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Assessing charging infrastructure needs in Québec

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Executive Summary

This study assesses the electric vehicle charging infrastructure required in Québec province through 2035. The analysis focuses on light-duty vehicles, including passenger cars, taxis, private-hire vehicles, and light commercial vehicles. The geographic scope covers 17 administrative regions, and results are presented at the provincial and regional levels. The results show that, as of the end of 2020, Québec had 27% and 12% of the public charging infrastructure needed by 2025 and 2030 respectively.

Keywords: EV, EVSE, infrastructure, energy consumption

1 Introduction

1.1 Motivation

Québec is leading the electric vehicle (EV) transition in Canada: it is home to more than 45% of Canada's EVs, despite hosting 23% of Canada's overall car fleet. The province passed the mark of 100,000 electric vehicles on its roads in April 2021. In the 2030 Plan for a Green Economy, published in 2020, Québec set a goal of having 1.5 million light-duty electric vehicles on its roads in 2030, which would represent about 30% of the light-duty fleet [1]. Montréal, the largest city in the province, has set additional electric vehicle targets, including a zero-emission city center in 2030 [2].

To accomplish these targets and maintain its electric vehicle leadership, Québec will need much more charging of all kinds. By 2021, charging infrastructure in the province has been built primarily by public utility Hydro-Québec as well as some private companies and has targeted electric vehicle early adopters. By estimating charging infrastructure needs for anticipated future electric vehicle uptake within Québec, the public and private sectors can coordinate financing, electricity grid upgrades, and other policy to deploy charging infrastructure more efficiently and ensure that charging is not a barrier for electric vehicle uptake.

1.2 Scope

Three categories of vehicles are included in the analysis: passenger cars (company and private), light commercial vehicles, and taxis (including private-hire vehicles). The model considers vehicle purchase trends, charging behavior up to December 2020, and the 2035 target of 100% zero-emission vehicle sales, interpreted

as 100% BEV sales for passenger cars and light commercial vehicles. Results are provided at the administrative region level for six charging categories: private home, depot (for light commercial vehicles), private workplace, public AC normal (including residential and destination), public fast urban, and fast highway corridor. Throughout this report, normal charging refers to chargers providing power less than or equal to 11 kW in alternating current (AC). Fast charging refers to a charger providing power greater than 25 kW using direct current (DC) electricity. This distinction reflects the Québécois market and its charging infrastructure deployment strategy.

1.3 Market characterization of vehicle and charging

1.3.1 Electric vehicle market

The development of the electric vehicle market (including battery electric vehicles [BEVs], and plug-in hybrid electric vehicles [PHEVs]) in Québec has grown steadily since 2010, with significant acceleration since 2018. Figure 1 below displays the cumulative BEV (dark blue) and PHEV (light blue) sales up to 2020 (left axis) along with new EV sales share (red line and right axis). Yellow dashes refer to the left axis and display the cumulative new EV sales in Greater Montréal (Montréal metropolitan area). Based on electric vehicle sales through 2020, there were approximately 51,300 BEVs and 40,800 PHEVs on Québec roads at the end of 2020, with 27,000 of the BEVs and 18,000 of the PHEVs found in Greater Montréal [3].

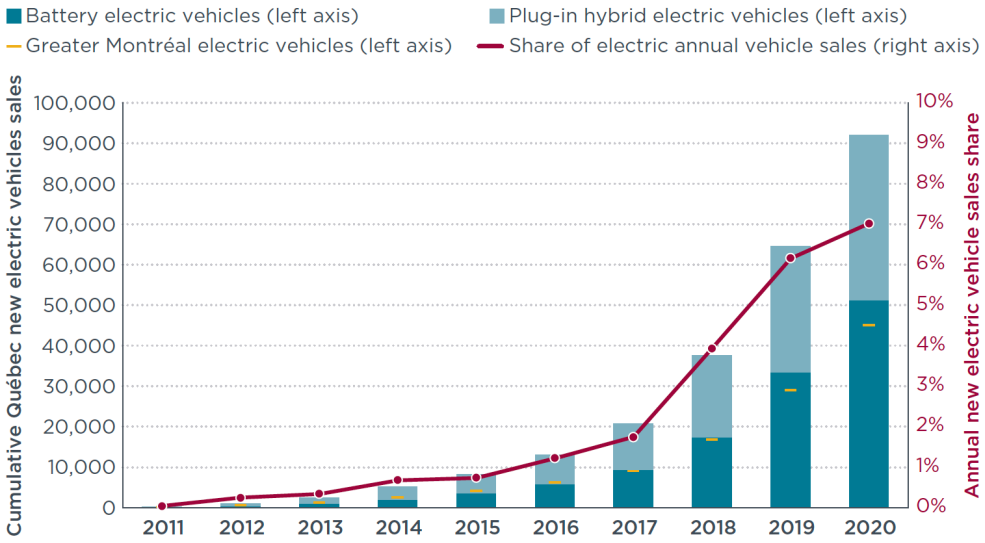

Figure 1: Cumulative new light-duty EV sales in Québec (left axis and blue bars) and Greater Montréal (yellow dashes) and annual new sales share (right axis and line) from 2011 to 2020.

In 2020 passenger EVs accounted for approximately 7% of passenger vehicle sales. On the other hand, EVs represent only slightly more than 1.3% of the total light-duty vehicle stock. Electric vehicles are unevenly distributed across Québec with the highly urbanized region of Montréal (also called Greater Montréal), accounting for nearly 50% of cumulative EV sales while being home to about 40% of total passenger cars.

1.3.2 Charging infrastructure network

Québec has a well-developed charging ecosystem with 5,689 public normal chargers and 690 fast chargers as of December 31st, 2020 [4]. Hydro-Québec, a state-owned public utility that manages the generation, transmission, and distribution of electricity, plays a major role in charging infrastructure rollout and operates the most extensive public charging infrastructure network in Québec, The Electric Circuit. It consists of more

than 3,100 public charging stations, including 466 fast-charge stations (mostly 50kW and some 100kW chargers), across the province as of mid-2021 (with additional stations in Eastern Ontario) [5].

2 Methodology

The methodology used to assess charging needs in Québec up to 2035 is similar to the method of a related study focused on France and is described in more detail in that paper [6]. An overview of the modeling approach and steps is provided in Figure 2 below. The blue rectangles represent the model steps and begin at the top left. The yellow trapezoids indicate the data inputs and assumptions between the model steps, and the grey ovals explain the question that is analyzed at each stage. The top left rectangle shows that the model starts with vehicle sales and stock projections. The following step allocates this stock to driver groups depending on the type of car (BEV vs. PHEV), home charging availability, commuting status (car commuter vs. non-car commuter), and accessibility to workplace charging. After this, the daily energy required is forecasted for each charging group. Finally, this electricity demand is apportioned by location and translated into a number of chargers according to charger utilization and power.

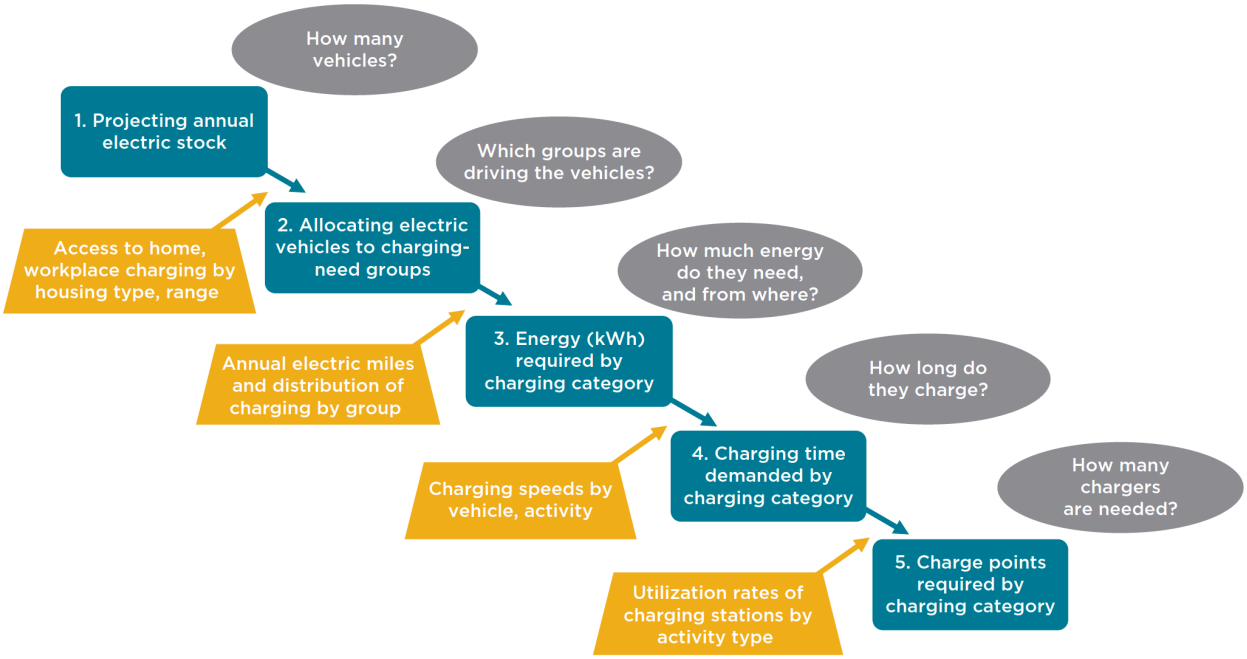

Figure 2: Summary of key modelling steps to assess charging needs based on electric vehicle uptake

The results in this paper are presented by charging category. Private chargers are reported in three categories:

- Private home chargers, typically found in homes or apartment complexes
- Depot chargers, which are clustered at sites that service several light commercial vehicles
- Private workplace chargers, which are available exclusively to employees at a workplace. For EV owners without access to home charging, including many living in Montréal, workplace charging can provide a convenient, dependable, and low-cost charging option.

Beyond private charging, a dense and reliable public charging network is key to inspiring confidence that charging will be available and convincing reluctant drivers to switch to an EV. Fast urban charging will be critical. Public charging takes several forms:

- Public AC normal chargers are of particular importance to EV owners who lack access to home charging, usually people living in dense urban cores like Montréal.
- Public fast urban chargers are heavily used by high-mileage fleets like taxis and professional vans. They are also important for EV owners without access to home charging.
- Public fast highway chargers are used to quickly charge during longer trips.

2.1 Québec electric vehicle uptake scenario

The first modeling step is to forecast electric vehicle sales as a percentage of annual passenger car sales. This study's projections for electric vehicle stock are shown in Figure 3 below. The figure's blue bars (left axis) display the projected increase in the number of EVs on Québec roads up to 2035, with light blue representing PHEVs and dark blue BEVs. The red and green lines (right axis) show the projected EV share of new sales (in red) and total vehicle stock (green) from 2020 to 2035 at the provincial level.

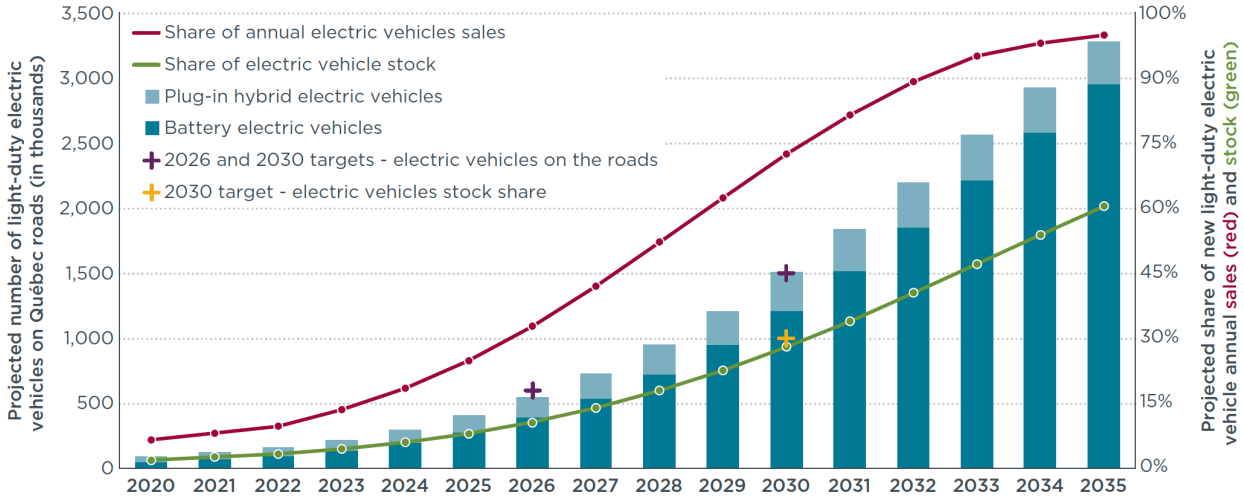

Figure 3: Number of light-duty electric vehicles on Quebec roads (left axis and blue bars) and new EV sales share (right axis and red line).

2.2 Allocation of electric vehicles to charging needs groups

The second modeling step is allocating the electric vehicle stock to charging need groups, each with distinct charging behaviors. For private passenger cars, four factors are considered: EV type (BEV or PHEV), commuting status (driving to work or not), workplace charging access (among commuters only), and home charging access. This resulted in 12 charging needs groups.

2.3 Energy required by charging category

For the third modeling step, we determine the total energy each charging needs group will use and allocate it to the different charging locations: private home, private depot, workplace, public AC normal, fast urban, and fast highway chargers. The energy need allocation for each group is based on previous ICCT studies and personal interviews with Hydro-Québec and the Québec government on their charging infrastructure deployment strategies [7]. The annual passenger electric vehicle kilometers driven are derived from a provincial average of 18,000 km per year [8], assuming that non-commuters drive 75% as many kilometers as commuters. The share of kilometers powered by electricity for PHEVs is based on an ICCT study of real-world usage of PHEVs [9]. Different assumptions are made for light commercial vehicles and taxis. They are assumed to drive 70 km and 190 km per working day (about 305 days per year), respectively, on average [10].

The electric kilometers are converted into energy based on vehicle efficiency. Passenger BEVs and PHEVs (including taxis) have efficiencies of 4.3 and 4.2 kilometers per kilowatt-hours (km/kWh), respectively and light commercial BEVs and PHEVs have efficiencies of 2.7 and 2.6 km/kWh, respectively. This is based on an ICCT study focused on the United States and the Canadian guide on vehicle fuel consumption and emissions, accounting for lower efficiency during cold winter months [11]. As technology improves, we estimate the per-km energy needed for each vehicle category to decline by roughly 1% per year. An additional assumption is made about chargers' efficiency. It is assumed that 90% of the electricity fed into the charger is passed on to the electric vehicle.

2.4 Charging speed by charging category

The fourth modeling step estimates the average charger power and vehicle power accepted. The average rate of power draw is the same for all vehicle categories (passenger and light commercial vehicles). It increases over time to reflect technological improvements in the vehicles and greater availability, and profitability, of higher-power charging. Table 1 displays the average rate of power draw (i.e. measured at the vehicle) for different chargers over the years. These wattages take into account a decrease in charging power during cold winter months [12].

Table 1: Average rate of power draw (different than the rated power) for different chargers and vehicles, 2020-2035

	BEV – AC normal charger	PHEV – AC normal charger	Urban fast charger	Corridor highway charger
2020	6.4 kW	3.3 kW	24 kW	60 kW
2030	8 kW	4.6 kW	80 kW	115 kW
2035	9.6 kW	5.3 kW	110 kW	145 kW

The power ratings in Table 1 represent the average power measured at the vehicle for all the electric vehicles across all the province's chargers of a certain category in a given year. This average power is lower than the rated maximum power of a charger because of different vehicle acceptance rates and variations in power over the charge cycle (e.g., power typically decreases as the battery approaches 100% charge). Additionally, the rated maximum power of chargers varies within each category. For example, urban fast chargers range from 25kW stations to 350kW or more with some 50kW, 100kW, or 150kW chargers, and one hub can consist of chargers with a variety of maximum power ratings.

2.5 Charger utilization and number of chargers

The final step is calculating the number of chargers of various types across the regions.

Public chargers. The hours per day of active power drawn from the different stations are forecasted and then multiplied by the charger output power in kW determined at the previous step to obtain the daily energy available in kWh. Finally, the energy required for the EVs determined in step 3 is divided by the energy provided by each charger to determine the number of outlets needed. The model reflects increasing utilization in hours per day with increasing electric vehicle penetration for both public AC normal and fast chargers, as shown in other studies. This results in different hours per day of active power drawn across regions, with higher usage in mature EV markets.

Based on the methodology of similar studies and adapting to the Québécois context, the average increasing usage of normal charging as a function of electric vehicles' stock share can be represented by the following equation:

$$\text{Average daily hours of active public normal charger usage} = a * \ln(\text{EV stock share}) + b \quad (1)$$

The a and b coefficients vary region by region and at a more granular level within Montréal metropolitan region. The a coefficient represents the rate at which the utilization will increase, while b represents the maximum usage assumed once the EV stock share reaches 100%. These coefficients are determined based on 2021 charge point utilization data [13] and different 2035 active utilization across regions ranging from 5.2 to 6 hours per day for normal charge points and 4 to 5 hours per day for fast charge points. A similar equation is used for the average daily utilization of fast charge points, but as a function of BEV share of vehicle stock since most PHEVs do not use fast charge points.

Workplace chargers. Workplace charging can occur either at private chargers reserved for employees or at public chargers near one's place of work (e.g., at parking garages or shopping centers). In this analysis, a third of charging while working occurs at public chargers. For the remaining private workplace chargers, utilization remains at 5 hours per workday through 2035.

Depot chargers. The analysis assumes that employers take a straightforward approach for depot charging for professional vans, installing one charger per two BEVs and one charger per four PHEVs. This can be accomplished either through power-sharing and smart charging across charging ports or by charging vehicles in shifts. Overnight charging allows these vehicles to receive the majority of their daily charging needs.

Private home chargers. The number of home chargers is determined by the number of EV drivers with access to home charging, as described in the housing section above. In this analysis, every BEV with access to home charging receives its own charger, but in cases where multiple PHEVs are in one household, they may share a charger.

3 Results

3.1 Summary of overall Québec results

Table 2 summarizes our 2025, 2030, and 2035 charging results, alongside data for 2020 for reference. As described above, the total number of EVs in this scenario increases from close to 100,000 at the end of 2020 to slightly above 1.5 million in 2030. Charging infrastructure across all home, workplace, and public types increases substantially to support this growing EV stock. We estimate Québec will need 94,600 non-home chargers in 2030, about 11 times the approximately 9,000 such chargers at the end of 2020. We estimate a need for 52,000 public chargers in 2030, 8 times the number installed in 2020.

Table 2: Summary of key results at the provincial level for 2020, 2025, 2030, and 2035

Area	Variable	2020	2025	2030	2035
Electric vehicles (including battery-electric and plug-in hybrid electric vehicles)	Total EV stock (thousands)	92	409	1,512	3,283
	Total BEV stock (thousands)	51	282	1,217	2,959
	Total passenger EV stock (in thousands, excluding light commercial vehicles)	88	393	1,430	3,072
	EV share of new light-duty vehicle sales	7%	25%	73%	100%
	EV share of Québec light-duty vehicle population	2%	9%	29%	62%

EV owner characteristics	Home charging access share	85%	82%	79%	78%
	Share of EVs used for commuting	70%	64%	58%	58%
	Workplace charging access share among EV commuters	34%	36%	38%	39%
	Home charging share of energy demand	73%	68%	64%	62%
	Home charging share of energy demand for passenger cars	74%	71%	68%	66%
	Work and depot charging share of energy demand	5%	7%	9%	10%
Number of chargers	Private home chargers (thousands)	76	303	1,081	2,381
	Workplace chargers (thousands)	2	8	24	44
	Depot chargers (thousands)	0.2	3	19	57
	Public normal chargers (thousands)	6	21	46	69
	Public fast urban chargers (thousands)	0.7 (total urban and highway fast chargers)	2.4	4.9	7.8
	Public fast highway chargers (thousands)		0.6	1.4	2.1

3.2 Electric vehicle energy demand

Figure 4 presents the total energy demand for charging in gigawatt-hours (GWh) per year for each EV charging setting from 2020 to 2035, including public and private stations. The figure includes charging needs for passenger cars, light commercial vehicles, and taxis. Energy demand from EV charging grows substantially, from an estimated 340 gigawatt-hours (GWh) of electricity in 2020 to 1,550 GWh in 2025 and 5,790 GWh in 2030. In 2030, 1,550 GWh, or 27% of the overall EV charging energy, is from public charging. For context, the total electricity produced in Québec in 2019 was 212 terawatt-hours (TWh), about 15% of which was exported, so EV charging demand in 2030 and 2035 would amount to 2.7% and 6.1% (respectively) of the electricity produced [14].

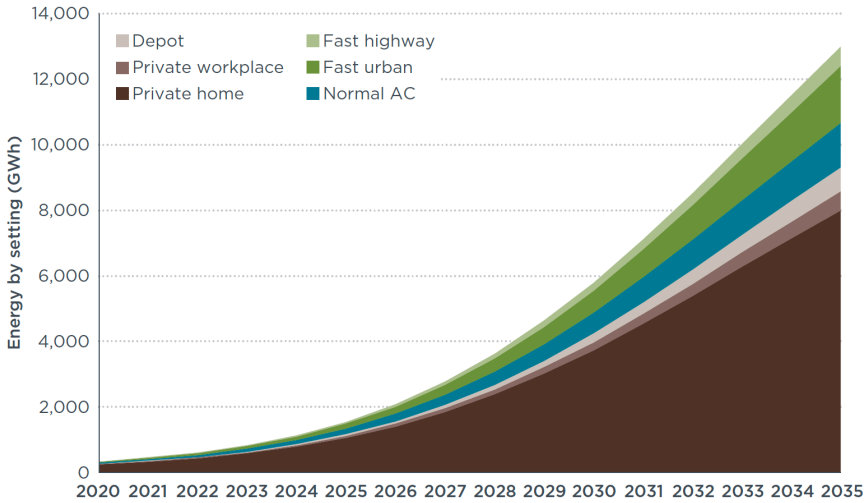

Figure 4: Energy demand (GWh) from electric vehicle charging per charging setting over the years

The figure clearly illustrates the large share of home charging electricity demand. Indeed, home charging is (and is likely to remain) the cheapest and most convenient form of EV charging when it is available. As shown in Table 2, in 2030, 73% of EV charging energy will come from home, private workplace, and depot charging. While private home electricity is forecast to increase in absolute terms, its share among all electricity needed decreases due to a reduction in home charging availability as EVs reach mass adoption. Indeed, while in 2020 85% of EV owners in this analysis have access to home charging [16], this share decreases to 79% in 2030. At a more granular level, only 38% of Montréal city EV drivers are forecast to have access to home charging in 2030. When focusing on this city, the projected 210,600 EVs will consume approximately 570 GWh of electricity in 2030: 206 GWh from home charging, 300 GWh from public charging, and the remaining 64 GWh from private work and depot.

3.3 Number of chargers

3.3.1 Public chargers

Figure 5 displays the number of public normal (left, blue) and public fast (right, green) chargers needed in Québec by 2030. Hashed colors indicate the amount of charging built through 2020. At the provincial level, as of the end of 2020, 27%, 12% and 8% of the forecast 2025, 2030, and 2035 public charging infrastructure is already in place. As indicated in these graphs, we forecast that Montréal region will need the highest number of both normal and fast chargers in 2030 with 10,100 and 1,370 units respectively. At the other end of the spectrum, Nord-du-Québec will need the lowest number of normal and fast chargers with 105 and 45 units respectively. Most fast chargers in Nord-du-Québec are located along highways and national roads, few are in towns or residential areas.

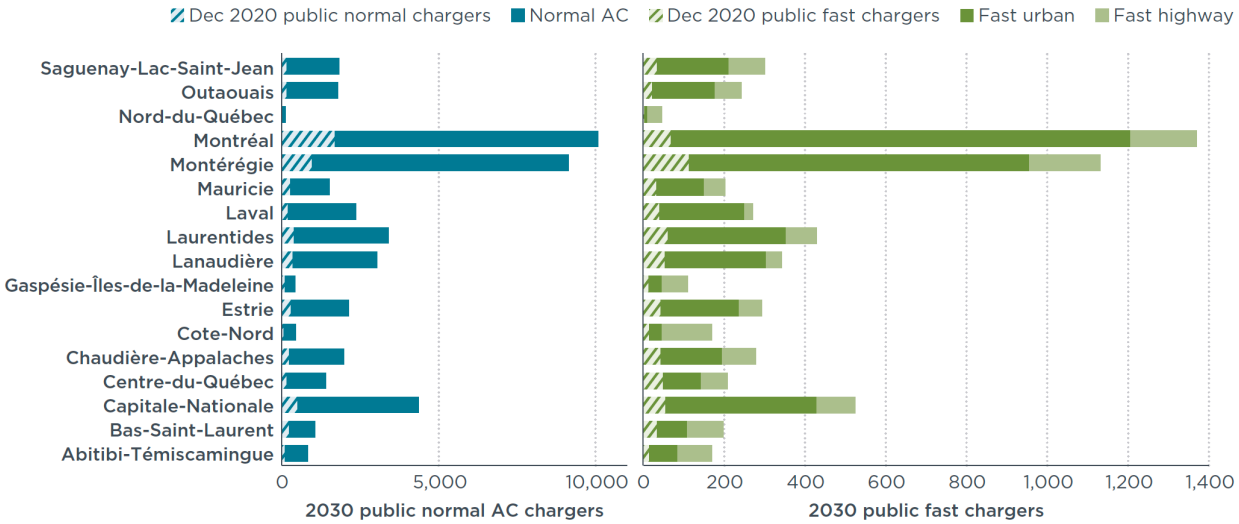

Figure 5: Estimated number of public normal (left and blue) and fast (right and green) chargers in 2030 per administrative region.

Overall, we forecast a need for around 45,700 normal and 6,300 fast chargers (4,900 in urban areas and 1,400 along highways) by 2030 at the provincial level. The need for 6,300 fast chargers exceeds the Québec government mandate that 2,500 fast chargers be installed by Hydro-Québec by 2030, meaning that further efforts might be needed, with commitments from the private sector for example. Additional public fast highway chargers will also be important as EVs become mainstream and are used for all travel needs. Our modeling forecasts an increase in fast highway chargers through 2035, reaching 610 in 2025, 1,400 in 2030, and 2,100 in 2035.

The share of 2030 charging needs already in place at the end of 2020 varies by region as shown in Figure 6 below. As of 2020, 12% of Québec's 2030 overall requirement for public charging infrastructure was already in place. For fast charging infrastructure, 11% of 2030 needs were in place at the end of 2020 while close to 12.5% of the normal charging infrastructure was in place. At the regional level, four regions had less than 10% of their 2030 needs in place at year's end 2020. The largest charging deployment challenges are in the very rural areas of Nord-du-Québec, Outaouais, and Saguenay-Lac-Saint-Jean and the very urban area of Laval. The mostly rural regions have had few chargers deployed up to 2020, and with EV uptake lagging the provincial average up to 2030, charger utilization is expected to be sub-optimal, resulting in more chargers needed. In the highly urban areas, the above average EV uptake in the years to come and the low home charging availability results in many public chargers needed.

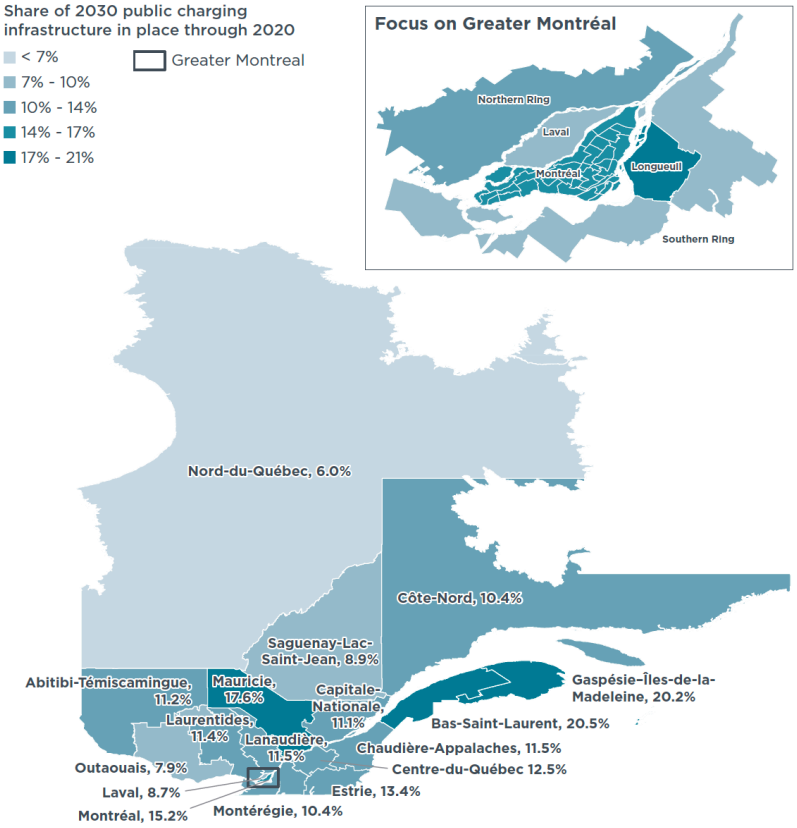

Figure 6: Share of 2030 charging infrastructure needed already in place in 2020.

3.3.2 Home chargers

Home chargers represent the largest category of chargers for every region, ranging from 86% of the total in Montréal in 2030 to 93% for Lanaudière. It is estimated that Québec will have around 1.1 million home chargers in 2030, of which 91% will be in detached houses. The region with the highest total number of chargers in 2030 (including private home) is Montérégie, with 281,000 units due to more EV owners having access to home charging than in Montréal.

3.3.3 Private workplace and depot chargers

As mentioned in the methodology, we report our numbers corresponding to the locations of the chargers rather than the activity meaning that many of the needed public chargers may be used by commuters during the workday. The assumption of one charger per two battery electric professional vans leads to a high number of depot chargers up to 2035, reaching 18,900 in 2030. Overall, the need for private workplace and depot chargers increases from 10,700 in 2025 to 42,600 in 2030, as shown in Table 2. At a more granular level, Montérégie and Montréal region have the highest needs of all regions in terms of both private workplace chargers with 5,200 and 4,600 units (respectively) and depot chargers with 3,700 and 4,100 units respectively in 2030.

4 Conclusions

This analysis uses a detailed bottom-up evaluation to quantify how much charging infrastructure Québec will require to enable a growing electric vehicle market and meet government targets through 2035. This is the first analysis to estimate charging and energy needs across 6 charging types (private home, depot, and workplace, and public normal AC, fast urban, and fast highway chargers) for all light-duty vehicles (private passenger cars, light commercial vehicles, and taxis) in the province. These results are provided at the regional level, enabling

targeted policies to make progress toward meeting these public charging needs. Based on the analysis, we draw the following conclusions:

Québec will require 8 times more public chargers in 2030 compared to 2020. As the electric vehicle stock grows from 92,000 electric vehicles in 2020 to above 1.5 million on Québec roads in 2030, public chargers will need to increase from about 5,700 to 45,800 normal and 700 to 6,300 fast chargers. This number of fast chargers exceeds Québec's government mandate for 2,500 fast chargers to be installed by Hydro-Québec by 2030, suggesting that other stakeholders, including the private sector, will also need to contribute to the charging network. Reaching this target for public chargers represents a 23% annual growth rate from 2020 to 2030. Additionally, 1.1 million private home chargers, 23,700 private workplaces, and 18,900 depot chargers will be needed by 2030. Montréal city represents a unique situation within Québec: Since more than 80% of households live in multi-unit dwellings in the dense city, only 38% of EV owners are expected to have private home charging in 2030. Therefore, public curbside and urban fast chargers will be of greatest importance.

Growing energy demand for electric vehicles over time can be beneficial if properly planned. Transportation electrification offers Québec an opportunity to dramatically reduce its energy imports and create economic benefits by leveraging its extensive hydropower production. Annual charging energy demand from electric vehicles will grow from 340 gigawatt-hours (GWh) in 2020 to 5.8 terawatt-hours (TWh) in 2030. The projected 2030 EV electricity demand amounts to about 2.7% of Québec's 2019 electricity production of 212 TWh, indicating that electric vehicles will not challenge the province's electricity generation or transmission infrastructure. However, charging may require localized upgrades in distribution infrastructure for areas with high EV uptake. This is particularly the case for Montréal, where we forecast EV electricity consumption of 570 GWh in 2030. A disproportionate share of that energy in Montréal comes from commercial settings (including fast charging) and multi-unit dwellings, whereas most other parts of the province will see the greatest energy demand in single-family residential areas.

The most-urban and most-rural areas require the greatest increases in public charging. Still, local needs vary, with DC fast charging playing a significant role in enabling urban access to electromobility. The regions with the lowest share of 2030 public charging infrastructure in place through 2020 are the mostly rural areas of Nord-du-Québec, Outaouais, and Saguenay-Lac-Saint-Jean and the heavily urbanized area of Laval. These four regions have less than 10% of 2030 public charging infrastructure in place as of the end of 2020, below the provincial average. However, the different settlement patterns across the province mean that charging will happen in different settings: in 2030, 79% of charging at Nord-du-Québec happens in private settings, compared to 74% for the provincial average and only 49% for Montréal city. Urban fast charging will play a particularly important role in enabling access to electromobility in cities. While Québec province had built 11% of its 2030 fast charging needs through 2020, this share is only 5% for Montréal city.

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