructure.

But you can't have two distribution service loops at the same voltage in one building. So if the existing service loop is inadequate, you can't just add a new one; the existing one has to be modified. In some such cases, the modification may require work to be carried out on Hydro-Québec's equipment, leading to additional costs to the customer.

There is, however, one exception: two distribution service loops are allowed in a building if the voltages are different.

Most electrical installations in residential buildings are 120/240 V. This is single-phase supply, which uses triplex cables: two energized conductors and one neutral.[24] The potential between an energized conductor and the neutral is 120 V, while the potential between the two energized conductors is 240 V.

In some cases, Hydro-Québec will also deliver electricity at 347/600 V. This is three-phase supply over quadruplex bundles, i.e. three energized conductors and one neutral. In this case, the potential between an energized conductor and the neutral is 347 V, whereas the potential between two energized conductors is 600 V.

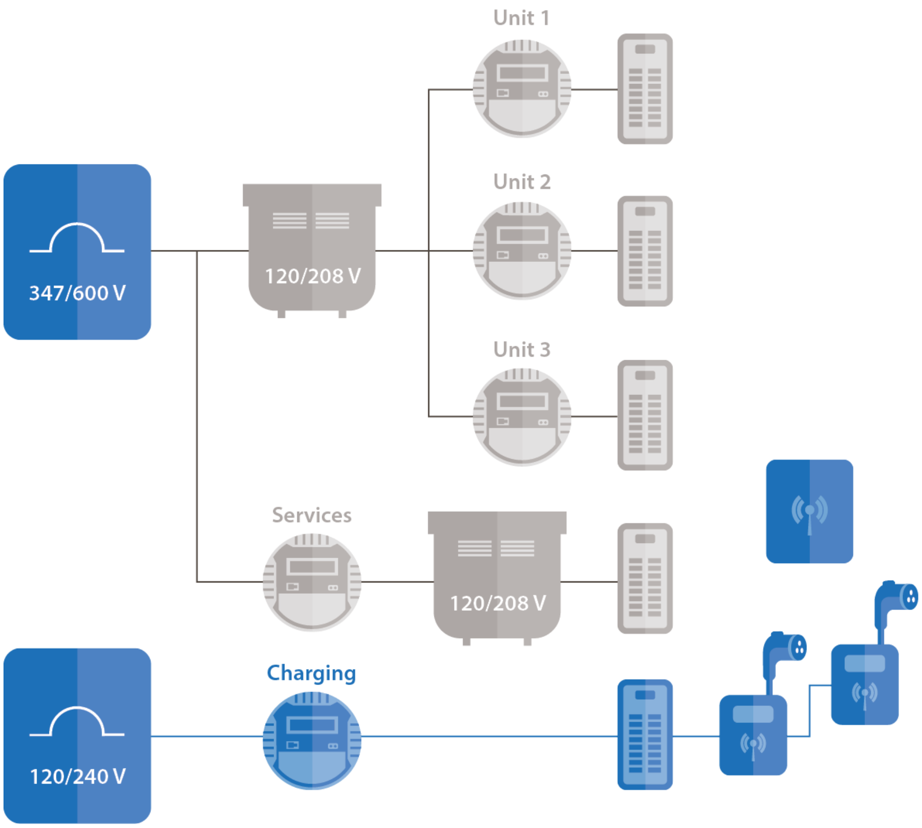
In residential buildings, 347/600 V connections are used when large amounts of electrical capacity are needed. But since this voltage is not compatible with household appliances, the situation requires a transformer that will step the voltage down to 120/208 V.[25]

24. There is also a ground conductor (usually bare) on the load side of the connection box; however, to simplify matter, it is not shown in this insert.
25. The attentive reader will have seen that, in this configuration, the potential between two energized conductors is 208 V, rather than 240 V which is the case in a single-phase configuration.

The solution therefore consists in adding a single-phase distribution service loop if the existing service loop is three-phase (see figure 11). It's also possible to add a three-phase loop if the existing one is single-phase; however, this is rarely advantageous in terms of cost.

You might want to ask a licensed electrician to estimate the cost of adding a service loop at a different voltage. The estimate will not include any costs for modifications to the Hydro-Québec system so you will need to communicate with Hydro-Québec to get a preliminary cost estimate.

Figure 11: Connection to a service loop at a different voltage



Since this solution is a variation on solutions 5.2.1 and 5.2.2, it has the same characteristics apart from the items shown below.

Technical considerations

Power (4.1.2): The supply voltage to a charging station has an impact on its power. A single-phase 30-A station connected to two phases of a 120/208 V three-phase circuit will deliver 6.2 kW.[26] The same station connected to a 120/240 V single-phase circuit will deliver 7.2 kW[27], for a gain of 16%.

However, a 120/240-V service entrance is generally limited to 500 A (120 kW). If requirements are greater than this, it's probably better to use a voltage of 347/600 V.

26. 30 A × 208 V
27. 30 A × 240 V

Other technical considerations: Adding a new service loop at a different voltage could obviate the power outage needed when a service loop is replaced.

Remember that to deliver electricity at a different voltage, Hydro-Québec must sometimes add equipment to its power system. This solution could therefore give rise to costs associated with the modification of the Hydro-Québec power system.

In all cases, the time frames for this type of work will be long.

Financial considerations

Connection costs (4.2.1): The principles set out under 5.2.1 and 5.2.2 apply here as well. But in some cases, adding a service loop at a different voltage might be less costly than replacing an existing one.

If a single-phase 120/240 V loop is added, the circuit is already at the voltage required by the charging stations. No transformer has to be installed.

Civil engineering (4.2.3): Adding a service loop will require work.

Electricity rates (4.2.7): The principles set out under 5.2.1 and 5.2.2 apply here as well. It's considered a new delivery point and a separate customer account. Your power demand and energy consumption will now be metered separately. Depending on the situation, this may have a positive or negative impact on your electricity bill, which in either case should not influence your choice of solution.

Operating considerations

Other operating considerations: Adding a separate service loop will make it easy to isolate charging station consumption from the rest of the building. It could also facilitate charging station communication and deployment management, especially in a condo building.

5.2.4 Connection to a separate service entrance

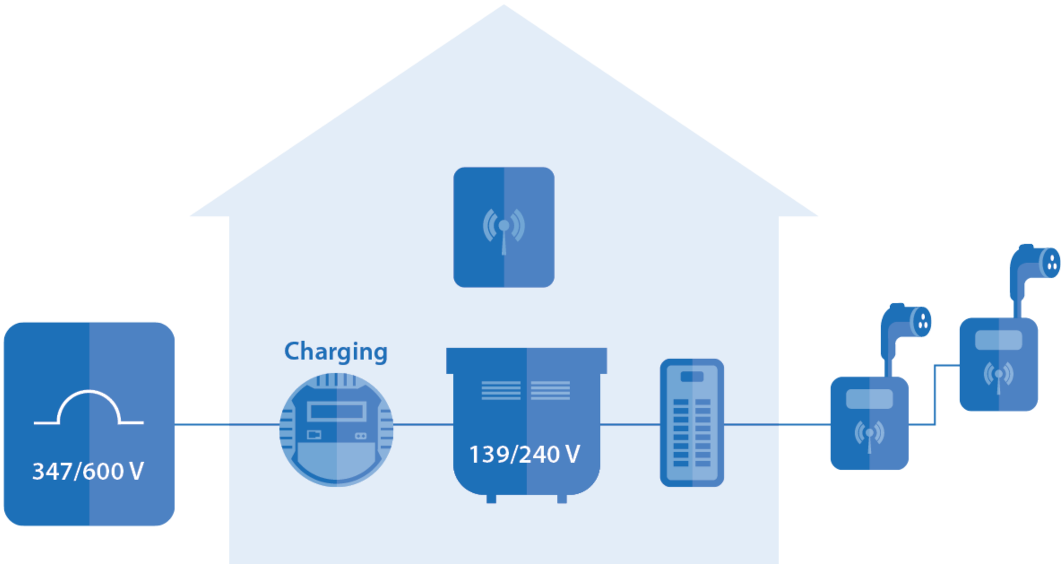
If the parking lot is outside, it can be connected to the power system through a separate service loop. This can be particularly advantageous when there's an overhead line near the parking lot. Tapping off from an underground line near the parking area is also a possibility.

Connection to the Hydro-Québec system can be done in two ways.

Scenario 1: Erect a small service building for the electrical installation (disconnects, transformers, meters and distribution equipment).[28] Connect the charging stations to this building (see Figure 12).

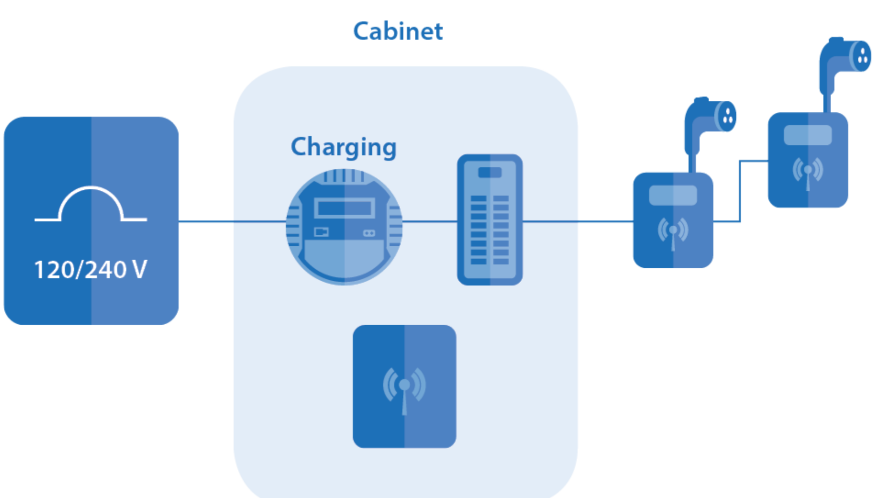
28. The equipment can also be installed outside if it's designed to tolerate it. Then you don't need a service building. However, such equipment is more expensive to purchase and maintain, especially in winter.

Figure 12: Connection through a service building



Scenario 2: Connect the stations directly to a cabinet designed for outdoor use. This solution is chosen when it's financially advantageous to get a 120/240-V supply directly from the power system, since no transformers are needed. This is the case, for example, for installations with power requirements of less than 120 kW[29].

Figure 13: Connection through a cabinet



Regardless of the solution chosen, the stations can be connected through underground cables. Another option: Use Jersey barriers. Attach the stations and the cables to the barriers. There are Jersey barriers specifically designed for this purpose. They have cable grooves and attachment points for the charging stations.

Since this solution is a variation on solutions 5.2.1 and 5.2.2, it has the same characteristics apart from the items shown below.

29. 120/240-V entrances are usually limited to 500 A.

Technical considerations

Power (4.1.2): As explained in Section 5.2.3, 240-V supplied stations are 16% more powerful than those supplied at 208 V.

If you decide to add a three-phase entrance solely for supplying charging stations, and the charging stations can be supplied at 240 V, you might want to install a transformer that will step the voltage down to 139/240 V, so as to avoid the 16% power loss due to the 208 V voltage.

Attention: This method might not be suitable for all charging stations.

Financial considerations

Connection costs (4.2.1): This solution can be very economical, especially if you connect directly to the 120 V/240 V system. Very little equipment needs to be added: a service box, a distribution panel and some wiring.

Civil engineering (4.2.3): This solution requires little civil engineering. This is especially true if Jersey barriers are used. Then there's no need to excavate in order to bury cable or erect poles.

If you opt for a small service building, you can simply install it on the ground near the charging stations.

Capital costs: The service building and the equipment installed on the ground are considered movable, so they're halfway between temporary and permanent installation.

An advantage of a temporary installation is that it can be considered a seizable asset. In fact, they can be leased from some suppliers. Then the landlord or condo doesn't have to finance the purchase.

Electricity rates (4.2.7): The principles in solution 5.2.3 apply here too. The charging station, if it is for the exclusive use of the residents, can be considered an outbuilding and is therefore eligible for Rate D or DP.

Operating considerations

Other considerations: Bylaws or regulations may prohibit overhead connections, service buildings or Jersey barriers.

And some people may find them visually offensive.

6 Rate overview

As at April 1, 2019 | For Information only

Rate D

- Domestic use (residential and agricultural)
- Demand not exceeding 65 kW
- Structure of Rate D:
  - System access charge: 40.64¢ per day
  - First tier of energy consumption, 40 kWh per day: 6.08¢/kWh
  - Remaining consumption: 9.38¢/kWh

Rate DP

- Domestic use (residential and agricultural)
- Demand of 50 kW or more
- Structure of Rate DP:
  - First tier of energy consumption, 1,200 kWh per month: 5.88¢/kWh
  - Remaining consumption: 8.94¢/kWh
  - Demand in excess of 50 kW: $6.21/kW in winter and $4.59/kW in summer

Rate BR

- For EV charging exclusively[30]
- Structure of Rate BR:
- Consumption associated with the first 50 kW of demand: 11.04¢/kWh[31]
  - Consumption associated with demand exceeding 50 kW, up to a load factor of 3%: 20.69¢/kWh
  - Remaining consumption: 16.27¢/kWh
  - Minimum: $12.33 per month (30 days) for single-phase or $36.99 for three-phase

30. Rate BR is advantageous if the charging stations aren't eligible for the domestic rate and the load factor is very low, i.e., less than 10%. When the electricity is used for other purposes such as lighting, Rate BR applies on condition that the installed capacity for purposes other than charging does not exceed 10 kW.
31. There are other Rate BR tiers, but they don't apply in the present context. To find out more about Rate BR, contact your Hydro-Québec representative at the number shown on your bill.

Rate G

- Domestic or general use
- Minimum billing demand not exceeding 65 kW
- Structure of Rate G:
  - System access charge: $12.33 per month
  - First tier of energy consumption, 15,090 kWh per month: 9.90¢/kWh
  - Remaining consumption: 7.62¢/kWh
  - Demand in excess of 50 kW: $17.64/kW

Rate M

- Domestic or general use
- Demand of 50 kW or more
- Structure of Rate M:
  - First tier of energy consumption, 210,000 kWh per month: 5.03¢/kWh
  - Remaining consumption: 3.73¢/kWh
  - Demand: $14.58/kW